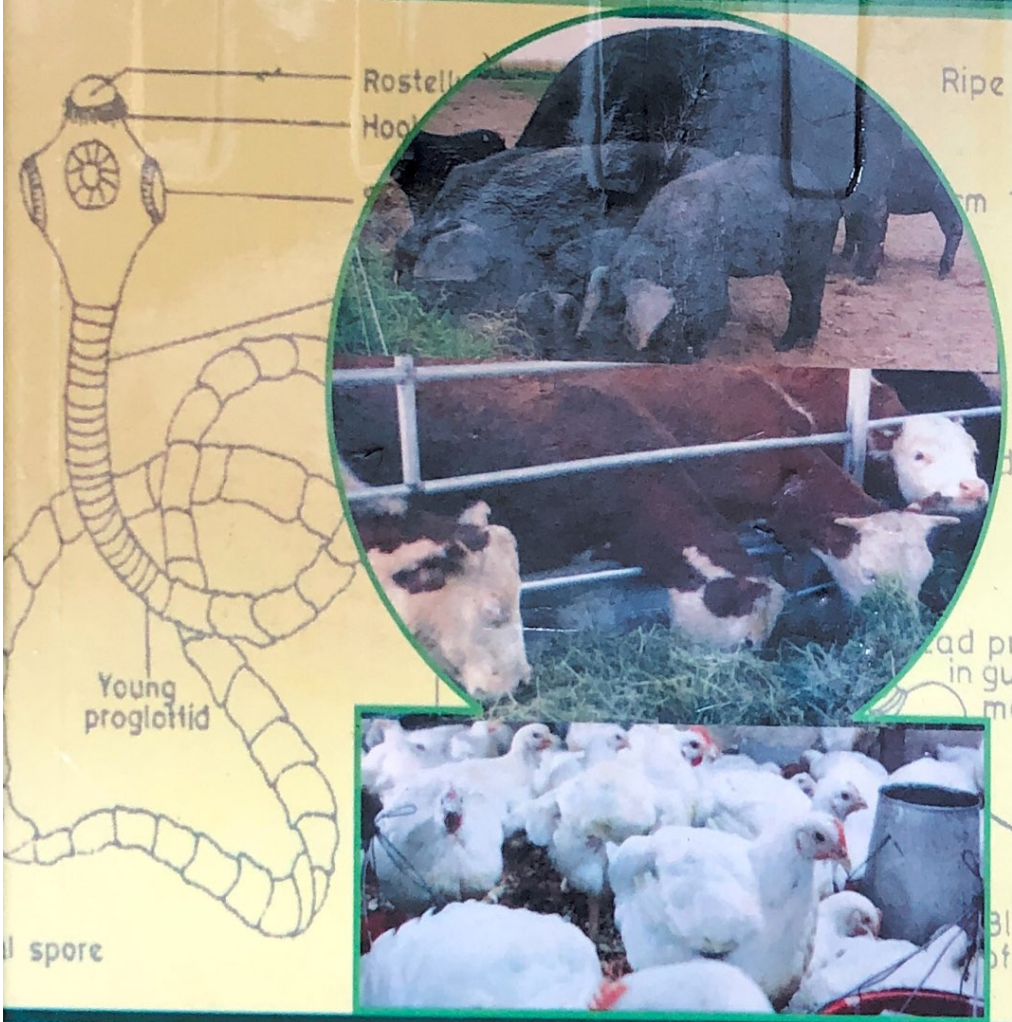
INTRODUCTION to Animal Production





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By

**Okukpe K. M., Adua M. M*., Sola-Ojo F. E.,
Chimezie V. O., Badmos A. A., Alli O.I.,
Adeyemi K. D., Yusuf A. T., Ajao B. H.
and Aderibigbe T. A.**

Department of Animal Production, University of Ilorin, Nigeria
E-mail: okukpekehinde@yahoo.com
or okukpe.km@unilorin.edu.ng;

Department of Animal Science,Nasarawa State University, Keffi, Nigeria

**E-mail: mangonlen@yahoo.com*

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DEDICATION

This work is dedicated to **Moshood Adewale Belewu (RAS)**, *a professor of Dairy Science and Ruminant Nutrition, an astute administrator whose character you love to love and hate to hate, all the while realizing that no man is an angel and none a devil. Real people aren't perfect, perfect people aren't real. Thanks for your understanding/ friendly disposition and at times unfriendly posture which all helped to make a better personality in me. I've learnt to look at the good things without expecting perfection. You've always say something related to Dale Quist words "become so relevant in life that the world cannot ignore you and even to the point where your enemies and critics would have no option than to consult you even to want to launch an attack on you. Be determined to determine what has determined to make you irrelevant"*

&

M.B. Yousuf *(a senior lecturer of Ruminant Nutrition)and all* ***student of Agriculture*** *whose main purpose is to make livestock farming a force to be recon with in the economy of the nation. We were born to make manifest the glory of God that is within us, and as we let our light shine, we unconsciously give other people permission to do the same. Thanks for giving me permission to do same.*

FOLLOW YOUR DREAMS. Or you will spend the rest of your life working for someone who did.

PREFACE

There is no doubt that there are a number of text book available to students on the subject of livestock production. This book is designed to provide a practical approach to the study of livestock as a business to which an average graduate can go into rather than looking for an ever elusive employment in our present age. It is suitable for teaching of undergraduate students of agriculture. It is presented in a format and style to make it easier for the reader to understand and to stimulate their interest towards a practical application of what is learnt in the study.

However, it is not intended to be a substitute for standard text books on the different livestock in this study. It is meant to serve as an overview of the fields of livestock since it contains as much facts as are required for practical application and passing the standard undergraduate university examination. The book will serve as a useful tool in livestock enterprise for students preparing for examination in general agriculture, animal production and livestock entrepreneurship. The book would have covered a major problem that plagued the students i.e. the acute dearth of readable and student friendly texts. The provision of this hand book is therefore borne out of the desire to fill this vacuum by providing this book from lecture notes and other materials in order to touch basic subject areas in animal production. Many people fail in life because they try to copy others, not realizing that everyone has a different question paper! Dare to be different, for so were you made.

ACKNOWLEDGMENTS

My first acknowledgment goes to the various authors of textbooks, journals, magazines and other numerous sources that I have made use of at one time or the other to make my lecture notes which culminated into this book. Whether cited or not, I hereby acknowledge every source of knowledge manifestly or remotely reflected here within.

The completion of this book involved the support of many people. I will like to start by acknowledging the support of my numerous students in the Faculty of Agriculture and the Faculty of Education, University of Ilorin and the College of Agric and Animal Science, Ahmadu Bello University, Mando road, Kaduna.

In the midst of many some stands out clearly for their specific contributions to this book such as MrJaiyeoba Clement K., Dept. of Animal Production, University of Ilorin, and the 2014/2015set of Sasakawa Africa Fund For Extension Education (SAFE) B.Sc. Agricultural Extension and Community Development programme, University of Ilorin, Nigeria.

I also wish to acknowledge the detailed work of several animal scientists and colleagues that edited this book in parts and advised on the order of compilation. I am very grateful to all of you. I specially want to express my gratitude and love for the most significant person in my life, my wife, Catherine Olukemi Okukpe, who has been my encourager for the past years. Her ability to critique and make thoughtful suggestions has been invaluable as well as her patience and endurance for the periods spent behind the desk and her willingness to handle many of my 'usual' responsibilities has enabled me to complete this work.

*And to the most famous, willing, and prolific contributor of all, the world-renowned Anonymous (**Jesus, the Christ**), a heartfelt expression of gratitude. I am very grateful and say thank you.*

My heart is at ease, knowing that what was meant for me will never miss me, and that what misses me was never meant for me.

Okukpe Kehinde *Matthias*

TABLE OF CONTENTS

Title Page		i
Dedication		iv
Preface		v
Acknowledgment		vi
Table of Contents		vii
	Chapters	
1.	Introduction	1-8
2.	Breeds and Origin of Livestock	9-29
3.	Nigeria Biotic Communities and Distribution of Livestock.	30-34
4.	Morphology of Farm Animals	35-44
5.	Feeding Habits of Farm Animals	45-53
6.	Principles of Nutrition	54-113
7.	Management of Farm Animals	114-154
8.	Agribusiness	155-160
9.	Livestock Diseases and Control	161-232
10.	Pig and Rabbit Production	233-236
11.	Beef Cattle Production	237-256
12.	Sheep Production	257-264
13.	Goat Production	265-275
14.	Feeding Systems	276-283
15.	Agricultural Marketing	284-312
	References	313
	Appendix	314-318
	Subject index	319-324

THINK ABOUT IT

Where you start doesn't matter, and what your parents or ancestors did is not the determining factor in what you do, just believe in yourself. Failure is an event and not a person, so in whatever challenges you've had you are not a failure. Are you pleased with where you are on the eight wants of life such as happiness, health, reasonable prosperity, security, friends, peace of mind, good family relationships and hope as this will determine where you will be in five years time from now. A desire for change without changing what you do will never be effective as it is often said that "insanity is doing the same things over and over again with the expectation of a different result". True contentment and total success come from the things money cannot buy. Do what you love to do and get paid doing it.

I've learnt that the five major factors to consider in making a choice of a career are talent, information, aptitude, interest and temperament.

TALENT is ones innate mental or artistic ability which could be discovered/ developed i.e. the natural endowment given to you by creation, what you enjoyed doing with little or no encouragement.

INFORMATION (available facts): Information about where these talents could be useful should be diligently searched through books/ counseling check for the meaning of these careers, mode of training, duration of training, prospects of the career and challenges of each career. Discover which of the careers your talent fitted into.

APTITUDE: Aptitude is one's ability to learn easily/ quickly. From the information gathered assess your capability to overcome all the challenges to meeting your career goals.

INTEREST: which of the careers do you have a reasonable and strong desire to pursue? This desire should give you inspiration and motivation to further your studies in such area and open your eyes to the area you'll desire to specialize.

TEMPERAMENT is a combination of inborn traits that subconsciously affects all our behavior i.e. the emotional state of an individual which tends to condition our responses to the various situations of life. It is the characteristic strength you possess. The psychologist group temperament into four sanguine (warrior, buoyant, lively and fun loving), choleric (strong-willed, practical leader, optimistic), melancholy (sensitive, perfectionist, faithful, self-sacrificing) and phlegmatic (witty dry humour, dependable, efficient). Check the one you belong to and try to overcome the challenges associated with it.

Lastly, follow the 4Ds of success (Desire, Diligence, Determination and Discipline) to attain your goals and the heavens will be your limit.

CHAPTER ONE
INTRODUCTION

Animal production refers to the total stock of knowledge with regards to the breeding, feeding, management, marketing and processing of animals and their products. It also includes the processing and sale of animals or their products. In a simple sentence Animal production is the scientific study of the structure, breeding and management of farm animals. It is synonymous with animal science, animal husbandry, etc. It involve various aspects such as livestock management, pasture/ forage production, animal nutrition, animal reproduction, animal health, animal breeding/ genetics, animal biotechnology, dairy science, animal product/ processing, etc. Livestock industry is one of the most important components of the agric sub-sector of the Nigerian economy in particular and the world in general. It is very important with the main objective of providing highly relished foods such as meat, milk, eggs and cheese, as well as wool, hides and skin, etc. These food items are very important nutrients. Animals utilize biological processes to produce this food items. During the early stone-age (Paleolithic period), man lived by hunting and fishing, as well as gathering snails and insects. Animal production started in the later stone-age (Neolithic period) when human beings started settling down to agriculture and started domesticating some animals. This saw the beginning of the production of poultry products such as eggs/ meat, animal fat and milk from animals.

The need for improvements in the overall livestock industry becomes obvious when viewed against

- The background of our ever growing human population
- The dwindling foreign exchange reserve which places more constraint on the importation of livestock and its products
- The present unsatisfactory protein intake across the country
- The present trend in the global crude oil situation that is reducing the country's foreign exchange earnings
- The need to improve on our exportation of livestock products to enable us earn more foreign exchange from agriculture. Nigerians depend largely on plants for their sources of protein, the biological value of which is not as high as those of animal sources. This is why there are so many cases of malnutrition. Plant protein is deficient in sulphur containing amino acid such as methionine, cysteine. Cereals are low in lysine, pulses are low in methionine but animal protein contains all the essential amino acid. Examples of animal protein include egg, fish, meat, milk, etc. The United Nations- Food and Agricultural Organization (FAO) recommended 65g as the average total protein requirement per person per day, 42.25g of this must be of animal origin and 22.75g of plant origin. However what operates in Nigeria is that total protein intake is 65g, 10.7g of which is animal origin and 43.7g of plants

origin. This shows that protein intake is far below the recommended level. The objective of animal science therefore is to find ways of replacing the traditional system of animal husbandry with the modern system; this involves a more systematic approach. It involves a systematic approach of careful selection and breeding, adequate feeding, proper maintenance of health and provision of adequate housing.

OBJECTIVES AND POLICIES FOR INCREASING THE SUPPLY OF ANIMAL PRODUCTS IN NIGERIA

The diet of majority of the people is based on plants products such as rice, wheat, cassava and legumes. In the third world, as much as half of the population suffer from hunger and malnutrition, usually both. Children suffers from kwashiorkor which is a result of carbohydrate-protein imbalance, although a large proportion of the African protein supply comes from plant origin. The biological value of this plant protein is not as high as those from animal sources. This is because of the fact that the vegetable proteins are deficient in the sulphur containing amino acids such as methionine, cysteine, etc which are essential amino acids. On realizing the short fall in the protein intake of Nigeria, the government in the mid-1970 embarked on massive importation of livestock products, a lot of foreign exchange was used for this. But in the late 1970s and early 1980s the government decided that much of this should be produced locally. This period therefore witnessed the establishment of some modern livestock farms such as Obasanjo Farm at Otta.

IMPORTANCE OF LIVESTOCK TO NIGERIAN ECONOMY

1. Food
2. Industrial products
3. Power
4. Recreation and Security
5. Manure and Fuel
6. Employment

Source of Food: Nearly half of the total food supply is contributed by mammalian, avian and aquatic life at the present time to meet the ever increasing human population of Nigeria. Research studies have shown that foods of animal origin are richer sources of most nutrients needed for a balanced diet than that of a plant origin. But the consumption of food products in terms of animal protein is limited due to cost. This is the main reason for saying that the capital production of animal product is a reflection of the per capital income of the population. The livestock industry provides a good source of animal protein which is needed for a balanced diet; these are meat, milk and eggs. Food of animal origin is of good dietary value especially for the development of healthy children in addition, mineral and vitamin, calcium, phosphorus, sulphur, iron, etc. are well obtained from animal origin.

2. **Source of Industrial products:** Livestock products play an important role in the manufacture of industrial products. Many vaccines are derived from animals and some animal extracts e.g. adrenalin and insulin (normally obtained from the pancreas of cattle).The white of eggs is used in the manufacture of pharmaceuticals, paints, varnishes, adhesives and printers ink. Soap, paints and shampoos can be manufactured from egg yolk. Animal products like wool, hides and skin provides clothing, shoes, jacket, brushes and rugs. Poultry feathers are used for the production of pillows, cushions, mattresses, dusters, insulation material, animal feeds and fertilizers.

3. **Source of Farm Power:** Livestock also produces draft power. Cattle are very useful in drawing farm implements for cultivation, ploughing, ridging and harrowing e.g. bullocks for tilling the soil; horses, donkeys and camels are used as beast of burden for transportation of farmers produce. However, the invention and extension of mechanical power during the 19th and 20th century has steadily decreased the use of animal power. Animal power still constitutes an important source of power in the developing countries but their role has been replaced in the developed countries.

4. **Source of Recreation and Security:** Domestic animals like horses and dogs have been used extensively for recreation and sports. Animals in the Zoo and circus are sources of recreation for both the young and the old. Wildlife and aquatic animals provide hunting and fishing opportunities respectively to great numbers of people all over the world. Dog, the first animal to be domesticated by man is used by the police to combat crime, and by individuals to guard their homes as well as by the blind as guide-animals. In some places, social status depends on the number of herds of cattle

2. **Supply of Manure and Fuel:** Livestock plays the important role of supplying manure for crops and fish ponds. In some places the manure is mixed with soil for plastering the floor and walls. In some rural areas it is used as fuels for cooking. It can also be used to generate cooking gas (Bio-gas).
3. **Source of Employment:** The livestock industryalso makes for desirable diversification through distribution of risk, establishment of basis for credit, better distribution of labour, more efficient utilization of home grown feeds such as maize, more flexible farm programs, development of superior markets and an opportunity for the application of wider experiences and superior managerial ability. It provides job opportunities for scientists who investigate livestock problems, workers in the farms and traders who sell the products or by-products of livestock.

CHARACTERISTICS OF NIGERIAN LIVESTOCK INDUSTRY

Nigerian livestock production industry is characterized by the following features.

1. There is a serious scarcity of reliable data about livestock statistics. This has resulted in wide variation an production estimates.
2. There has been generally very little or no integration of livestock into farming

system. Most of the livestock generally obtain their feed by grazing natural range or scavenging on domestic waste with little or no supplementation to ensure good levels of maturity.

3. The bulk of the livestock population is almost entirely in the hands of small scale producers such as the nomadic pastoralist in the North who follow their herd in search of forage across state, national and international boundaries. The trans-humans system adopted by this group of producers, as generally complicated planning and has not been conducive to the introduction of any improvement plans or the adoption of technological innovation to boost production.
4. Poultry production is the leading and most developed industry which most government have been able to popularize, yet it is still in the hand of the private sector.
5. Government intervention in the industry by way of direct production has been the same in almost all the cases and it has been a woeful failure.
6. In spite of the inability of the domestic industry to meet the country's demand for livestock products, government has introduced a number of measures against the importation of livestock product.
7. Ecological condition over vast areas of the country presents a variety of management problem on account of the adverse effect of the biological components of the environment on animal health and general productivity.
8. The livestock industry in Nigeria has been adversely affected by high cost of feed ingredients due to the low level of maize production, competition between livestock and man for the available grains, as well as on availability of other feed components.
9. The majority of the rural communities in the Southern States generally have little or no knowledge of animal production techniques.

Problems of livestock production in Nigeria

1. Nutrition: It is well known that at a given level of management and disease control, livestock production is a function of the level of the feeding. The nutrient requirement of different classes of animals at different production levels have been well documented for all specie in temperate countries of the world. In Nigeria, very little is known about the effect of the warm environment on the nutrient requirement of animals for good productive purposes. Livestock ration formulated here in Nigeria is based on the requirement of the different livestock specie of temperate region which of course is grossly inadequate for our environment. Non-ruminant animals for example are very sensitive to poor quality ration for their optimum performance. The ration being fed to monogastrics (non-ruminants) are too expensive because most of the materials (feedstuff) are being competed for by man. Within the past years, the prices of ingredient of livestock feed have been on the increase and this is

why hoped that in the foreseeable future ruminant will probably be the cheapest source of producing animal protein in Nigeria.

2. **Type of animal:** Generally animals that are indigenous to our climate are very small, have slow growth rate, high mortality rate and not very economical in an intensive system of agriculture. Selection of animals for improved performances and veterinary care are not adequate. An indigenous cow will probably take 5 to 6 years to reach market weight of 200kg, whereas an exotic breed will reach the same weight in about 3years. Similarly our local poultry takes a longer time before laying of eggs starts. But indigenous animal can tolerate humidity, light intensity, high temperature and are more resistant to disease and parasite than the exotic breeds.
3. **Marketing and distribution:** Over ninety percent of cattle and seventy percent of sheep and goats are located in the Sudan/ Sahel savanna zone where they are managed under traditional system. Only few of these animals are slaughtered in that location, majority find their way to markets in the South. About 60% of these animals are transported from the North to the South on foots, the rest by truck or rail. Truck shipment is expensive and animals are left without food and water for about 2 or 3 days, though it is the fastest means of transporting the animals. Rail (train) transport is cheaper but slower than road (truck) transport. Animals are uncared for while on transit which leads to a loss in weight and even death at times. The third means of transport is trekking, heavier losses both in terms of weight and number ofusually encountered, it is extremely slow and also exposes animal to a number of diseases, injuries and other hazards. For most livestock and its products it is scarce to find an organized market for effective distribution and sales because there is always a general lack of market information with regards to quantity and quality of product in demand and where demanded.
4. **Lack of qualified manpower:** Livestock industry is a complex one which requires a largeteams of different professionals all working together to ensure that the production, marketing and distribution systems within the enterprise operate efficiently. But there is a general lack or shortage of qualified manpower at all levels of livestock production in Nigeria e.g. extension agent, livestock breeders, veterinary doctors, etc. These qualified people are supposed to manage specialized areas like breeding, nutrition, reproductive physiology, pasture agronomy, meat processing, etc.
5. **Capital:** This is a limiting factor to many things. Livestock production is a capital intensive industry in terms of investment in high quality breeding stock, housing, equipment, land acquisition, hiring of good quality labour, considerable credit facilities, this entire are required for a successful livestock operations. But unfortunately credit facilities to farmers are not

easy to come by. This is not saying that money is not being lent for agric practices but most of the money goes to government cooperation, institutions and big farmers. Because of the difficulties encountered in securing adequate capital, livestock production has been left in the hands of peasant farmers.

6. **Low level of private sector participation:** There has been very little private sector participation in livestock production particularly cattle. Perhaps one of the reasons for the low response of foreign partners in joint participation in livestock project is the general conclusion of international financial agencies that livestock project have relatively low success rate and have the lowest rate of returns in developing countries.
7. **Lack of adequate data:** There is lack of adequate data of livestock at State and Federal levels for proper livestock programme planning.
8. **Religious belief:** This affects livestock production in Nigeria for example Moslem does not eat pork and so pig raising in Moslem dominated States is discouraged. Another example is eating of dogs.
9. **Irregular policies on animal production: Poor access to drugs and veterinary services** Most animal production activities take place in rural areas, which are not accessible to proper veterinary services. Many that are accessible find the high cost of drugs and veterinary services exorbitant. Therefore, livestock farmers resort to patronizing readily available quacks that could wreak havoc on livestock production by using fake drugs, expired vaccines, and wrong diagnosis and prescriptions for treating diseases. Sub-standard and all manner of low quality drugs and vaccines are currently in the market and can easily be purchased and used virtually by everyone.
10. **Difficulties in acquisition of drugs and other necessary inputs: Inconsistent government policies**The inconsistent or failed government policies are detrimental to the progress of livestock industry. Government sometimes ban the importation of animal products not readily available in the country in a bid to help local livestock industry without providing viable alternatives. An example is the ban on the importation of poultry meat without sustainable local poultry production. Lack of proper implementation of government loan schemes for livestock production have resulted in a moribund program. There is lack of sustainable incentives to reduce financial losses incurred by livestock farmers during glut or disease outbreak. Inconsistent policies on agriculture with changes in government, most policies/ progammes that came into being by one political party though sustainable are often changed when there is a change of government.

Expectations after getting the problems solved

1. Getting enough food supply both in terms of quantity and quality that will keep pace with the ever increasing population at a fair and stable price.
2. To significantly increase production of minerals that would support domestic manufacturing activities.
3. To expand production of export products as foreign exchange earner.
4. To create employment opportunities that will absorb majority of the increasing labour force thereby stopping the present tide of migration from rural to urban areas.

.FACTORS INFLUENCING THE DEMAND FOR MEAT AND MEAT PRODUCTS

Demand for meat depends largely on habits, availability, price and taste. Meat is mostly distributed by butchers who purchase/ slaughter them with prices depending on the amount of flesh possessed by the animal. Consumers demand exerts a powerful influence on the type of animal produced. Hence factors such as prolificacy, economy of feed utilization, size, longevity, etc should be put into consideration. Consumers demand is changing with increase in urbanization to smaller and less fatty cuts of meats as well as high quality steaks and roasts. To meet this demand the producer has to breed and market younger animals with maximum cut-out value, blocky conformation and short leg/neck.

The following qualities cannot be overlooked when estimating the value of livestock products

1. **Palatability** - people eat meat because they like it. The palatability of meat is influenced by tenderness, juiciness and flavor of the lean.
2. **Attractiveness and eye appeal** this is an important quality when selling meat to a buyer. The colour of the lean, degree of fatness and marbling are leading factors that determines buyers appeal.
3. **Moderate amount of fat/bone** most people discriminate against much fat. The popular types of bones preferred by Nigerians are the chewable bones popularly called 'biscuit bone'.
4. **Small cut** in view of the small purchasing power of an average Nigerian, small cuts that are within his reach financially are preferred.
5. **Processing of meat** the educated/ working Nigerian women prefer frozen meat sold in cold stores (steaks, chops, hamburgers) that is not time consuming in preparation and will assist in meal preparation with maximum speed with little stress.
6. **Economy of supply and demand** when the demand is high during festive celeberation e.g. Christmas, Sallah, New Year etc, the price of meat escalates. During harsh weather conditions such as a period of drought, prices fall in markets close to the scene of the disaster. But the reverse prevails in remote markets where their unavailability makes meat scarce leading to a rise in price.

Table 1.1: Common species of livestock, body weight and recorded lifespan

Common Name	Species Name	Mature Body Weight (Kg)	Mature Age	Longevity (year)	Maximum Recorded Lifespan (yr)	Birth Weight (kg)
Dairy Cattle	Bos taurus/ indicus	464-653	5yr	20-25	30	25-45
Horse	Equus Caballus	450	3-5yr	20-25	50	45-55
Goat	Capra Hircus	26-102	2yr	10-15	18	2.5 - 3.5
Swine	Sus scrofa	70-128	–	16-18	27	1.0 - 2.0
Sheep	Ovis aries	34-80	2yr	10-18	20	2.0 - 4.0
Rabbit	Oryctolagus Cuniculus	3.0-4.9	1yr	5-8	>13	0.04-0.08
Chicken	Gallus Domesticus	1.5-3.3	20-30wks	2-5	30	0.049-0.065
Turkey	Meleagris Gallopavo	5.0-14.8	28-35wks	-	12.3	0.052-0.056

Table 1:2 SUMMARY OF LIVESTOCK TERMINOLOGY

escription	Cattle	Sheep	Goat	Rabbit	Pig	Chicken	Turkey	Duck
Adult Male	bull	ram	buck	buck	boar	cock	tom	drake
Adult Female	cow	ewe	doe	doe	sow	hen	hen	Duck/hen
Young Ones	calf	lamb	kid	kitten	piglet	chick	poult	Duckling
Act of Mating	servicing	tupping	servicing	servicing	coupling	mating	mating	mating
Parturition	calving	lambing	kidding	kindling	farrowing	hatching	hatching	hatching
Fresh meat	beef	mutton	goat meat	rabbit meat			pork	chicken
Matured Female	heifer						gilt	

CHAPTER TWO
BREEDS AND ORIGIN OF LIVESTOCK

Introduction

What is a breed? It is a group of animal possessing certain characteristics that are common to the individuals within the group and these characteristics distinguish them from other group of animals within the same species. These characteristics are the trade mark of that breed and are transmitted from one generation to another. In simple term, breeds are a group of animals that originated from the same ancestors and have similar characteristics. It is a stock of animal within specie having a distinctive appearance and typically has been developed by deliberate selection.

Species could be defined as animals that are capable of interbreeding. It is the largest group of organism where two hybrids are capable of reproducing fertile offspring using sexual reproduction e.g. Keteku is the result of the cross between the humpless N'dama or Muturu and any of the humped cattle.

Ruminant animal - These are animals with four stomach compartments and they chew the cud. They belong to the mammalian family, the order Artiodactyla, sub-order ruminantia and genus Bovidae (cattle), Ovis (sheep) and Capra (goat). These ruminants are able to convert grasses and legume (forage) which cannot be eaten by man into appetizing and highly nutritious foods such as milk and meat

BREEDS OF CATTLE

ORIGIN: The families of mammals that include all types of domestic cattle are known as bovidae. They are the dominant family of hoofed mammals. All domestic cattle can be divided into two main sub-groups

1. *Bos taurus* (humpless cattle)
2. *Bos indicus* (humped cattle)

These two types of cattle first existed in large numbers in Northern Asia at about 800BC. The great majority but not the entire indigenous tropic breeds are Zebu of one variety or the other. These Zebu cattle are parts of the 5types of Zebu that have been described to be associated with human migration to different parts of the world. Cattle were imported to the North-East of Africa by the nomadic tribe. Three major types of cattle were imported into or migrated with the nomads into North-East part of Africa. These are the ancestors of most of the cattle in Africa today.

The cattle were

1. Hamitic Longhorn,
2. Celtic Shorthorn, and
3. The Zebu

Hamitic Longhorn and Celtic Shorthorn are considered to be ancestors of *Bos taurus* while the Zebu is of the *Bos indicus*.

These cattle mix at various terms and ways to produce the Sanga cattle. Hamitic Longhorn entered Egypt at about 5000BC and they were followed at about 2750 to 27500BC by the Celtic Shorthorn. As the Celtic Shorthorn people came, there arouse a sort of competition and there was voluntary Southward migration of the owners of Hamitic Longhorn until they reach Morocco and then they further subdivide into two groups so the route of migration is

Route of Migration

1. Westward along Mediterranean, -
2. South-Westward via Tibetan highland, - HLh e.g. Kuri/ Ndama
3. Morocco to West-Africa, -
4. Southwards up the Nile -

1. Northern mediterrenean lithoral, -
2. Southward along the Nile - CSh e.g. Muturu
3. From Morocco (Iberian Peninsula; France/ England to be ancestors of Jersey and Guernsey).

Another group of HLh is Kuri or Budama that has sound characteristics. Incidentally N'dama seems to be the cheap breed of beef cattle in West-Africa. It has survived due to their resistance/ tolerance to Trypanosomiasis and are common in the West African coast while Kuri or Budama are isolated around Lake Chad, they are great swimmers. N'dama are predominant locally in Oyo, Shaki, Sapateri. From the CSh arouse the Muturu refers to as the West-African dwarf Shorthorn. They are also resistant to Trypanosomiasis and are less tolerant than the N'dama. The latest arrival and the third type of cattle is the chest humped Zebu, they were imported in small numbers to Egypt by the Arab invaders as early as 2500 to 2000BC. Today, they are represented by the White- Fulani which incidentally is the most widely distributed breed of cattle in Nigeria. Zebu cattle hold their existence to being resistant to Rinderpest than the humpless or Sanga cattle. They are found largely in semi arid part of the country.

Classification of Cattle: Cattle can be classified on the basis of origin and use

On the basis of Origin:

- Order- Artiodactyla (even toe hoof animals)
- Sub-Order- Pecora
- Family- Bovidae
- Genus- Bos (Bibovine; Busontine; Bubatine; Taurine- *Bos taurus, Bos indicus*).

E.g. Zebu cattle (***Bos indicus***).

s/n	Breed	Origin
1	White Fulani (Bunaji) Lh	Sudan/ Sahel savanna belt
2	Sokoto Gudali Sh	Sudan/ Sahel savanna belt
3	Red Bororo (Rahaji) Lh	North-East Nigeria

4	Boran	East Africa, Kenya
5	Beef master	Southern part of Texas (USA)
6	American Brahman	India
7	Africanda	South Africa

Lh- Longhorn, Sh- Shorthorn

Bos taurus

s/n	Breed	Origin
1	Hereford	Corn belt of America
2	Aberdeen Angus	North Scotland
3	The Red Angus	USA
4	Jersey	USA
5	Guernsey	USA
6	N'dama	Coastal region of Nigeria
7	Muturu	Coastal region of Nigeria
8	Kuri (cross between hump/ humpless)	Nigeria

Classification on the basis of use: Animals are usually bred for specific purposes. Classification of cattle base on use can be divided into-

1. Beef cattle: Mainly produced for meat and characterized by their great width, depth of the body and relatively short leg. They convert feed efficiently into high quality meat for human consumption e.g. Aberdeen Angus, Brahman, etc
2. Dairy cattle: This is characterized by lean angular form and a well developed mammary system. They convert feed efficiently into maximum high quality milk e.g. White Fulani, Jersey, Friesian, Holstein, etc.
3. Dual purpose cattle: These are intermediate between the milk and beef type both in conformation and production of milk and meat e.g. Short horn-Sokoto Gudali, Muturu, etc
4. Draft cattle: This combine the characteristic required for good work which include free moving limbs, sound feet, long legs, great size and ruggedness with a quiet temperament and submission to discipline. They can do different types of works like ploughing, harrowing, seed sowing, fertilizer application, etc e.g. N'dama.

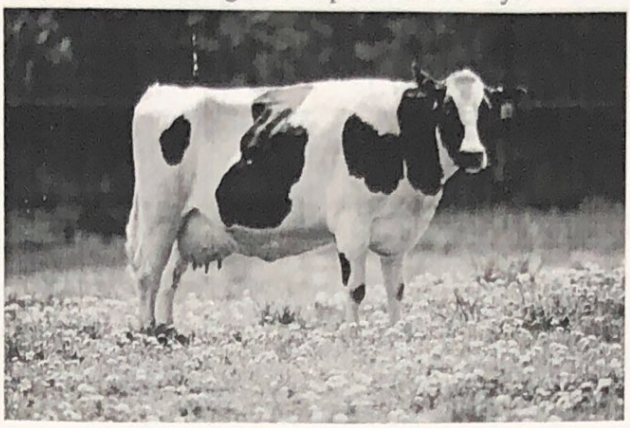
1. N'DAMA: In West Africa they are the most widely distributed breed found in areas like Guinea, Gambia, Sierra Leone, Liberia, Nigeria, Cameroon, and Ghana. Many of the animals are imported to Southern Nigeria and Ghana as ranch and foundation stock for distribution to farmers. It is preferred in the tse-tse fly infested areas of Southern Nigeria because of its resistance to Trypanosomiasis and its relatively large size when compared to Muturu. N'dama has a compact well proportioned body with a good beef

conformation set on short legs. Age at first calving is 3years; it reaches full maturity at about 5years of age or earlier under good feeding and management practices. The cows have breeding life span of 14 to 15years. It is a good meat animal weighing about 18kg at birth, 134kg at a year old, 300kg has matured cow and 320- 365kg as matured bull. It is humpless, with a small dew lap, a small milk producer, golden yellow to brownish in colour and sometimes with white markings on the face, belly and legs.

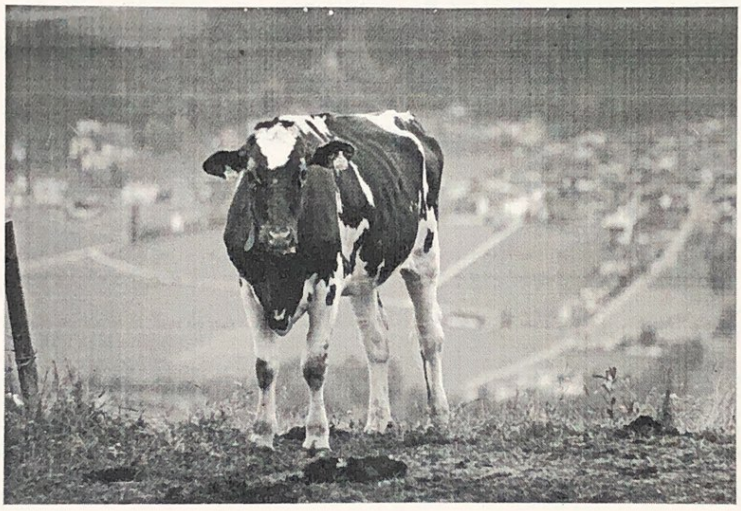
2. MUTURU: It is found in the forest zones of West Africa where they are reared for meat and it's highly resistant to Trypanosomiasis. It is a small animal weighing about 230kg at maturity, 12kg at birth and reaches mature weight in 3 to 3.5years. It is very rugged, black to brown in colour with broad head.
3. BUDAMA: These are large animals and they are one of the heaviest breed in West Africa. An excellent swimmer, weighs about 300 to 800kg, with an average of 500kg for bulls and 360kg for cows. It is a milk and meat producing animal.
4. WHITE FULANI: They are owned exclusively by the nomadic Fulani in the central pastoral belt of Nigeria. It is a range type of cattle, white in colour with black points or markings. It is a large animal with average of about 130 to 135cm at withers. Weighs about 355kg at maturity for cows and 450kg for matured bulls. Birth weight of 23kg. Birth weight of 23kg, 76kg at 6months, 130kg at 12months, 210kg at 24months and 280kg at 36months was recorded at Shika farm. Average calving age is 3years 7months with calving interval of 1year, Life span of 9 to 10years and heat period of 12hours. Bulls are placed in service when they are 3 to 4years of age. White Fulani is a dairy type of cattle with a well developed and strongly attached udder although the milk yield is low. When raised under good management and feeding condition it is capable of producing much more milk. For example, data from Shika farm near Zaria showed that milk production recorded in 305 lactation day rose from 1,182kg in 1961 to 1,455kg in 1980. Some outstanding cows are recorded to produce 2,245kg. In addition to these dairy qualities, White Fulani is able to fatten rapidly, so serve as a dual purpose.
5. SOKOTO GUDALI: This breed is bigger and heavier than the White Fulani, it is a short horned cattle found in Southeast of Sokoto State and also in the derived Guinea/ Sudan savanna. The colour varies from white to grayish white to cream white. Average age at calving is 3years; the active life span is 10years. It is resistant to Trypanosomiasis more than the White Fulani. It has potentials for dual-purpose as well as draught animal.

DAIRY BREEDS

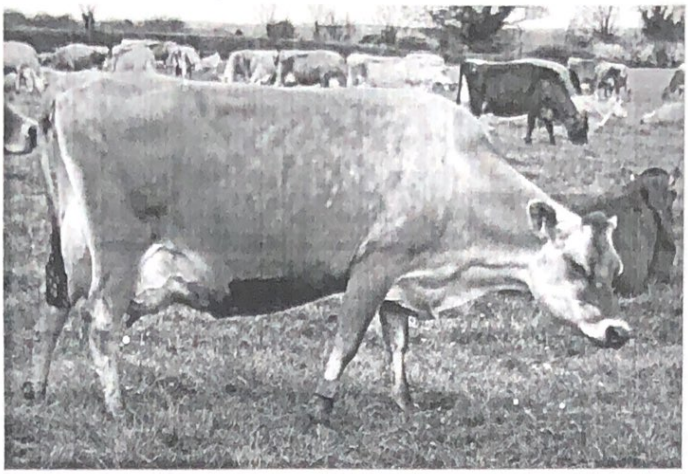
1. FRIESIAN: This is also known as Holstein Friesian, the colour of which is black with white. Average milk yield is about 4800litres per lactation which is higher than any other breed. Matured cow weighs 680kg, bull 998kg and a birth weight of 45kg. The calves are strong and vigorous with males ranked high as beef producers among the dairy breeds. It has a gestation period of 279days.



2 .AYRSHIRE: The colour is brown and white in varied proportion with horns that are long, curved upward and slightly backward. This breed is noted for its good legs and grazing ability, a good uniform production of milk averaging about 4,300L per lactation. Udders are attached high up the hind and they extend far forward with flat even lower surfaces while the teats are short regularly spaced and of uniform size. Mature cow weigh 544kg, bull 840kg, heifer 320kg and steer 350kg. Gestation period is 278days.



3. JERSEY: They are in varieties of shades of yellow ranging from almost white to nearly black, they have a grey ring of hair behind a black muzzle. Average yearly production of 3,400L of milk with 5% butter-fat content. Use in making butter. In tropical area Jersey is usually crossed with Zebu breeds. The cow weighs 464kg, bull 680kg, heifer 280kg and steer 320kg. Gestation period is 278days.

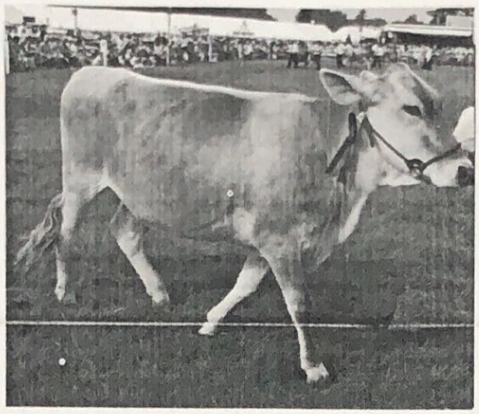


4. GUERNSEY: It is about the same size as Ayrshire breed. They are fawn in colour usually with white markings. Average yield is 3,600L per lactation with milk having 4.5% butter-fat content. The mature cow weighs 449kg, bull 771kg, heifer 290kg and steer 320kg. Gestation period is 282days.

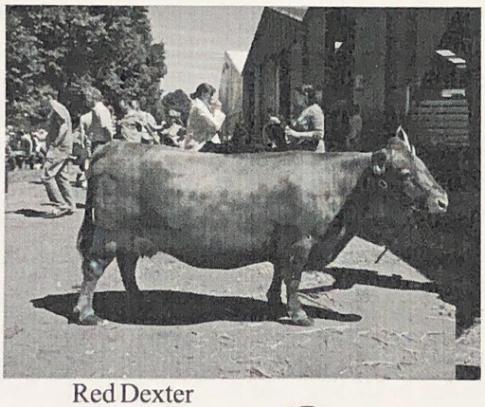


Characteristics of West African breed of cattle

1. Very hardy
2. Have greater tolerance to heat and humidity
3. Tolerant to some diseases e.g. trypanosomiasis
4. Withstand stress and can travel long distances without water
5. Late maturing
6. Have compact/ blocky shape body
7. Are most of dual purpose (produce meat and milk)
8. Generally long legged animals
9. Some are humped
10. Powerful shoulder for use as draught animals
11. Loose, thin and pigmented skin
12. Low milk yields/ small udder
13. Slow growth rate
14. Small body weight.



Brown swiss



Red Dexter



Hereford

SHEEP AND GOAT

Family: Bovidae (hollow horn)

Genus: Capra (Goat); Ovis (Sheep)

They are closely related but goats can be distinguished from sheep by these features

1. Presence of beard
2. Strong smell of the buck
3. Exposure of the anus

Goats are more intelligent, independent and possess greater ability to fight and fend for themselves.

Origin of Sheep: Sheep belongs to the

Family- Bovidae

Sub family- Caprinae

Genus- Ovis

Ovis aries (domesticated sheep)

Sheep were domesticated almost at the same time as goat and it occurred before crop agriculture was fully developed. The original centre of domestication was Aralo-Capsian Steppe, from where it spread to Iran and there was an Eastward movement to India and SouthEast Asia, another Westward movement to Western Asia, Europe and Africa.

There are 4 major types of sheep introduced into Africa.

1. Moufflon: This came from Europe via North African Coast. They are small and thin legged with hairy coat. They are distributed from Sudan and East-Africa to West Africa. Typical breed include Dinka of Sudan, Baluba of Tanzania, Dwarf forest breed of West Africa.
2. The Screw-horned hairy Sheep of Urial origin that came via Egypt. They are long legged, thin tailed hairy Sheep of the higher rainfall savanna area of

3. The Wool Sheep of the Ammon type: Introduced into Africa from two sources- (i) the north via Isthmus of Suez (2000BC) and spread as far as central Chad, (ii) via the straits of Bab-el-Mandele.
4. Fat rumped hairy type: Introduced into East Africa from the Arabian Peninsula. The first 3 wild species contributed to the genetic makeup of the modern breeds of Sheep. Sheep are valued for their meat and wool and, as such, they are classified into the meat and wool type. The wool types can be subdivided into the long woolen breed, the short woolen breed and the mountain breed.

Meat type: It is use for meat, milk, skin and hair. Mainly found in the tropics. Can be divided into two- hairy and the wool, hairy can be divided into two again- the small type (West-African dwarf) and the larger type (Guinea, Hausa (Yankasa), Fulani (Ouda).

1. West-African dwarf: Found all over West-Africa especially in the humid areas, it has fine hairs usually white in colour or a mixture of black and white. Possess a well developed neck ruff. It is hardy and tolerant to Trypanosomiasis. The matured weight is 25 to 30kg, but under good management it can be greater than 30kg.
2. Ouda: Found in Senegal, Chad and Nigeria (Sokoto, Kaduna zone), similar to Fulani cattle types. They are large, long legged, long tail and they possess moderately long flappy ears. Males are horned which are quite large, emerging sideways and slightly backward and with a twist. They are susceptible to helminthes and Trypanosomiasis. It has two colours, amber and white, the amber reaches up to the abdominal region, the posterior region is white. Mature males and female weighs averagely 68kg and 36 to 41kg respectively.
3. Yankasa: This is a fairly big animal with a mature weight of 30-35kg. The ram has well developed horns while the ewe is polled (hornless). They occur throughout the northern region of Nigeria, they have short ears. They are usually white in colour though there may be some black spots on the head. They are brought down to the South during festivals.

Exotic Breeds

1. Africana sheep: Originated from Colombia and Venezuela. It has brown, shade tan and brown/ cherry red and dark red colour. It is mostly polled (hornless).
2. Barbado sheep: Coat is short and coarse wool; colour is tan, tan with pale/ black belly. The male is horned while the female is polled.
3. British Milk Sheep: Originated in the UK, brownish in colour, large size, polled and it has woolless face/ legs. Has high milk yield with high fat and protein contents.

4. Charollais Sheep: Originated from France, it is whitish in colour and is use for meat/ fleece and polled. The fleece weighs between 2 to 2.5kg. The wool is short and fine.
5. Dorper Sheep: Originated from South Africa, it is hornless, has good body length with short light collaring hair and wool. It has black head with white body. It is very hardy, has high reproductive growth rate with good mothering ability.
6. Hampshire Sheep: Originated from South England. It is very active with mild disposition. Ram weighs 275lb (pounds, 2.2lb = 1kg), ewe weighs 200lb. Its ear is moderate in length and thick with coarse dark/ black/brown hair. It is a meat breed.
7. Jacob Sheep: The colour is black and white, has four horns, ewes weighs about 100 120lb. the animal is curious and agile, ram is born with horn bud. It's a meat breed.
8. Medium Wool Merino Sheep: originated from Australia, it is a wool purpose breed with heavy fleece; It is brown in colour and hornless.
9. Nellore Sheep: Originated from Andrapradesh in India. It has white colour with black spots or reddish brown colour, The male has horn while the female is hornless, it is a meat or hair purpose breed. The ewe is about 30-35kg in weight while the ram weighs 40 - 45kg.

Origin of Goats: They are widely distributed and very important in subsistent agriculture because of their ability to adapt and maintain themselves in harsh environment.

Family- Bovidae

Genus- Capra

There are 5species

1. *Capra hircus* (true goat bezoar)
2. *Capra ibex* (ibex)
3. *Capra caucasica* (caucasicara tur)
4. *Capra pyrenaica* (Spanish ibex)
5. *Capra falconeri* (Markhar)

The Bezoar of South West Asia is the main ancestor. The Markhar of NorthWest India and the Bezoar are found to have contributed to the genetic makeup of some breeds in India and Western Asia. The ibex and Bezoar are part of the ancestors of goats in North and East Africa.

Classification: There are 4 methods of classification

1. Origin
2. Body size
3. Hair shape and length

4. Function

1. Origin: On the basis of origin there are-
   i. European type e.g. Saanen, Alpine
   ii. Oriental type e.g. Angora, Nubian, Damascus
   iii. Asiantic type e.g. Kashmir, Jamnapari
   iv. African type e.g. Red Sokoto (Maradi), West African Dwarf
   v. South-American type e.g. Moxoto, Marota.
2. Function: On the basis of function
   i. Milk type: The does have large and well developed mammary glands e.g. Anglo-Nubian, Jamnapari, British Saanen, Sudanese Nubia.
   ii. Wool bearing type: These produce substantial quantities of wool use for industrial purposes like blanket, carpet e.g. Angora.
   iii. Meat type e.g. Jamnapari, Fegian, Nubian
   3. Body size:
   4. Hair shape and length:

Nigerian breeds

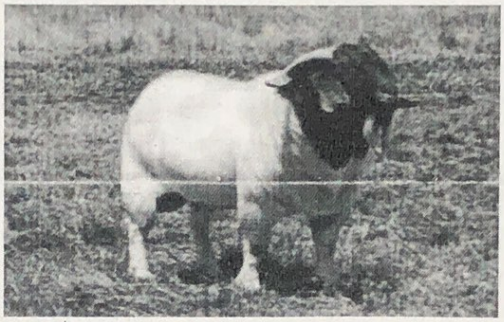
1. West-African Fouta-Djallon: This is resistant to Trypanosomiasis, weighs about 25kg at maturity, buck height is 48-62cm/ doe height 44-58cm, mean birth weight is 1.4kg, weight at one year is 12.85kg with an average daily body weight gain of 53g. This breed is fairly black, brown or white in colour.
2. Red Sokoto (Maradi): This is the most important Northern breed characterized by fairly long leg, prominent forehead, black mucous membrane, short to medium horn, short neck, red colour and fairly big size. At maturity it weighs about 30kg, it's a very good milk purpose animal.
3. West-African Long-legged (Sahelian): Found in North-Eastern part of the country around Lake-Chad. Brought into the country from the neighboring countries. The long legs help in adaptation to environment and trekking long distance. Weighs about 25 to 35kg at maturity. It has semi-pendulus ear, long neck/legs. A dual-purpose breed for meat and skin.

Exotic breeds

1. Nubian: Exist in all colour, black and white, red and white and in all combination, but the popular colour is brown. It originated from UK. It's a popular breed with Roman nose, large size, long pendulous ears, and a milk purpose breed. Milk is rich in butter fat and good for cheese making. Average milk yield is 1,979kg per lactation year.
2. Angora: This breed is from Angora division in Turkey, it is almost pure white in colour. The outer coat is made up of long strands of hair known as mohair.
3. Saanen: Originated from Switzerland. It has forward facing ears. A big animal,

white in colour, mature weight of doe is 54kg while that of buck is 84kg. Milk yield is 2,250kg per lactation.

4. Alpine: Originated from Switzerland, brown/ white or other colours, it has dished/ curved noses and upright ears. A milk breed.
5. Toggenburg: originated from Switzerland, it has medium size, chocolate colour and a well developed udder (a milk breed).
6. Danish Landrace: Originated from Denmark, has varied colour, it has medium-large size with short to long hair and most have horns. Average milk yield is 800litres per lactation.
7. Golden Guernsey: Originated from Channel Island off the coast of Britain. It is use for milk production with large butter fat and protein. It is cream/ brown in colour and hornless.
8. Daera Din Palah: Originated from Punjab in Pakistan, a milk-purpose breed with black colour, large size and well developed udder. It has a long hanging twisted ear with a spiral horn.
9. Oberhasli: Originated from Switzerland, it is black in colour and a milk-purpose breed.
10. La Mancha: Originated from USA. It has short ears and a well developed udder. It is chocolate in colour.



Boer goat

PIGS

Position of pigs in the zoological scheme

Kingdom	- Animalia
Phyllum	- Chordata
Class	- Mammalia
Order	- Artiodactyla (even toed)
Family	- Suidae
Genus	- Sus
Specie	- *Sus scrofa*
	- *Sus vittatus*

Pig has some special attribute that makes it suitable as a reliable source of animal protein-

i. High fecundity
ii. Rapid growth rate
iii. High efficiency of feed utilization
iv. Short generation interval
v. Rapid rate of return on capital invested
vi. It produces more nutritive products when compared to beef.

Origin: There are two conflicting theories-

(i) Domestication has centred in different regions

(ii)Domestication from one centre i.e. Western Asia, from where it was taken to South-East Asia, Europe and Africa. All the present domesticated breeds are derived from two wild types

1. *Sus scrofa* i.e. the European wild pig
2. *Sus vitttatus* i.e. the Eastern and South-Eastern Asia wild pig.

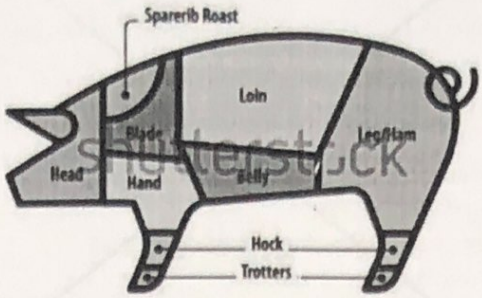
Sus vittatus is said to have been introduced into Europe by the Neolithic settlers from the East with other domestic animals. From 1770- 1870 Chinese pigs were introduced into Britain and these were cross-bred with old English pigs. In 1830, pigs of the neopolithan breeds were introduced into Britain and cross-bred with the local types. The cross breeding of Chinese neopolithan pigs with the old English pigs produce the ancestors of the modern British breeds of pigs.

The modern American breeds were derived from crosses that included the Mediterranean and European pigs. Domestic pigs in countries in West Africa are related to the Mediterranean types of pigs. Today, everywhere in the tropics indigenous breed are being up bred or replaced by Exotic breeds particularly breeds from Egypt, America and Scandinavian countries.

Types of Pigs: Pigs can be classified into 3 types-

1. Pork type
2. Bacon type
3. Lard type

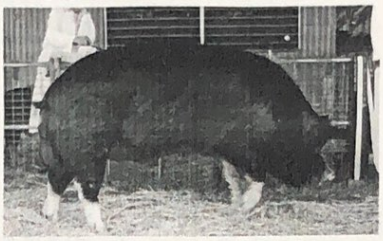
1. Pork type: This type combines muscling, length of body and ability to reach market weight fast without excess body fat. The pigs can be marketed when it reach a live-weight of 40-60kg or can be marketed as heavy porkers at 60-80kg. It has a back fat thickness of about 2.5 to 3.8cm.
2. Bacon type: This is very popular in Denmark and Canada, has well developed ham and long body with sufficient muscle for producing desirable bacon. It's back fat thickness is 1.3 to 2.5cm.
3. Lard type: They are grown to heavy weights of between 100 and 150kg. It is fed diets that promote fat deposition. At slaughter, the fat is removed and processed into lard. It has back fat thickness of 8 to 10cm.



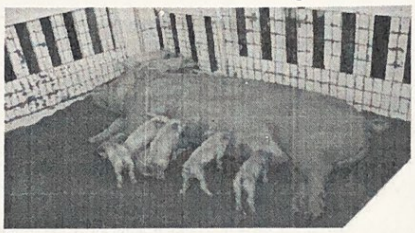
Breeds of pigs

The British breed

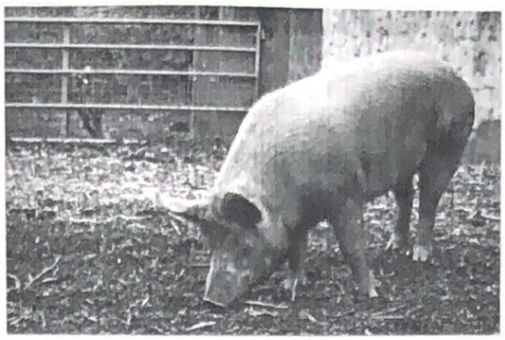
1. Berkshire: This is a very large black pig with 6 white points on its feet, nose and tail. It has a long and curved snout. It has a long teeth but not deep body, and short legs. It is a good meat type with erect ears. It takes about 6 to 6 1/2 months to reach market weight of 92kg instead of the 4 1/2 5months for the faster growing breed of pig. The average litter size is 9 - 11 piglets.



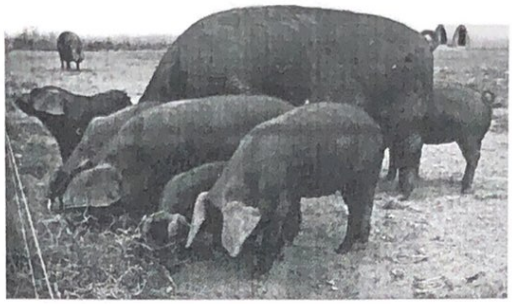
2. Yorkshire (Large White): It is usually referred to as the mother breed because it is one of the most prolific breed known. The sows are heavy milkers. It is used for the production of bacon in the temperate zones and pork in the tropics. It is a large long white pig. It has long thin erect ear that are inclined in colour. The head is long with slightly dished face with broad snout. Average litter size is about 12 to 16. It has a good temperament and is used extensively for cross breeding purpose



3. Tamworth: This is a golden-chestnut coloured pig. It is a bacon type of pig with a long narrow back and coarse hair. It is the most undeveloped of all the British pigs, it is slow maturing, very hardy and less susceptible to sun-burn, they therefore do well in the tropics where feeding and management condition are poor. In most part of the world they are used for cross breeding programmes.

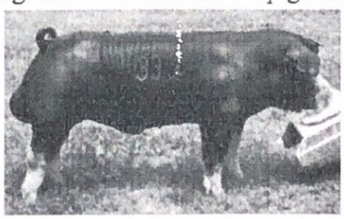


4. Large black: it is used extensively in Africa. It is a solid black coloured pig, has long body with droopy or floppy ears, a very good meat type (pork), it is used extensively for crossing native pigs in the tropic.



American Breeds

1. Poland China: At one time it was the most popular in USA but as recently gone back to the 4th position. It is a very large black lard type of pig with 6 white points like a Berkshire. The difference between the two breeds is that Poland China has a long face, drooping ear and a white point on its nose. Poland China was obtained from crosses of about 6 breeds of pigs. This breed is not prolific with an average litter size of about 7- 9piglets.

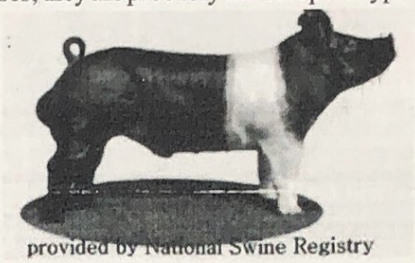


2. Duroc Jersey: The breeds name is adapted from the combination of names of two popular strains of Jersey-red and Duroc. The Jersey-red are large animals noted for their rapid growth and largeness while the Duroc is large but more compact. In the early 1940s the breeds name was shorten from Duroc Jersey to Duroc. The Duroc is the leading breed of pig in America. It's red in colour with shades varying from light-red to dark red with slightly dished face and

drooping ears. The breed popularity is attributed to the valuable combination of the large size, great feeding ability, prolificacy and hardiness. The Duroc also grows fast with moderate feed demand. It is able to utilize grass very well and can be raised on the outdoor system requiring little capital for housing.

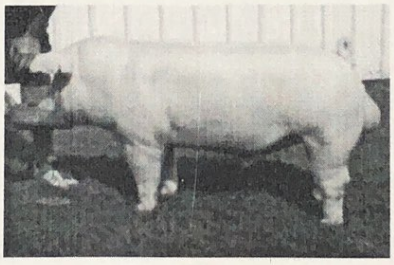


3. Hampshire: This is one of the youngest breeds in America, developed around 1880 and very popular throughout the Corn Belt. It is a black pig with a white belt around the neck. It is very active, prolific, good nursing mothers and they gain weight very rapidly reaching a mature weight of 90kg in 5months. Litter size is about 11-13. They are commonly used throughout the world for breeding purposes; they are probably the best pork type of pig.

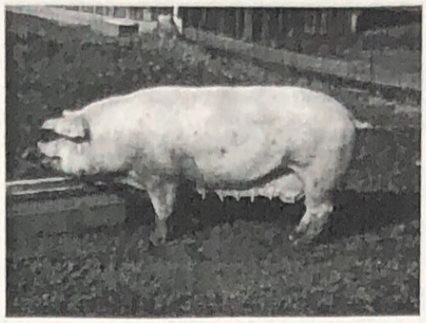


provided by National Swine Registry

4. Chester White: They originated from Chester country in Southern Pennsylvania. They are white in colour, noted for their extreme soundness, confinement adaptability, crossing ability and productivity. They are extremely good, durable, and very aggressive and can be used for breeding programmes without getting tired.



5. American Landrace: White in colour with long drooping or floppy ears, long narrow head and long body. It is prolific, fast growing and contains a high proportion of lean meat. Usually referred to as mothers superior. It is originally developed in Sweden and Denmark where it was especially selected for its excellent carcass length and hams for producing bacon meat. Used for all forms of pig meat production.



AFRICAN BREEDS OF PIG

1. Bakosi: It is found in the Republic of Benin, it is small, black long bodied pigs, possessing long conical head.
2. West African Dwarf: West African dwarf is of the Mediterranean type, it is black or white or mixture of both colour. They generally have poor conformation, not very fecund, grow slowly. They are very small animal with erect ears, long and pointed snout. Live weight at maturity is about 60kg.

POULTRY

Poultry is used as a general name for any bird that is used as food by man. There are four common species of domestic poultry, though with addition of two recently -

1. Chicken or fowl
2. Duck
3. Geese
4. Turkey
5. Guinea fowl
6. Quail

The Order of the Chicken is

Order Galliform
Family Phasianiade
Genus *Gallus gallus* or *Gallus domesticus*

Origin: Domestic fowl probably originated from South-East Asia. It is also believed that all domestic chicken originated from 4 wild species, namely

1. *Gallus gallus* - Red jungle fowl
2. *Gallus lafayetti* - Ceylon jungle fowl

3 *Gallus sonnerattii* - Grey jungle or Sonnerat fowl
4. *Gallus varius* - Java jungle fowl

Gallus gallus was assumed to be the main ancestor because of its wide distribution. It is believed that there are several centre of domestication e.g. India, South-East Asia, Iran, Italy, and Northern Europe.

Classification of domestic fowl: Domestic fowls are usually classified using two criteria

1. Place of origin
2. Utility

1. Classification based on place of Origin

a. Mediterranean class: These have small bodies, white ear lobes, large and mostly single combs. They are also early maturing and produce white shelled eggs. They have nervous disposition, non-broody. Mature cockerels and hens weigh approximately 2.7 and 1.8kg respectively. The hens are good layers with high efficiency of feed conversion but don't produce good carcass e.g. Leghorn, Anconia, Minorca.

b. Asiatic class: Have large bodies, red ear lobes and produce tinted or brown shelled eggs, they are broody and weak in disposition, they have yellow skin e.g. Brahma, Langghan.

c. American class: Developed by Americans. It is characterized by yellow skin, red ear lobes and brown shelled eggs e.g. Rhode Island Red, Plymouth Rock, New Hampshire.

d. British/ English class: It has a white skin, red ear lobes and lay redish brown shelled eggs e.g. Sussex, Dorking.

2. Classification based on Utility:From the stand point of using pure breeds for eggs or table meat production, it is necessary to classify the breeds into light and heavy breeds. The light breeds typified by the Leghorns are small, early maturing and produce small white shelled eggs. The heavy breeds are the opposite of the light breeds and are notoriously broody, almost all the heavy breeds lay brown eggs.

Light Breeds	**Heavy Breeds**
1. Anconia	1 Orpington
2. Campine	2 Brahma
3. Minorca	3 Langghan
4. Leghorn	4 Cochin
	5 Dorking
	6 New Hampshire
	7 Plymouth Rock
	8 Sussex
	9 Rhodes Island Red In the Tropics

	Heavy Breeds	Light Breeds
1.	Rhode Island Red	White Leghorn
2.	New Hampshire	
3.	Australorp	

Local breeds: Over 80% of the breeds raised in Nigeria are local breeds, it is small, early maturing and rather of nervous disposition and produces white shelled eggs but like the heavy breeds it is notoriously broody.

Breeds of Guinea Fowl: Guinea fowls are very rugged birds that produce eggs with hard shell. The young guinea fowl is called keet. The different breeds include Pearl breed, White guinea fowl, Lavender guinea fowl, Royal purple, Coral guinea fowl, Buff guinea fowl, Bundotte, Proclain, Opaline, Light lavender guinea fowl, Pied guinea fowl, Pewter guinea fowl, Chocolate guinea fowl, Brown guinea fowl, Powder blue guinea fowl, Violet guinea fowl, Bronze guinea fowl, Sky blue guinea fowl, Slakes guinea fowl.

The Pearl Guinea Fowl:

1. It has dark grey with white dotted colour throughout the plumage.
2. It has a beautifully dotted feather.
3. It is an egg purpose or sometimes kept for ornamental purpose.

White Guinea Fowl:

1. It is a pure white coloured bird with few black hairs on the back of the neck.
2. Its male is of lighter colour.

Lavender Guinea Fowl:

1. It has a light blue colour with white dots; it is a very popular bird.

Royal-purple Guinea Fowl:

1. It has very dark black colour with purple chin.
2. It has dots and barring in the flanked area.

Coral-blue Guinea Fowl:

1. It has dancer beautiful coral blue colour and neck, breast and back.
2. It has few dots and bars in the flank area and it is very colourful.

Brown Guinea Fowl:

1. It is dark brown colour with white dots.
2. The male is slightly lighter than the hen.

Turkey: Turkey is not the most meat purpose breed of poultry as it is mostly consumed during certain period. The female is called hen while the male is tom. The adult weighs about 27pounds, cockerel about 18pounds. The various species include bronze turkey, Slate turkey, Bourbon turkey, Broad breasted turkey, Narragansett turkey.

Bronze Turkey: The colour is shimmering, green bronze which appears metallic in

the sun. It originated from North America.
Slate Turkey: Not popular, it is practically extinct. Its colour is ash blue and sometimes dotted with black.
Bourbon Turkey: It has unique reddish colour with the tom weighing 33pounds and the hen 18pounds.
Broad breasted Turkey: It is widely used for cross-breeding purpose, it has breastbone that exceed large breast. It needs assistance for breeding (artificial insemination).
Narragansett Turkey: Originated from Rhode Island, it is grey (dull black) with white bar on wings, the beak is horn coloured. The head is red-blue white coloured. It has a calm disposition, good maternal qualities, easily maturing/ good laying ability and has excellent meat quality.

Duck:
Pekin Duck: Originated from Mallard in China, it is a dual purpose breed with adult weight of 8 11 pounds, lifespan of 9 12years and lays about 200 eggs per year. Its eye appears black/ grayish blue. It can be used as watchdog.
Roven Duck: Originated from France, it is used for decoration as it has beautiful colour and for general purpose. It is a heavy breed with darker and highly flavoured flesh.
Mulard Duck: this is a hybrid between male Muscovy and female Pekin duck. It is a dual purpose breed (meat and forage graze).

RABBITS

The domestic rabbit descended from the European wild rabbit originating around the Mediterranean Sea. It was first domesticated by the Romans. The first serious breeding of rabbits was done by the French monasteries between the 6th and 10th centuries. By the 17th century breeding became common and was documented in England. The distribution of rabbits all over the world was done by the voyagers of England. Rabbits are noted for their meat, fur and they are used as pets. They can be raised relatively easily as they require very little space.

Classification of rabbit

Kingdom	-Animalia
Phyllum	-Chordata
Class	-Mammalia
Order	-Lagomorpha
Family	-Leporidae
Genus	-Oryctologus
Specie	-cuniculus

Breeds of rabbit: At present there are many breeds being use for meat and skin purposes in the tropical world. The world breeds of rabbits include

1. Chinchilla
2. New Zealand White
3. New Zealand Red
4. Californian Red
5. Californian White
6. Yellow Silver
7. Angora

1. Chinchilla: This breed adapt well in Nigeria, it beat the New Zealand White and Californian in performance. It is dark grey to black in colour with adult weight of 3.5kg. It has a slow growth rate than New Zealand and California White and it is raised more for fur than meat.
2. New Zealand White: It is white in colour; adult buck weighs from 4 - 5kg and does from 4.5 - 5.5kg. The young have a low feed to meat conversion ratio.
3. California White: It has a white body with black marking on the nose, ear, feet and tail. Weight of the adult is 3.6 to 4.5kg. This breed is well fleshed on the back giving a good meat to bone ratio.

Breeds of Guinea pig

Abyssinian guinea pig: originated from Ethiopia. They are very delicious, feed on forage, high reproductive ability, has varied colour, short long rough coat.

Lilac silkie guinea pig: originated from U.S.A. It has long hair that flow back over the face and white in colour.

CHAPTER THREE
NIGERIA BIOTIC COMMUNITIES AND THE DISTRIBUTION OF LIVESTOCK

The biotic communities or areas covered by living organisms and their distribution are dictated and controlled mainly by climatic factors such as rainfall, temperature, humidity, light intensity and duration, and wind. These factors determine the survival of animals within a specific environment. The ability of animals to adapt to this environment through efficient control of their body system influences their survival. Livestock are either completely covered with hair or feathers and are warm blooded animals and this assists them to maintain a definite body temperature. The only means of heat loss in livestock is evaporation from respiratory surfaces/passages and anus, though the total surface area for evaporation is small compared with the total body area of the animal and so not efficient for thermal regulation. That is, the amount of heat gained cannot be compensated for by the amount of heat lost through the respiratory surfaces/passages, anus and by panting or sweating.

NIGERIA

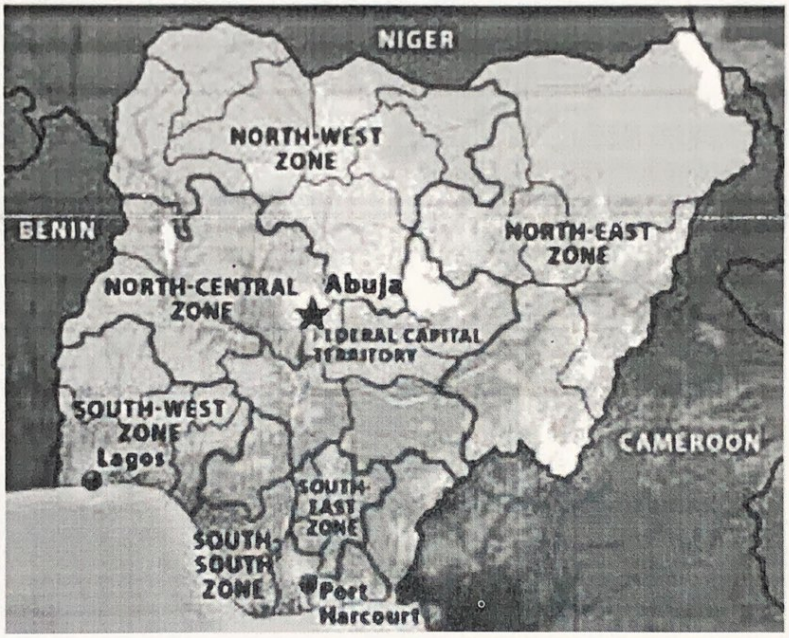




Figure 3.1: Geopolitical zones in Nigeria and the States within the zones

NORTH EAST	NORTH WEST	NORTH CENTRAL	SOUTH EAST	SOUTH WEST	SOUTH SOUTH
Adamawa (Yola)	Jigawa (Dutse)	Benue (Makurdi)	Abia (Umuahia)	Ekiti (Ado-Ekiti)	Akwa-ibom (Uyo)
Bauchi (Bauchi)	Kaduna (Kaduna)	Niger (Minna)	Anambra (Akwa)	Lagos (Ikeja)	Bayelsa (Yenagoa)
Borno (Maiduguri)	Kano (Kano)	Kogi (Lokoja)	Ebonyi (Abakaliki)	Ogun (Abeokuta)	Cross-river (Calabar)
Gombe (Gombe)	Katsina (Katsina)	Kwara (Ilorin)	Enugu (Enugu)	Ondo (Akure)	Delta (Asaba)
Taraba (Jalingo)	Kebbi (Birnin-Kebbi)	Nassarawa (Lafia)	Imo (Owerri)	Osun (Oshogbo)	Edo (Benin-city)
Yobe (Damaturu)	Sokoto (Sokoto)	Plateau (Jos)	-	Oyo (Ibadan)	Rivers (Port Harcourt)
-	Zamfara (Gusau)	-	-	-	-

The biotic communities in Nigeria can be grouped into two major zones -

a. **Forest zone** which is made up of vegetation having mainly trees and consist of the following local biotic communities
   1. Mangrove swamp forest (salt and fresh water swamp).
   2. Tropical rainforest.

b. **Savanna zone** this is made up of mainly grasses and is divided into three areas
   1. Southern guinea savanna
   2. Northern guinea savanna
   3. Sahel savanna

1. Mangroove Swamp Forest- this is found in areas along the coast especially in States like Delta, Cross River, Rivers, Akwa-Ibom, Bayelsa, Ogun and Lagos

Characteristics of Swamp Forest

i. It has tall woody trees
ii. Plants mainly have aerial roots.
iii. It has evergreen trees with broad leaves.
iv. It has high rainfall of over 250cm throughout the year which results in water logging.
v. Its water is a combination of fresh and salt water.
vi. Common plant species found are white mangrove, red mangrove, raffia palm, coconut, etc.
vii. Common animals include Tilapia fish, oysters, crabs, snakes, birds, and kingfishers. The livestock common in the area are the small indigenous animals such as sheep, goats and poultry which are able to counterbalance heat gain and heat loss. The high humidity/temperature and excessive rainfall in this area makes heat loss through evaporation very low. It is difficult for large animals such as cattle, donkeys and horses to exist comfortably in this area because of the difficulty in regulating the body temperature easily.

2. Tropical Rainforest This biotic community can be found in States like Edo, Delta, Ondo, Imo, Abia, Lagos, Ogun, Anambra, Rivers, Bayelsa and Akwa-Ibom.

Characteristics of Tropical Rainforest

i. The vegetation has tall trees with buttress roots, evergreen and broad leaves.
ii. The trees exist in different heights or layers i.e. bottom or lower, middle and upper layers.
iii. It has numerous climbers, creepers, epiphytes and parasitic plants.
iv. It has little undergrowth due to canopy formed by the tall trees.
v. Plant species are not in pure stand i.e. trees are scattered.
vi. The biome experience high rainfall of over 200cm, high temperature and high relative humidity. The high temperature, high humidity and excessive rainfall also provides good conditions for various pests, parasites, growth of fungi, and endemic diseases which limit the extent to which livestock can be kept.
vii. Plant species include Iroko, Obeche, Mahogany, African Walnut, Opepe, Ebony, etc. Dense growth of trees/shrubs does not favour the growth of grasses, making it difficult to develop good pasture for grazing animals.

viii. Animals commonly found include monkeys, snakes, chameleon, squirrels, etc.Common livestock include goats, sheep, poultry, Muturu, and N'dama cattle.

3. Southern Guinea Savanna This biotic community is found in States like Enugu, Kogi, Benue, Kwara, Oyo, Ebonyi, Osun and Ekiti States.

Characteristics of Southern Guinea Savanna

i. It is the largest of all the biotic community in Nigeria.
ii. It has moderate rainfall of between 100150cm. rainfall is seasonal and the other climatic factors are less severe than in the forested areas.
iii. It has tall grasses.
iv. It has tall trees with broad leaves, which varies from fairly closely spaced trees on the fringes of the forest in the south to the more open woodland towards the north. It generally has less tree growth and the sun is able to reach the ground to enable the growth of luxuriant grasses which provide grazing for animals.
v. The trees are scattered and deciduous i.e. they shed their leaves during the dry season.
vi. Important trees include the locust bean trees, shea-butter and Isobelina.
vii. Important animals commonly found in the biome include antelopes, lions, leopards, zebra, etc. A larger population of livestock exists in this area than in the wet tropical forest zone. There are better prospects for developing livestock farming in this zone with good planning than in the forest belt.

4. Northern Guinea Savanna - This biome is found in States like Plateau, Kaduna, Bauchi, Niger, Taraba, Adamawa and Kano States.

Characteristics of Northern Guinea Savanna

i. It has low rainfall of about 50-100cm per annum. The low rainfall/humidity, high temperature favours low pests/parasites which can be easily controlled. The low humidity makes loss of heat by evaporation faster than in the super-humid and humid belts.
ii. It has scattered and short deciduous trees. The area is more open than the Guinea grassland. It has large area of grassy plains interspersed occasionally with stunted trees.
iii. It has short but numerous grasses.
iv. Some of the trees have thorns while others have thick barks.
v. Some of the trees wither in dry season and sprout at the beginning of the rainy season.

vi. Common plant species found include acacia, date palm, silk cotton plants and baobab.

vii. Common animals include snakes, lizards, deer, lions, leopards, antelopes, etc. This area stretches across the whole of West Africa and the bulk of the cattle, sheep, goats, poultry, donkeys and horses are found here. It is suitable for developing large livestock farming because of the environmental conditions, especially the availability of natural grazing pastures.

5. Sahel Savanna- This biome is found in the extreme northern parts of Nigeria such as Borno, Katsina, Sokoto, Yobe, Kebbi, Zamfara, Kano and Jigawa.

Characteristics of Sahel Savanna

i. The biome has high temperature and very low rainfall (below 50cm per annum). It's a semi-arid region with scrub forest covered by short grasses. The rainfall is scanty, the humidity low and temperature is high.

ii. It has short and scanty grasses.

iii. It also has short and tough shrubs or trees.

iv. Grasses are fewer, poorer and in patches.

v. It has many drought resistant and scattered plants.

vi. Important plant species include acacia, gum Arabic and date palm.

vii. Many Fulani herdsmen are found in this area. The limiting factor in the development of the livestock industry is the scarcity of water. Cattle, sheep and goats thrive well in this area, and it is the home of camels.

6. Desert- This biome is located at the northern borders of Sokoto, Katsina, Dutse, Yobe and Borno States.

Characteristics of Desert

i. A desert has little or no rainfall in most of the year.

ii. It has high temperature and very low humidity.

iii. It has fewer grasses and shrubs.

iv. The plants have special features which enable them to live in desert e.g. absence of leaves, swollen and succulent stems, long roots, etc.

v. Common examples of trees are baobab and Cacti trees.

CHAPTER FOUR
MORPHOLOGY OF FARM ANIMALS

Morphology is the study of forms and structure of an organism. Morphology of farm animals deals with the study of forms and structure of farm animals. Preliminary information about an animal is obtained by visual observation of a set of external morphological characteristics defined as the conformation, shape and form.

Conformation is basically a combination of soundness, structures and balance. It is the way an animal is pulled together in a way that supports the animal's health, well-being/ longevity and productivity. In order to know conformation, knowledge of the following is required

1. The names of the various body parts.
2. Standard of conformation corresponding to stated production types.
3. Rules for describing and estimating conformation.

Parts of the animal body: It is important for student, herd owner, animal or dairy cattle judge or veterinarians to know the parts of the animal as such knowledge is necessary in giving oral presentation (when giving measure of competency in evaluating the physical merits of dairy cattle in judging). If an animal gets injured severely, the herd owner will want to use the proper terms in communicating with the attending veterinarian. Thus, every one interested in animal science must learn their parts. The knowledge of external body part of farm animals is important because it enables a clear/ easy description of animal when judging/ selecting animals and to properly apply husbandry/ veterinary practice

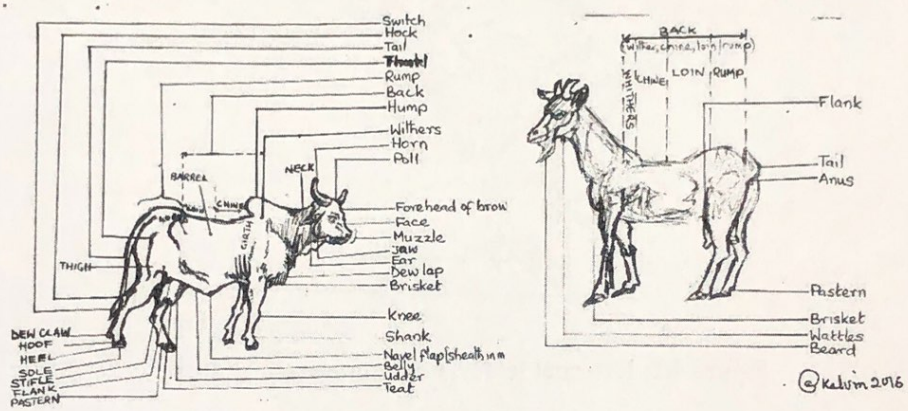


Figure 4.1: External features of ruminant animal.

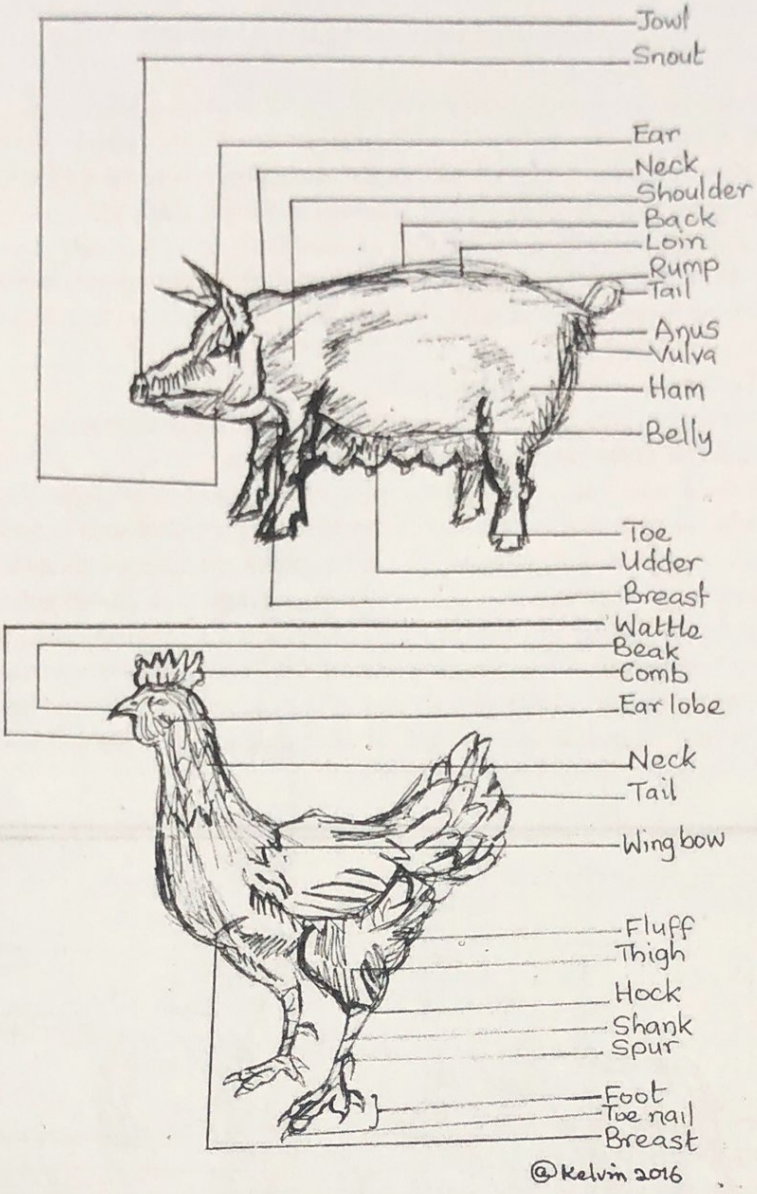


Figure 4.2: External features of monogastric animal

Head of animal

Poll This is the region between two horns

Muzzle This is the moist black portion of the upper lip

Jaw This is the lower portion of the face

Mandible it is also referred to as the lower jaw

Other portion of the head include the eye, nose (nostril), fur, ear, and horn in some cases.

Neck

Crest This is the upper part of the neck

Throat This is the lower part of the neck

Trunk

Withers This is the highest part of the trunk just behind the junction between the neck and trunk. It is also known as hump in cattle.

Back This is the region from the hind withers to the end of the last rib along the top line.

Loin This is the flat region behind wither to the back, up the rump region.

Rump This is the region of sacrum extending from the behind loin to the tail head (dock).

Flank This is the hollow in front of the hip

Hindquarters This is the area bounded by the point of hip to the dock above.

Shoulders This is the region of scapular i.e behind the neck and straight above the fore leg.

Point of shoulder This is prominent along the anterior border of the shoulder region.

Girth This is the circumference of the chest.

Brisket This is the fleshly prominent mass lying between the fore-limb i.e. the muscled part between the front legs.

Hind Limb

Stiffle This is the joint between the femur, patella and tibia lying roughly at the junction of the leg with the trunk.

Thigh This is the part of the hind limb between the rump.

Hock This is the part of the large joint above the hind and cannon

Hind cannon This is the part between hock joints and fetlock joints

Fetlock joint This is the region just above the pastern

Pastern This is the portion of leg between fetlock and coronet.

Coronet This is the junction between the skin and hoof.

Hoof This consist of two digit with interdigit space in between them

Dew claw This is the two horny buds and posterior phase of fetlock joint.

Ham The rear leg of a pig is the ham,

Fore Limb:

Elbow - This is the joint at the junction of the foreleg with the trunk.

Fore-arm -This is the part of the leg between the elbow and knee.

Knee - This is the joint between the fore arm and cannon (shank).

Fore-cannon - This is the part between the knee and fetlock.

NOTE: Eleven traits used by livestock producers to select animals are visual observation, anatomy, conformation, breed character, muscle, finish, structural soundness, body capacity, frame size, comparison and performance data.

Five swine sex classes are barrow, gilt, sow, boar and stag.

Pork chops come from the wholesale cut of a hog's back called the loin.

The four cuts that represent about 75% of the total retail value of the hog carcass are Boston shoulder, picnic shoulder, ham and loin.

High value wholesale cuts of beef come from the loin, rib, round and rump.

The wholesale cut of beef that compares in location to the leg or ham on a hog is the round.

When the carcasses are hanging on the rails, the wholesale cuts at the top for beef and pork respectively are round and leg.

When a pork carcass is hanging in the rail, the wholesale cut that includes the belly area called the side yields the retail cuts of spareribs and sliced bacon.

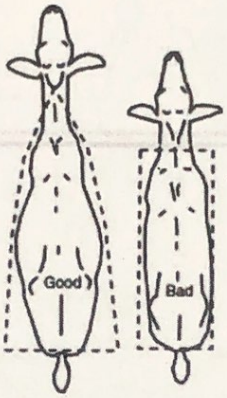
Conformation Standard: In estimating an animal value on the basis of external conformation, knowledge of the standard for a farm animal production types and breeds is necessary. Every production type has a specific conformation and the usefulness of an animal for a given line of production can be assessed based on the relationship between types of performance and conformation. However, in assessing the conformation of an animal, the external appearance can only provide an indication of the production possibilities of individual and very little information about actual production.

Conformation Standard of cattle: Cattle can be categorized as beef, dairy, dual purpose and drought types. The conformation standard varies depending on the class to which they belong.

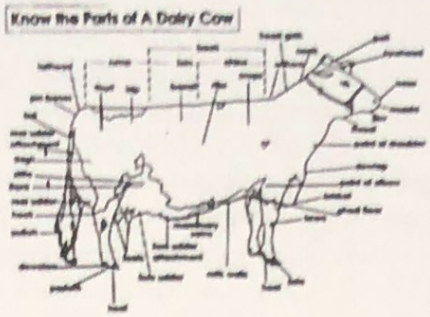
Beef Cattle - this is characterized with a wide thick back, with the rump referred to as being **square in shape.** The hind and forequarters are deep, wide, strong and far above ground. The loins are thick with strong ridge. The proportion of the whole beef cattle body lacks fullness and thus thickness. They have well flattened belly and the udder is usually poorly developed with little milk being produced. These animals are efficient in the conversion of feed into high quality beef for human consumption.

Dairy cattle - These are characterized by a lone **angular frame.** It has well developed mammary system i.e well developed udder/ teat, a large girth and deep belly. The rump is well pronounced and has sunken eyes. Though the mammary glands are the

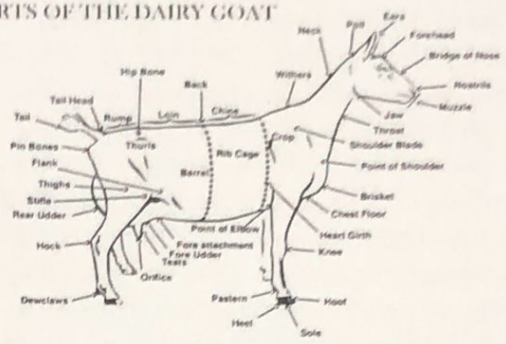
building block of the dairy industry, the type or conformation of animals to which those glands are attached is also important in producing milk because conformation affects intensity, length and number of lactations. Desirable dairy conformation involves functional traits associated with high milk production over a long productive life. There are two principal criteria for evaluation of dairy cows - 1. Performance in the pail, and 2.Physical characteristics that affect attractiveness, milk production and longevity. There are two general means of evaluating the physical characteristics of dairy cattle; type classification and show ring judging. The purpose of type classification is to encourage the breeding of dairy animals that are both functional and beautiful. In this classification, each animal is scored (at the farm) in comparison with a theoretical perfect animal of the breed. Points are assigned to important physical characteristics and a total score classifies the animal as excellent (90 - 99), very good (85 - 89), desirable or good plus (80 - 84), good (75 - 79), moderate or Fair/ acceptable (70 - 74), and poor (65 - 69). The following is a brief list of these characteristics - Size (stature, length, width and body capacities in relation to age; Type (strength and general openness); Udder (teat size/placement, udder depth, strength of the suspensory ligament; Leg/feet (set/bone quality plus functional use). The characteristics are scored in the range from 50 (or 60) to 100 depending on the breed. The average score per general characteristic of cows classified is traditionally set at 80 points. The more the cow corresponds with the conformation standard (ideal cow), the higher the score.

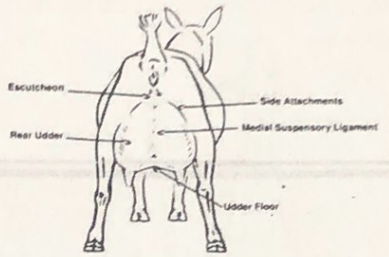


Conformation Standard for Sheep/ Goat: Most breeds of sheep and goat in the tropics are reared for meat though there are no fixed standard for both sheep/ goat. Animals with reasonable amount of flesh are identified from external features. Ideal meat types of sheep/ goat are medium to large in size with medium width, deep and compact body. Other desirable features include a clear / alert eye, short/ thick neck, and deep-wide chest with well developed ribs. A wide/ strong back and thickness of the loin with leveled rump of good length which is fixed squarely into the loin and a large leg of mutton or chevon are important meat traits.

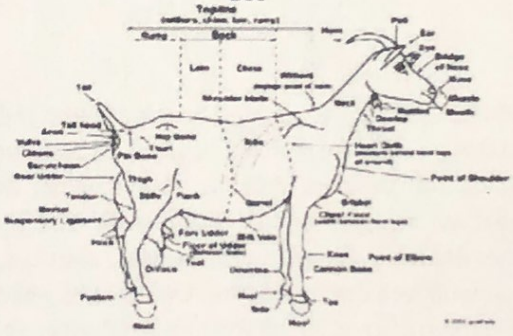


PARTS OF THE DAIRY GOAT





Basic Goat Body Parts
Doe





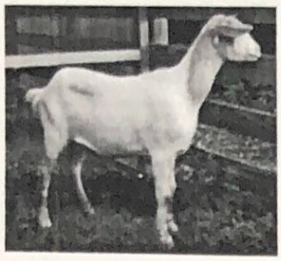
Normal goat



Slightly Roman nose with droopy ears



Good muscle mass



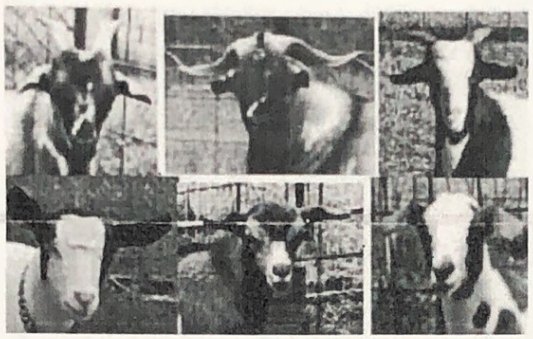
Poor muscle mass



Split Scrotum



Normal scrotum



Various ear types that meet breed standard



Too erect ears



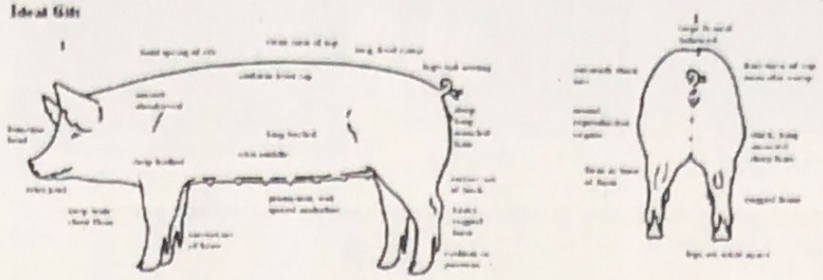
Too droopy ears



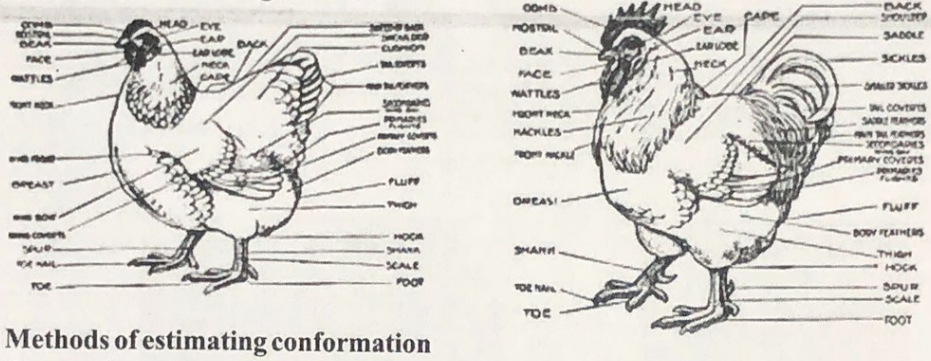
Four teats instead of two

Figure 4.3: Specific features of some animals.

Conformation Standard of Pig: An ideal meat type pig should have a strong back with a definite arch and sturdy legs placed squarely under a body. The profile is approximately twice as long as its weight with a cylindrical body.



Conformation Standard of Chicken: Each recognized breed or stock of chicken has characteristics, shapes and form. The configuration of the hair is a good indicator of the health/ vitality of the chicken. A good quality chicken should have a relatively broad leveled back without a sharp break between the back and tail, the breast should be full and the abdomen should be expanded and free from fat. The bird should be alert with bright prominent eyes with no obvious abnormality. It should walk gracefully with its head up without evidence of lameness, sore feet or crooked legs. Good egg type chicken usually are strong with moderately long head and bright eyes, a flat top is preferred to a round skull. Soft texture skin/ bright red comb are attributes of a standard chicken for egg production. Meat type chickens possess similar features but in addition they have big head/ broad back region with area that is well lined with meat along the entire leg of the bird.



Methods of estimating conformation

The conformation of an animal is estimated either by surveying the general appearance, thus providing a general (visual) estimation or by the point estimation. Both visual and point estimation sometimes involve taking linear measurement of the animal body.

General or Visual estimation: This is the oldest method of estimating the commercial value of animals. It involves examining the animal as a whole for some production

traits through palpation or grasping. The estimation starts with an assessment of the overall shape of the animal with particular reference to anatomical view of the animal. A more detailed inspection is then carried out which involves an assessment of the animal skin that is the thickness and flexibility condition of the hooves/hair, skeleton/muscle development and the expression of sex linked character from these, the state of health, condition and constitution of an animal can be assessed.

Point estimation: This is a less subjective method than general estimation as more attention is paid to individual body part. Point estimation involves the use of a 100 point scale. A particular number of pointsis awarded for each body part and also for such characteristics as general appearance. The number of point awarded in a particular body part depends on its importance to the line of production concern e.g. in dairy animal, more point is awarded in the mammary gland. The maximum score for a particular trait for the external conformation is given only when the structure of that part fully conformed to the standard. An animal of perfect anatomical view will receive 100 points for conformation. Generally, an animal with scores more than 84 points for conformation is regarded as having an excellent build. It is rated as very good at 81- 84points, good at 71 - 80points, passable at 65 - 70points, failure at less than 65points. The maximum number of points given for particular characteristics is the multiple of 5. The maximum grade for any of the relevant trait is 5. On finding a defect, the grade of particular trait can be reduced from 5 to 1. A very well developed trait is rated as 5, a well developed one as 4, adequately developed as 3, inadequately developed as 2, failure as grade 1. Once the individual conformation trait has been assessed, using the modified scale, the grade allotted to each is commuted to points using the appropriate multiple and then the conformation standard of the animal can be assessed.

Table 4.1 Point scoring of cow conformation

Conformation characteristics	Maximum points	Estimation degree	Multipliers	Maximum number of points
General appearance	15	1 - 5	3	15
Head and Neck	5	1 - 5	1	5
Forequarters	15	1 - 5	3	15
Mid-part of barrel (back, loins, belly)	15	1 - 5	3	15
Hindquarters (rump, pelvis, breadth, length, shape)	20	1 - 5	4	20
Legs	10	1 - 5	2	10
Udder (size, shape and suspension of teats)	20	1 - 5	4	20
	100			100

Example: Conformation measurement score was taken on a cow and the following was obtained for each of the body part measured. Determine the conformation and the grade.

General appearance	Well dev.
Head and neck	Well dev.
Fore quarters	Adequately dev.
Mid part of barrel	Adequately dev.
Hind quarters	Well dev.
Legs	Adequately dev.
udder	Very well dev.

Conformation Characteristics	Max. no. of points	Estimate in degrees	Multipliers	Max. no of points
General appearance	15	4	3	12
Head and neck	5	4	1	4
Fore-quarters	15	3	3	9
Mid part of barrel	15	3	3	9
Hind quarters	20	4	4	16
Legs	10	3	2	6
udder	20	5	4	20
				76

71- 80 = Good

CHAPTER FIVE
FEEDING HABITS OF FARM ANIMALS

Feeding is the act of taking in substances that provides necessary nutrients into the body while habit is an action done on regular basis or an action performed repeatedly and automatically usually without awareness.

Feedstuff is any product whether artificially or naturally produced which when properly mixed can be of value in a diet. Feedstuffs or feed ingredients are synonymous with feed, food/ fodders. It consists not only the chemically occurring plants/ animal products/ by-products but also the chemically synthesized mixtures that are used as supplement to natural food.

A **feed** is a mixture of feedstuffs, blended or processed in a form which is acceptable to livestock. A feed is said to be balanced when it supplies all the required nutrients in the required amounts and proportions in respect of a specified breed, class (age) or condition of livestock.

A **ration** is a feed offered to an animal or group of animals over a specified period of time e.g. daily ration or daily allowance or weekly ration depending on age Chick ration, Growers ration, Layers ration, etc. A balanced ration refers to a feed mixture just sufficient to meet the 24 hour requirement of a specified animal.

A **diet** is a feed which is formulated for special purpose such as experimentation, for sick animals (e.g. diabetic patient) or for special physiological purposes. Ration and diet are almost the same.

Classes of Poultry	Ration
Broilers 0 - 6 weeks	Broiler starter
Broilers 7 - 10 weeks	Broiler finisher
Layers/ Breeders 0 - 8 weeks	Chick starter
Layers/ Breeders 9 - 16 weeks	Growers mash
Layers/ Breeders 17 weeks	Layers mash or Breeders mash

Livestock can be conveniently grouped into mammals and birds. Most livestock belong to the class Mammalia and order Artiodactyla. The mammals are hairy, give birth to live young ones and suckle their young; they also undergo a period of embryonic development within the womb of the mother e.g. Cattle, Sheep, Goat, Pigs, Rabbit and Horses.

Poultry: These are birds in which the hind limbs are well developed but the fore-limbs are modified to form wings adapted for flying in the air. They lay external eggs inside which the young develop. Example of birds are chickens, ducks, turkeys, guinea fowls and quails.

Based on the types of digestive system they have, livestock can also be grouped into ruminant and non-ruminants.

Ruminants: These are grass eating animals which chew-the-cud (ruminate) and have complicated stomach consisting of four units or chambers (Rumen, Reticulum, Omasum and Abomasum i.e. true stomach). Examples of ruminants are cattle, sheep, goat and camel.

Non-ruminants: They are also called monogastric animals. They have a simple stomach like man e.g. pig, poultry. There are some non-ruminants that eat grass (**non-ruminant herbivores**), they have a simple alimentary system but their large intestine is extended to handle the digestion of cellulose. These animals include the camel, horse, donkey and the rabbit.

The Behavior of Development

Behavioural **ontogeny** is the study of the effect of interactions between animals and their environments, upon the changes in behavior during development. It is important to study this aspect of **ethology** (scientific study of the behavior of animals in their natural environment) because the mortality rates of infant animals are high and a full understanding of the development behavior is necessary in successful livestock management e.g. turkey are said to be very sluggish, their rate of death even in the brooder house is high, they can even dip themselves into the brooding fire, they can starve themselves if there is no food every where in the pen even if others are eating .

The behavior of the foetus, the neonate, nursling, weanling and pre-pubertal animals has been studied in many species of animals by various methods. In the foetus, movement (kinesis) is the major form of behavior. It occurs throughout the greater part of pregnancy and also the movement occurs independently of the presence of other fetuses in the uterus. These muscular activities of movement help to develop the muscles and also the physical development of the foetus itself. As parturition approaches the movement increases in frequency and intensity, and by this means the foetus adopts the right posture for delivery.

Postnatal behavior: Within the first few hours after birth locomotion is developed in ungulates (hoofed animals e.g. horse, pig, cattle, and goat). It takes longer in carnivores. Immediately after birth the neonate ruminant tries to raise the head and neck while it is still lying on its side. It then moves onto its chest and then tries to mobilize its hind-quarters. It flexes its fore-limbs and then tries to stand on its four feet. It takes several attempts before it is successful. Next it attempts to walk. Its attempt is unsteady and this unsteady form helps to draw further attention of the mother and stimulates the maternal drive. The next stage for the neonate is the exploration of the environment and it does this by nosing (trying to touch all it comes in contact with) using the tactile hairs on the muzzle. In these activities the neonate is usually intercepted by its mother, she makes herself the principal focus of the

attention of the young one, and orientation develops. This is the time when imprinting occurs. The neonate is attracted to the shaded underbelly of its mother. Through a trial and error examination of the underbelly the neonate find the udder. The protruding teat now becomes the focus of the neonate. Successful teat-seeking is learned and often aided by maternal udder tilting. Udder-tilting is the mother's adjustment before milk let-down. This reflex in turn facilitates the suckling reflex from the young one. Multiparous dam lies on their sides exposing the entire teat for the neonate.

Ingestive behavior: An animal needs a lot of energy to meet its enormous and complex metabolic needs and this makes the animal wants to eat and drink. The desire to look for food and water is referred to as ingestive drive. The behavior of eating and drinking is regulated by a system involving the hypothalamus, the amount of glucose in the blood and the degree of emptiness of the stomach. In any animal when the available energy falls it would get to a low level which will send stimulus or trigger-off to the hypothalamus and through this system, the animal would begin to look for food. This is to enable the animal to meet or reverse the energy deficit. There is a time delay between the sensing of hunger and feeding, and it varies in animals. This time delay is short in herbivores because they only have to rise and graze, but it is longer in carnivores which depend upon predation for food. The significance of food chasing behavior therefore varies from species to species and environment to environment. Hunger and thirst are terms used to describe ingestive drive. The hunger and thirst centres (reflex action) are located in the hypothalamus and they receive stimuli from glucose receptors (nerve endings) in the liver and the gut or gastrointestinal tract (GIT). However, the activities of hypothalamus are subjected to cortical function e.g. when there is food and the brain says or indicate that you shouldn't eat as in the case when fasting or sick. Ingestive homeostasis is a situation of keeping balance in the body i.e. energy equilibrium. It is an internal balance or equilibrium produced by feeding on one hand and the metabolic activities involving the food eaten and that stored on the other hand. Energy intake must meet energy expenditure for a steady state of body calorie-fuel balance.

Total body calorie - Fuel input = Internal heat production (metabolism) + External work (behaviour) + Maintenance of energy reserved (fat deposition).

Feeding behavior is strongly influenced by reinforcement (positive and negative). The reinforcement includes food palatability and environmental factors. Another type of reinforcement is social association of feeding e.g. pigs eat more when there are a number of them eating together rather than if there is a single one eating. During periods of rapid growth of the body an animal increases its feed intake to supply the nutrient required for the formation of new tissues. On the other hand, food intake decreases when the growth rate reduces.

If during the early stages of growth, insufficient food is available, growth will be retarded, but if an additional supply is then offered the animal will eat more to compensate and the growth rate will be accelerated. However, in cases of extreme growth retardation this "catch-up" (catching-up with the usual growth rate) may not be complete. There are regulatory systems in the body for water and salt, therefore there are appetite for salt as well as for thirst.
Nutritional deficiencies however do not exhibit themselves as appetite for specific nutrient. Never-the-less they create what is called **depraved appetite** e.g. sometimes you could observe a cattle chewing on a bone which is not normal but could be due to its need of calcium or when goats that have been kept in an enclosure/ fed on grasses are released and are observed to move to the fire area to lick on ash, indicating a depraved appetite for salt. The regulation of salt and water intake is controlled by the hormones (Antidiuretic hormone ADH) and Angiotensin.

Grazing behavior: Daylight plays an important role in the grazing pattern of ungulates i.e. these animals shows diurnal patterns of grazing e.g. Horses, Cattle, Sheep and probably wild ruminant such as deer (in temperate region) and antelope (in tropics). These animals start grazing at sun-rise and they continue for most part of the daylight hours. However, night grazing is also practiced e.g. Goat. Herbivores graze less when the weather is very hot or extremely cold or wet. Fly-worry also reduces grazing as the animal devote much of its time to body care. On arid ranges (dry areas with sparsely populated vegetation) ruminants have to travel long distances in order to get water. The quality and the nature of pasture determines the grazing travel time of herbivores. Horses may travel between 3 and 10km daily, taking 2 to 3hours; cattles 2- 8km taking about 2hours; and sheep about 6km taking about 2hours. In milking cows grazing is planned around milking time and they graze actively after each milking session. After active grazing, ruminants lie down on their chest to ruminate and that posture facilitates regurgitation for rumination.

House feeding: Although pigs may be fed *ad libitum*, it is more usual for them to receive controlled ration twice daily. Poultry are supplied feed *ad libitum* because of their high metabolic rate. In both pigs and poultry the dietary composition influences the feed intake. As the percentage of fibre is increased the animal eat less and at a very high level of fibre content the feed intake decline such that there is a weight loss. The reduced feeding in this case is due to reduced palatability of the fibre and the inability of the animal to consume enough nutrients. The weight loss is a result of insufficient caloric intake. On the other hand highly palatable feed increases intake. If the same feed is pelleted, more of it will be eaten than if it is inform of powder or mash. This may be because powdery feed is absorbed faster leading to a negative feedback inhibition of the hunger centre located in the hypothalamus. Other factors affecting feed intake are-

(a) High ambient temperature: This drastically reduces feed intake because it also reduces the metabolic rate and because eating feed further increases body temperature the animal will reduce intake of feed to reduce body temperature.

(b) Sex males eat more than females and therefore they increase in body weight more rapidly. This difference in feed intake between sexes is not present at birth but appears during the stages of maturation. In some species the female stops gaining body weight in early adulthood but males do not e.g. rats. Oestrogens in conjunction with adrenal hormones tend to reduce feed intake.

(c) Stress stress factors such as loud noise, cold, injury, crowdiness, etc all reduce feed intake. These stresses cause the release of hormones such as adrenalin which depress feed intake.

(d) Diseases most diseases cause decreased feeding behavior either directly or indirectly.

(e) Age - older animals tend to eat less because they are not growing rapidly as the young or have stopped growing.

Specific species ingestive behaviours

1. **Cattle:** The tongue is the prehensile organ which is used to encircle the grass and pulled into its mouth. In the mouth the lower incisors and the dental pad are used to cut the grass. Cattle can not graze close to the ground. The cattle chew while moving around looking for the next patch of grass. During the warm or hot season, more grazing is done at night but peak feeding or grazing is done- (i) shortly before sunrise, (ii) mid-morning (about 10 - 11AM), (iii) early afternoon (3- 4PM), (iv) at dusk i.e. before sun-set. Cattle attempt to graze when they are only several days old (6 - 8days), and as suckling period reduces, they graze more often. Rumination follows grazing and during a 24hours cycle cattle may ruminate 15 - 20 times. In temperate countries cattle would drink between 1 to 4times a day but in hot environment they drink more often if they have the opportunity. It is possible for cattle to go without water for about 2- 7hours.
2. **Sheep:** It has splint upper lip and they can therefore graze close to the ground. The grass is cut between the incisors and the dental pad. The tongue does not play a role. Grazing start at sunrise and continues during the whole day (light time) except for periods of rumination which may be as many as 15times a day. Sheep rarely graze at night and they graze in group facing the same direction. Ewe dams are not good foster-mothers and tend to suckle their own lambs. Within one hour of birth most lambs have successively sought out the udder. If it failed to do so within that period or it is prevented from doing so, its drive for suckling becomes inhibited. In the first week of birth, lambs suck as often as 60 - 70times in 24hours. Each lasting for 3minutes, but later they are not

allowed more than 20hours per sucking. If there are two lambs, each develops preference for one particular teat.

3. **Goats:** Goats are browsers i.e. they tend to pick and choose the food they eat. They preferred twigs (small branches/leaves of trees especially and dry ones). They sometimes strip back of trees if they cannot get the leaves. Goat can withstand a high level of bitterness and sometimes may prefers bitter tasting vegetation. Goats tend to disperse when they are foraging and they keep in contact with each other by hearing or perhaps by smelling rather than seeing.

4. **Pigs:** Pigs have well defined sense of smell and will readily root for food. Rooting is the most important ingestive behavior in pigs. They show these activities even if they are given powdery feed. Pigs are omnivores and if they are on free-range they would eat varieties of vegetable materials and also some animals including earthworms. Palatability (taste) plays an important part in the feeding behavior in the pigs. They prefer sugary food items and like soybeans, fishmeal and grains. Feed intake is reduced in pigs by too much salts, fat or cellulose. They prefer wet feed to dry feed. Feeding behavior in pigs is stimulated by the sight of other pigs eating.

5. **Poultry:** Free-range birds will grab a large food object and run to avoid competition. They tend to scratch the ground in backward steps. They would then step a pace backward to examine a scratched area for food. Visual stimulation plays a part in food selection in chicken. They show a preference for certain food and laying birds will show specific selection for calcium. Chicks learn feeding behavior from their mother when they are in association otherwise they learn by operant conditioning. Poultry drink frequently each day and they would visit water trough in 30 - 40times a day

Both mammals and avian specie perceive the temperature and the texture of feed before it can taste. Just like most activities in the gastrointestinal tract (GIT), the sensory information about this visual nature is sent to the brain through the autonomic nervous system. Parasympathetic nervous system increases the activities of G.I.T. while the sympathetic decreases it. The parasympathetic nervous system consists of 12 cranial nerves, 5 of which convey information about sight, smell, taste, texture and temperature of feed to the brain. Despite their hard mouth the avian specie still have some of the cranial nerves. Temperature also has a way of determining food intake.

Salivation: This means the production of saliva. Saliva performs the following-

1. It aids oral manipulation of feed within the mouth
2. It is the medium for taste
3. In some livestock specie, saliva contains amylase enzymes (amylase for conversion of starch to maltose).

In mammals there are three types of salivary glands

1. Parotids - it is the largest, triangular in shape and located ventral to the ear.
2. Submaxillary - it is located ventral to the parotid.
3. Sublingual - it is closely associated with the tongue and found below the floors of the mouth.

Both parotid and submaxillary has major ducts to the mouth while the sublingual has many openings through the floors of the mouth. Each gland is similar in structure and organized into lobules which consist of acini or extensive ductile. Each acinus is composed of mucous and/ or serous secretive cells held in place by myoepithelial cells. The acinus is connected to intercalated duct which subsequently leads to a major excretory duct. An intercalated duct in the excretory duct differs in composite cells. Intercalated ducts are narrow, long, frequently branched but have no secretory cells while the excretory ducts on the other hand, have goblet cells and thus add to the fluid nature of the saliva. Acini of different glands differ in the proportion of mucus and/or serous secretive cells. The parotid is made up of the serous cell while the submaxillary and sublingual are made up of both mucus, serous and secretory cells. In the acini with two types of cells the mucus cells lies inside while the serous cell lies in outside. There is no amylase secretion in pig. Serous cells when present can only be found in the serous cells. Animals that chew the cud (ruminants) have large salivary glands. Serous saliva is thin and watery while mucus saliva is thick and ropy. The amount and type of feed consumed will determine the quantity of saliva that will be produced. Research as shown that when pig consumes corn, potato, mixed feed and milk, corn meals, potato meals, mixed feed meals and milk meals of saliva will be produced respectively. The amount and consistency of saliva produced depends on the amount and nature of feed consumed and it is commensurate with the need for lubrication/ sensory evaluation. The control of saliva is neutral via the autonomic nervous system. The parotid is exclusively inervated by glosopharygeal nerves while the sublingual and submaxillary are stimulated/inervated by the facial and trigerminal nerve. The type of nerve stimulated will determine the amount and consistency of saliva that will be produced. If parasympathetic nerves are stimulated/inervated there will be increase in blood supply leading to more serous saliva. On the other hand, if sympathetic nerves are stimulated there will be decrease in blood supply leading to a minimal mucus supply. Neural input to salivation is necessary in order to maintain adequate number of cells. Upon stimulation both serous and mucus secretory cells release their respective cellular inclusion. The fluid is drawn from the acini glands to increase the volume of saliva. Vascular electrolyte that entered the acini lumen is reclaimed by duct exchanged in a process similar to what happen in the kidney.

Saliva in the avian differ from that of mammals by being of continual thick (serous), ropy consistency.

The salivary glands present in avians are-

1. Lingual
2. Mandibular
3. Single glands at an angle to the beak
4. Multiple glands present on the roof of the mouth and pharyngeal area.

Saliva in avians is wholly oriented towards lubrication of feed at the back of the mouth. There is no amylase secretion in avians.

Mastication: This is the process of reducing feed particles size within the oral cavity. It is aimed at increasing the surface area of feed for saliva to act increasing the ability to taste. The process is absent in avian becausethey lack teeth. Feed particles size reduction in avian takes place in the gizzard. There are different types of teeth

1. Canine (shovel-like) - used for biting, the upper canine is used for grabbing and shearing.
2. Incisors - used for tearing
3. Premolar used for cutting or dividing the food
4. Molar crunches the food

Mastication is made possible by masseta muscles which actually provide the force for mastification. The masseta muscle moves the mouth in an up and down version. Lateral movement in ruminants is made possible by supplementary muscle.

Structurally the tooth is made up of three parts- Enamel, Dentine and Pulp. Enamel is subjected to wear and it is replaced by substances from the dentine. Vascular and neural supplies are present in the pulp. The structure of the teeth is fairly similar to that of bone, however teeth is more calcified than bone, the primary protein connecting the teeth to the jaw is collagen. Nutrition of young animals affects the development. Teeth development is sensitive to protein calorie balance. Deficiencies or inadequate vitamin D, Calcium and Phosphorus can affect teeth development. Inadequacy or toxicity of fluorine can affect teeth development.

For mammals I2/2 C1/1P2/2 M3/3

For sheep I0/3 C0/1 P3/2 M3/3

Note: in sheep the space between the front and cheek teeth is called **diastema** and in place of the missing upper incisors and canine there is the **dental pad**.

Tongue and taste: Tongue is an important organ for food assessment. It plays a vital role in the movement of food within the mouth. In mammals, the tongue is bonded on all regions by the teeth. The teeth in conjunction with the pallet and tongue form the oral cavity which is only sealed in by the lips. Taste buds are present throughout the oral cavity but it is mostly concentrated on the tongue. Taste buds are most concentrated on the top rear aspect of the tongue where a warm fluid environment favours chemoreception.

Taste bud - is the functional unit of a tongue. Each taste bud is associated with larger papillae. There are two types of papillae the circumvallate and fungiform,

the circumvallate papillae are located in the top rear aspect of the tongue while the fungiform are located throughout the tongue. Taste buds are located in the crevices of the circumvallate papillae while those located on the fungiform are located close to the surface. In each taste bud,we have taste cells, support cells and nerve elements. The taste cells have dark staining and a shorter lifespan when compared to the supporting cells. Taste cells projects cilia into the pore that contacts the oral cavity for chemoreceptor. Different taste buds communicate with the central nervous system (CNS) via different cranial nerves; the front to third of the tongue is innervated by facial nerve while the last is innervated by glosopharyngeal nerve. Taste buds at the floors of the mouth communicate with CNS via phagus cranial nerves. In the avian specie taste buds are only limited to the back of the mouth or dorsal part of the tongue. There are no taste buds in the anterior half of the avian tongue though they have papillae; the reason is that the anterior half is keratinized. Innervations in avian tongue are through the glossopharygeal nerve which also serves the larynx, pharynx and the cranial part of the oesophagus. Taste in the avian is both qualitative and quantitative. Research has shown that they can recognize/ perceive taste of salt, bitterness, acids etc. Taste in mammals is far developed than avian and this has been taken as an advantage in the weaning of piglets through the use of distinctive flavoured ingredient (fishmeal) that was in Sow ration as part of the piglets feed.A cue relating the taste of milk to feed is established by the piglets. Avian specie taste better when water is the medium of taste rather than dry feed. Avian can also perceive flavor but differentiate feed more by sight. .

CHAPTER SIX
PRINCIPLES OF NUTRITION

Nutrition is the process by which food is taken in by living organisms in order to supply the nutrients required for the continuous metabolic reactions going on in the body. It is the science that seeks to interprete the relationship of food to the functioning of living organisms or the supply of substrates/nutrients to an animal's body. There are two types of nutrition autotrophic (holophytic or photosynthetic/ chemosynthetic) and heterotrophic nutrition (holozoic, parasitic, saprophytic/ symbiotic). Animal nutrition involves the use of complex food substances to provide necessary nutrients for growth/ development within the digestive system.

AVIAN DIGESTIVE SYSTEM

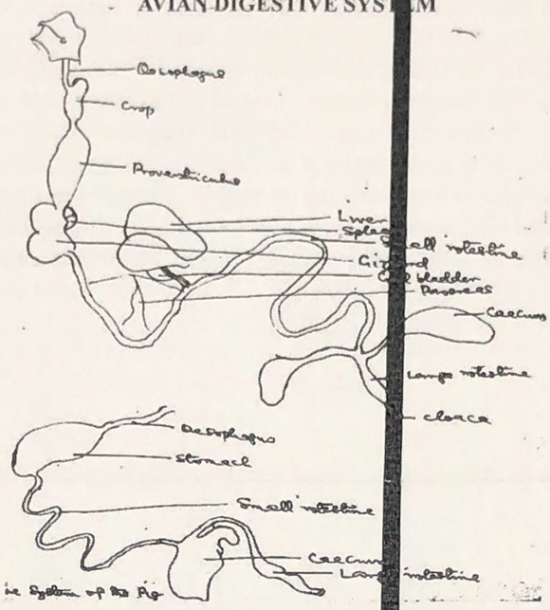


Figure 6.1 Structure of a monogastric digestive system

The passage connecting the outside environment to the metabolic wall of the animal is referred to as the digestive system. The development and the anatomy of the alimentary canal is an important determinant of the type of food that is nutritionally useful for any specie of animal. The carnivore for example has a relatively short alimentary canal while the herbivore has a long digestive system. The relationship of the length of the body to the length of the digestive tract is about 1: 4 for cats/chicken, 1: 6 for dogs, 1: 14 for swines and 1: 27 for sheep/goats. Therefore, the type of food most useful for chickens would closely resemble those for cats/dogs rather than for cattle/sheep. The distinctive characteristic of the mouth of the chicken is the absence of lips and teeth, both of which are replaced by horny mandibles which is referred to as the beak. The tongue in the chicken/turkey is shaped like the barb end of an arrow.

The projections at the back of the tongue deserve to force food toward the back of the oesophagus when the tongue is moved to and fro.

Salivary glands secrete mucous saliva which lubricates food as it passes down the oesophagus. The **crop** is a pouch which forms an enlarged specialized area of the oesophagus. Little digestion takes place in the crop whose function is for storage. The **proventriculus** is the acid secreting section of the digestive tract of the avian specie and it is similar in function to the stomach of such other animals as the pig, dog and cat. The stomach usually opens into the small intestine but in birds the proventriculus leads into the gizzard which in turns opens into the duodenum. Hcl and pepsin which aids protein digestion are secreted by the walls of the proventriculus. No rennin is secreted since no milk is produced by the avian species unlike in the mammal. The **gizzard** is an oval shaped organ lying between the proventriculus and the duodenum. It is composed of two pairs of red powerful muscle covered internally with a thick horny epithelium. The main function of the organ is to grind coarse food particles. The process of grinding is usually aided by the ingestion of grits or gravel. With properly ground rations the role of the gizzard is reduced. Immediately after its attachment to the gizzard, the small intestine is folded into a loop called the **duodenum**. Inbetween the loop of the duodenum is the pancreas which is supplied with a number of ducts called pancreatic ducts. The pancreatic juice is slightly alkaline and neutralizes the juice secreted by the proventriculus. The pancreatic secretion contains a number of enzymes such as trypsin, lipase, amylase which helps to hydrolyze protein to polypeptides, fat to glyceride/fatty acid and starch to disaccharides respectively. The **bile** is a pigment secreted by the liver and stored in the **gall bladder**. The chief function of the bile is the proper absorption of dietary fat in the small intestine. The **small intestine** comprises two distinct parts i.e. **duodenum** and the lower small intestine (**ileum**). The enzymes of the lower small intestine complete the digestive processes initiated by pancreatic enzymes. Here peptides are broken down to amino acid, fats to fatty acids, and disaccharides to simple sugar. Since there is no specialized area in the GIT of the avian specie for extensive bacteria action, it is important that any food fed to chicken must be readily digestible by the enzymes secreted in the GIT. The epithelia linning of the small intestine has tremendous surface area which makes rapid absorption of nutrient possible. It is possible for the chicken, for example, to completely digest and absorb a full meal in 3 hours. The **caecum** is represented by two blind pouches given-off from either sides of the junction between the lower small intestine and the large intestine. It is about 10-15cm in length and usually filled with faecal matter. With highly digestible ration fed to poultry the caecum has very little function in digestion. However, in adult bird fed highly fibrous rations, some level of digestion within the caecum is expected by the presence of numerous microorganisms. Though, the usefulness of such digestive product is questionable since it is posterior to the active absorptive region of the GIT.

The large intestine in the avian specie is usually short and consists of a short rectum usually about 3 - 4cm long. The rectum leads to the cloaca. The **cloaca** is a chamber common to the digestive, urinary and reproductive passages which opens externally through a vent. The urine is discharged through this chamber and excreted with faeces.

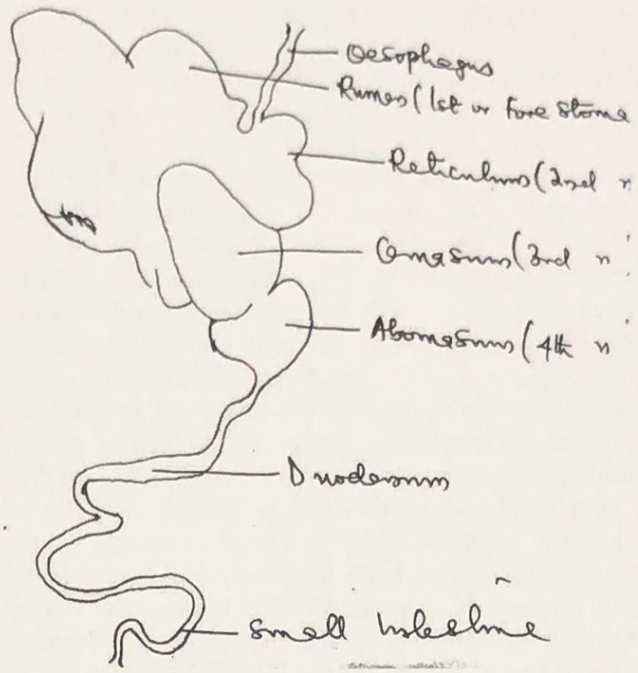


Figure 6.2 Structure of a ruminant digestive system

The Ruminants Gastro-intestinal tract (GIT)

The ruminant animal such as the sheep, goat and cattle are characterized mainly by the possession of complex digestive tracts which is an anatomical adaptation to their dietary habit. The ruminant animal handles a considerable amount of fibre and therefore requires considerable and prolonged physiological processes before being broken down to utilizable forms. The various compactment of the ruminant stomach and their anatomical designation are the **Rumen** or the first stomach, the **Reticulum** (2nd stomach), the **Omasum** (3rd stomach) and the **Abomasum** or 4th stomach, true stomach or the secretory stomach. The rumen and the reticulum are contiguous i.e. sharing a common boundary, and hence communicate freely with each other. The **reticulo-rumen** represents the most extensive portion of the ruminant stomach and it is endowed with numerous muscular folds which aids the mixing up of ingested food substances. The reticulo-rumen serves as an initial storage unit where the food substances are initially reduced in size by various digestive processes. The reticulum and the omasum communicate by means of the **Reticulo-omasal orifice**.

In the young ruminant animal there is the **oesophageal groove** or tube which enables liquid diets of the young animal to enter directly into the abomasums without passing through the reticulo-rumen. An oval organ which lies to the right of the reticulum is the omasum whose lumen is filled with a number of laminae. The omasum is linked with the abomasums by means of a groove which is called **Sulcus omasi**. The abomasum (true stomach) is similar in a number of respects to the simple stomach of the carnivore. The abomasums is linked to the duodenum by the pylorus. It must be emphasized that the matured rumen is richly supplied with a number of projections called Papillae which gives the rumen a fur-like appearance. The small intestine of the ruminant animal is similar to that of the monogastric, and terminates at the ileo-caecal junction. The caecum is a blind sac-like outgrowth of the large intestine where-in some food may initially enter for some degree of digestion.

Physiological aspect of rumination

Both the rumen and reticulum of the ruminant serve mainly as fermentation vat while both the omasum and abomasums serves to prepare food for gastric digestion by enhancing the removal of excess water and facilitating the normal acid/enzyme digesting phase in the glandular stomach. The rumen contains billions of microorganisms whose function is not only to breakdown cellulose into digestible polysaccharides but could also synthesize a number of other chemical substances which could serve as ruminant food. The chief product of ruminant fermentation are the short-chain (volatile) fatty acids which include acetic acids, C_2 (60%), propionic acid, C_3 (20%), and butyric acid, C_4 (20%). Certain other alcohols may also be produced. These short-chain fatty acids are usually absorbed through the ruminant walls. This volatile fatty acid (VFA) provides energy sources and may also be synthesized into other fatty acids and ketone bodies. Propionic acid is of great importance in ruminant nutrition because its configuration CH_3CH_2COOH, C_3 makes it highly glucogenic within the liver cells and thus provides about 50% of the glucose which enters the ruminant metabolic system.Butyrate may be glucogenic as well as ketogenic and therefore more nutritionally useful. The cattle and most ruminant animals are endowed with the ability to synthesize protein from fatty acids because of the symbiotic activities of the rumen microorganisms. This represents a marked contrast to the metabolism of the non-ruminant mammals that lacks such specialization.

It must be emphasized that the ability to efficiently handle dietary fibre is not found in the young ruminant animal at birth. Thus a calf feeding on the mothers' milk metabolizes food in much the same way as the monogastric animal until it is about 4months of age when the rumen would have developed sufficiently to assume its full nutritional responsibility.

Although several advantages arise from ruminant digestive system, the process of fermentation generates so much gas which must be eliminated through belching. Any interference with the mechanism of elimination of gas produces a syndrome

in cattle which is referred to as **bloat**. This is a disease condition which is usually associated with cattle grazing on lush legume pasture. Some of the method of reducing the incidence of bloat is the administration of oil or the introduction of canula (a tube introduced into the digestive tract). Another problem with ruminant metabolism is the formation of ketone bodies which is a specific disease of ruminants. The formation of ketone bodies brings about a disease condition referred to as **ketosis**. This is believed to arise from the inability of the liver to detoxify or metabolize short-chain fatty acids in the blood stream due to increased stress which may be brought about by lactation.

CHEMICAL COMPOSITION OF THE ANIMAL BODY

The animals' body is made up of chemical substances derived from the food (plant/ animal products) they eat. The chemical substances in the food that are required for normal functioning/development of the body are called nutrients. Animal feed/feedstuff is composed of **dry matter (DM)** and **water**. The dry matter is the part of feed remaining after dehydration of food and it is made up of organic (carbohydrate, protein, fats/oils, and vitamins) and inorganic (minerals) materials. The main component of the DM of pasture grass/all plant as well as many seeds except the oil seeds (groundnut, cotton, soybean, etc) is carbohydrate. In contrast the carbohydrate content of the animal body is very low. One of the main reasons for the difference between plants and animals is that, whereas the cell walls of plants consist of carbohydrate material, mainly cellulose, the walls of animal cells are composed almost entirely of protein. Furthermore, plants store energy largely in the form of carbohydrates such as starch and fructans, while animals' main energy store is in the form of fat.

Water metabolism: Water is the most abundant constituent of the body which provides the fluid region between which the chemical reaction of the body takes place and chemical substances transported. For example, about 95% of the foetus is made up of water and each concentration approaches 75% of the body weight of the adult animal on a fat-free basis.

Distribution of water: Intracellular water represents about 50% of the body weight while extracellular water constitutes about 20%. Extracellular water consists of blood plasma which is about 5% of the body weight and interstitial fluid which is about 15% of the body weight. Intracellular fluid (ICF) refers to all such fluids within the cells and represents about 50% of the body weight. Extracellular fluid(ECF) refers to all such fluid outside the cell, constituting about 20% of the body weight. The body fluid is a state of flux as there is a constant exchange of water between the fluid compactment of the body. An adult man weighing about 70kg for example contains about 49litres of water most of which is contained in the muscle.

It has been observed that the body could loss practically its entire fat and over 50% of its protein and still live whereas a loss of 10% water leads to death.

The exact percentage of water in the body as well as an animal water requirement is affected by the following factors-

1. Specie of animal
2. Size of the animal
3. The age of animal
4. The sex of the animal
5. The physiological state of the animal e.g. pregnancy, lactation, egg production, fleece production.
6. The climate of the area i.e. temperature, relative humidity, etc.
7. Type of feed i.e. feed composition/amount of water in feed.
8. Amount of salt consumed
9. Season of the year/ physical environment
10. Physical exercise/ heat load

In cattle for instance, water is about 95% the weight of the embryo. When the animal is just delivered the water content is about 75 - 80%, when 5months old it is about 66-72%, and at maturity 50 - 60%. This implies that the body water content diminishes with age. This is because the body water and fat has an inverse relation i.e. the higher the body fat the lower the water content. In general term the more active a given tissue is, the more its water content. The fact is illustrated by the following-

Tissue	**Percent Water content**
Liver	75
Kidney	81
Heart	79
Bone with marrow	75 - 80
Bone without marrow	46
Thyroid	80
Spleen	73
Skin	70
Adipose	10 - 30
Dentine	10

For example the bone tissues whose chief function are for support and protection rather than for physiological activities have low water content. This is also true of the dentine which is a hard protective tissue. Adipose tissue is also low in water since it is inactive and serve only as food reserve and at times as protective material. An exception is the cartilage which is rather inert but has high water content. This is necessary to give the tissue its softness and elasticity. The higher fat content explains in part the lower water content of the female animal and the castrates.

Functions of Water

The functions of water are numerous and varied

1. Digestive and secretory function: The digestion of food takes place in solution which emphasizes the importance of water in the digestive process of the animal. For example, digestive secretion is aqueous in nature and thus water helps to transport the digestive enzyme within the GIT. About 500 - 1500cm^3 of water is required per day for the production of saliva in man, 700- 1000cm^3 of water is required per day for pancreatic secretions and 100- 400cm^3 of water is required per day for bile synthesis.

   Milk is about 85% water and therefore requires a large quantity of water for its turn over. The lactating animal will require about 2.5 - 4litres of water to produce 1litre of milk.
2. Medium of transportation of nutrient/ excretion of wastes: Water is a very important medium of transportation. Food materials have to be transported from the intestine to the tissues of the body and all metabolic wastes have to be carried to the organ of egestion, all of which requires water. Food and waste products are transferred either in solution or in colloidal state in the blood and liver. High salt intake increases water requirement in much the same way as high protein intake also tend to increase water requirement. The peculiar need for water in high protein diets is related to the amount of urea produced, and since urea is highly toxic, it therefore has to be diluted and excreted. The blood contains over 80% water while plasma contains over 90% water. A reduction in plasma water content increases blood viscosity which inturn tends to clog the transport system. This may result from a reduction in blood volume. A failure in the central circulatory/ nervous system is a consequence of reduced blood volume.

   NB: Blood plasma makes up about 55% of the total blood volume and it is the yellow liquid component of blood in which the whole blood is suspended. It is the intravascular fluid part of the extracellular fluid. It is mostly water (90% by volume) and contains dissolved proteins, glucose, clotting factors, mineral ions, hormones and carbondioxide (plasma being the main medium for excretory product transportation). Plasma is the liquid portion of blood i.e. a protein salt solution in which red and white blood cells and platelets are suspended. It contains albumin (the chief protein constituent), fibrinogen (responsible in part for the clotting of blood), globulins (including antibodies), and other clotting proteins. Blood plasma is prepared by spinning a tube of fresh blood containing anticoagulant in a centrifuge until the blood cells fall to the bottom of the tube. The blood plasma is then poured or drawn off. Plasma helps in maintaining a satisfactory blood pressure/volume, supply critical proteins for blood clotting/immunity, medium of exchange for vital minerals such as sodium/potassium and thus helps to maintain a proper balance in the body, which is critical to cell function.

   Blood serum is blood plasma without fibrinogen or other clotting factor i.e. whole blood minus both the

cells and the clotting factors. Serum is clearer than plasma because of fewer proteins. Serum is the preferred specimen in clinical testing as the interference that may be caused by a plasma specimen because of the presence of anticoagulant is eliminated.

3. Helps in body temperature regulation (thermoregulation): Water is very important in body heat regulation because of its peculiar property of.
   (a) High specific heat which enables the body to store heat effectively without raising its temperature appreciably.
   (b) A high internal heat conductivity which enhances the transfer of heat from the interior to the body surface.
   (c) A high latent heat of evaporation which causes a great deal of heats to be used in the evaporation of water during which the body surface is cooled.
4. Helps in lubrication of specific area of the body: Water being a component of the synovial fluid serves as a lubricant for various surfaces including the joints, conjunctiva of the eye, the pericardium and the peritoneum.
5. Helps in hydrolytic/ specific functions in the body: Several biochemical changes within the body depend on specific hydrolytic processes, all of which invariably requires water. As a component of cerebrospinal fluid, water functions as a cushion for the nervous system. In the ear it transport sound and it is concerned with sight being an important component of the aqueous humour.

Sources of body water

Animal body lacks the facility to store bulk water for along period. A normal functioning of the body mechanism results in an un-interrupted loss of water and since the body must maintain its total water content at a relatively constant level it is necessary that a continuous supply of water be made available. The animal obtains its water from the following sources-

1. Drinking free water: Through liquid intake such as during drinking, sucking of oranges, etc.
2. Water from feed: As a component of the food eaten. In this circumstance the proportion of water varies with each type of food e.g. it can range from 60g/kg in concentrates to over 900g/kg in some root crops. Water content of growing plants is related to the stage of growth, younger plants contain more water than older ones.
3. Metabolic water: From the oxidation of food i.e. metabolic water
   $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$
   Some desert animals are able to derive their entire water requirements from free/metabolic water e.g. Kangaroo rat, which does not drink at all throughout a lifetime and may not know what to do with water if offered.
   The amount of water intake increases with the degree of sweating and thirst. When an animal sweats, thirst-sensation may not be strong enough to want

the desired amount of water required by the body. Thus a man may drink half as much water to replace that lost during heavy duty. It is only after sufficient rest that thirst sensation becomes sufficient to enable the drinking of sufficient amount of water. When water loss due to heavy sweating are not replaced, a subject may suffer an increase in pulse rate, there may be increased respiration, there may be the feeling of prinkling sensation on toes and fingers, increase concentration of blood, there may be diminished blood volume, development of gastrointestinal upset accompanied by nausea (feel like vomiting), loss of appetite and difficult muscular movement. Failure to take in sufficient water or fluid leads to a state of dehydration which may bring about 10 - 12% loss of body fluid. When this happens the temperature suddenly rises during which a number of body tissues are brought under considerable heat stress. Animals vary generally in their requirement for water; since the tissues of growing animals contains over 75% water, its requirement is greater than for the adult animal. There is no evidence that under normal conditions an excess of drinking water is harmful, and animals usually drink what they require.

Routes of water losses

1. Urine, through the kidney.
2. Faeces, through the gastrointestinal tract.
3. Expired air/CO_2, through the lungs.
4. Sweat, through the skin.
5. Milk, eggs, spermatozoa, tear-drops, and other products, through the udder, reproductive channels, eyes etc.

ENZYMES, COENZYMES AND VITAMINS

Enzymes are organic catalyst, usually proteinous in nature, which speed up the rate of chemical changes in living cells but are not themselves used up in the process. They accelerate metabolic reactions without changing their composition in the process. Enzymes are catalyst (a substance that accelerate chemical reactions) but unlike non-protein catalysts H^+, OH^-, metal ions, etc each enzyme catalyzes a small number of reactions, frequently only one i.e. they are **reaction specific catalyst**. Enzymes bind temporarily to one or more of the reactants of the reaction they catalyze. In doing so, they lower the amount of activation energy needed and thus speed up the reaction e.g. catalase catalyzes the decomposition of hydrogen peroxide into water and oxygen, $2H_2O_2 \rightarrow 2H_2O + O_2$; Carbonic anhydrase found in red blood cells where it catalyzes the reaction $CO_2 + H_2O \rightarrow H_2CO_3$. It enables red blood cells to transport carbondioxide from the tissues to the lungs. One molecule of carbonic anhydrase can process one million molecules of CO_2 each second; acetylcholinesterase catalyzes the breakdown of the neurotransmitter acetylcholine at several types of synapses as well as at the neuro-muscular junction (the specialized synapse that triggers the contraction of skeletal muscle). One molecule of acetylcholinesterase breakdown 25,000 molecules of acetylcholine each second.

This speed makes possible the rapid "resetting" of the synapse for transmission of another nerve impulse.

In most enzyme substrate reactions, the forces that hold the enzyme and its substrate are non-covalent i.e. an assortment of hydrogen bonds, ionic interaction and hydrophobic interactions. Most of these interactions are weak and especially so if the atoms involved are farther than about one angstrom from each other. So successful binding of enzyme and substrate requires that the two molecules be able to approach each other closely over a fairly broad surface. Thus the analogy that a substrate molecule binds its enzyme "like a key in a lock". This requirement for complementarity in the configuration of substrate and enzyme explains the remarkable **specificity** of most enzymes. One of the enzymes needed for the release of energy within the cell is succinic dehydrogenase which catalyzes the oxidation of succinic acid by the removal of two hydrogen atoms.

Characteristics of Enzymes

1. All enzymes are protein in nature - although a few ribonucleoprotein enzymes have been discovered and, for some of these, the catalytic activity is in the RNA part rather than the protein part.
2. Enzymes are usually involved in reversible reactions.
3. Enzymes are ph specific i.e. they are affected by the acidity or alkalinity of their surroundings. They are destroyed by strong acids or alkali.
4. Speed up biochemical reactions.
5. They are specific in action i.e. an enzyme or a group of enzymes deals with only one process.
6. They operate within a specific temperature range above or below which they become inactive or denatured. Work best at optimum temperature of 37°C.
7. Can function outside the organism producing them.
8. They do not loose their chemical composition at the end of the reaction i.e. not used up or changed during reaction.
9. Like any other catalyst act in very small quantities and catalyze large amount of substrate.
10. They require the presence of non-proteinous molecules called co-enzyme for their catalytic function.

Functions of Digestive enzymes

1. Helps in breaking down protein food into amino acids.
2. Helps in breaking down fats and oils into fatty acids/glycerol.
3. Helps in breaking down of carbohydrates into glucose, fructose and galactose.
4. Aids the absorption of digested food through the addition of water to the food.

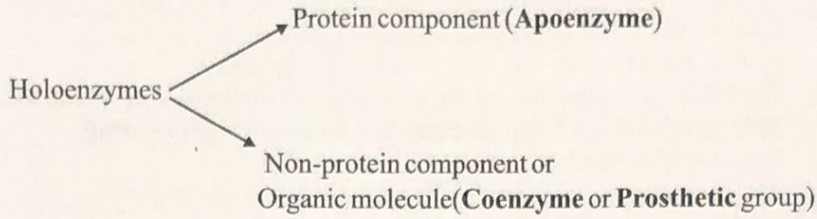
Types of Enzymes: The two major types of enzymes are intracellular enzymes and extracellular enzymes.

1. Intracellular enzymes are enzymes which function inside the cells of living organisms e.g. enzymes that catalyze cell respiration inside the mitochondria.

2. Extracellular enzymes are enzymes which carry out their functions outside the cells e.g. digestive enzymes (ptyalin, renin, pepsin, amylase, trypsin, erepsin, lipase, maltase, sucrose and lactase).

Classification of Enzymes: Enzymes can be classified on three major bases on the basis of substrate, enzyme composition and chemical reaction.

1. Classification based on substrate Initially enzymes were named by adding a suffix **ase** to the name of the substrate on which they acted e.g. enzyme that hydrolyze starch (amylon) is called amylases, enzyme that hydrolyze protein is called proteinases and enzyme that hydrolyze fat (lipos) is called lipases.
2. Classification based on enzyme composition On the basis of their composition, enzyme composed wholly of protein are known as **simple enzymes** while those composed of protein plus a relatively small organic molecule are called **complex enzymes** or **holoenzymes**.



When the binding between the apoenzyme and non-protein component is non-covalent, the small organic molecule is called **Coenzyme** while when it is covalent bond, it is called **prosthetic group**. Many coenzymes/prosthetic groups are water soluble derivatives of vitamins e.g. B-vitamins such as B_1 (thiamine), B_2 (riboflavin) and B_3 (nicotinamide). The non-protein component of an enzyme may be as simple as a metal ion or as complex as a small non-protein organic molecule. Enzymes that require a metal ion such as Zn^{2+} (as in carbonic anhydrase), Cu^{2+}, Mn^{2+}, K^+ and Na^+ in their composition are known as **metalloenzymes** if they bind and retain their metal atoms under all conditions with very high affinity. Enzymes which have a lower affinity for metal ion, but still retain the metal ion for activity is known as **metal-activated enzymes**.

3. Classification based on chemical reaction This new method of classifying enzymes is based on the nature of chemical changes brought about on a substrate e.g changes which involve oxidation the enzymes will be called oxidases. All digestive enzymes belong to the class called hydrolases. The class hydrolases generally refer to enzymes that break up various bonds (breaking large molecules into smaller particles) in the presence of water.
   According to the International Union of Biochemistry (IUB) nomenclature system, naming of enzymes should be on the basis of chemical reaction type

and reaction mechanism, so as to facilitate the integration of information from widely divergent areas of metabolism. The major features of the IUB system are as follows

1. Reaction and enzymes that catalyze them are divided into 6 classes each with 4 to 13 subclasses.

Number	Classification	Biochemical properties
1	Oxidoreductases	Act on many chemical groupings to add or remove hydrogen atoms i.e. catalyze the joining together of two molecules with accompanying hydrolysis of a higher energy bond.
2	Transferases	Transfer functional groups between donor/acceptor molecules e.g. A + B + C = A + C + B. Kinases are specialized transferases that regulate metabolism by transferring phosphate from ATP to other molecules.
3	Hydrolases	Add water across a bond, hydrolyzing it i.e. catalyze the hydrolytic cleavage or breaking up of carbon-oxygen, carbon-nitrogen or carbon-carbon bonds.
4	Lyases	Add water, ammonia or carbondioxide across double bonds, or remove these elements to produce double bonds i.e. catalyze the breaking up of bonds by elimination or addition reactions.
5	Isomerases	Carry out many kinds of isomerization: L to D isomerizations, mutase reactions (shifts of chemical groups) and others i.e. work on isomers and usually change the spatial configuration of a molecule in a living cell.
6	Ligases	Catalyze reactions in which two chemical groups are joined (or ligated) with the use of energy from ATP i.e. catalyze the joining together of two molecules with accompanying hydrolysis of a high energy bond.

2. The enzyme name has two parts. The first names the substrate or substrates while the second ending in ase indicates the type of reaction catalyzed.
3. Additional information, if needed to clarify the reaction, may follow in parenthesis e.g the enzyme catalyzingL-malate + NAD^+ = pyruvate + CO_2 + NADH + $H^+$is .designated 1.1.1.37 L-malate: NAD^+ oxidoreductase (decarboxylating).4. Each enzyme has an enzyme code number (E.C.) that characterizes the reaction type as to class (first digit), subclass (second digit) and sub-subclass (third digit). The fourth digit is for the specific enzyme e.g. EC 2.7.1.1 denotes class 2 (a transferase), subclass 7 (transfer of phosphate), sub-subclass 1 (an alcohol functions as the phosphate acceptor). The final digit denotes the enzyme hexokinase or ATP. D-hexose 6-phosphotransferase, an enzyme catalyzing phosphate transfer from ATP to the hydroxyl group on carbon 6- of glucose.

Reactions that require coenzymes include oxidoreductions, group transfer and isomerization reactions, and reactions that form covalent bonds (IUB classes 1, 2, 5 and 6). Lytic reactions, including hydrolytic reactions such as those catalyzed by digestive enzymes, do not require coenzymes (IUB classes 3 and 4).

Uses of Enzymes

1. Enzyme is used in diagnostic enzymology to detect/ manage important medical disorders. Marker enzymes such as alkaline phosphatase (ALP), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) are used to detect internal injury, liver/ kidney problems, trauma, etc.
2. Exogenous enzymes are added to poultry feed to increase the availability of starches, proteins/ minerals which are enclosed within the fibrous cell walls of feedstuffs or bound in chemical forms that the animal is unable to digest and therefore inaccessible to their digestive enzymes. Such exogenous enzymes include cellulose (ß -glucanase), hemicellulase, xylanase, phytase, amylase, protease, pectinase, lipase and galactosidase.

   These exogenous enzymes improve weight gain by 46%, apparent metabolizable energy (AME) by 33% and fat digestibility by 193% in broilers fed naked oats based diets. It also reduces feeding cost, improve feed conversion ratio (FCR), liveability and egg weight in layers. The addition of an enzyme blend containing xylanase, amylase and protease increase ileal digestible energy of corn soybean diets in 28day old broiler chickens.
3. Helps to breakdown antinutritional substances in certain feedstuffs. Antinutritional factors are not digested by endogenous enzymes of the animal and can interfere with normal digestion causing poor performance/ digestive upsets.
4. In poultry digestive enzymes have helped to neutralize the effects of viscous, Non-starch polysaccharides, NSP such as pectin, cellulose, ß-glucans/

arabinoxylans in cereals, thereby increasing the availability of nutrients and retarding the adverse effects of antinutritional factors present in feed components

5. Enzymes are also added to diets of monogastric animals to breakdown specific chemical bonds in the raw materials that are not usually broken down by animals own (endogenous) enzymes complements, thereby releasing more nutrients/ improving the performance e.g. phytase helps to hydrolyse phytate in feedstuff to release phosphorus, other minerals/ nutrients. Birds fed rice husk diets supplemented with commercial enzymes performed better than those without commercial enzyme.
6. Exogenous enzymes are used as supplement in young animals because of the immaturity of their digestive system and inadequate endogenous enzymes to improve feed utilization.
7. Enzyme is also use to increase the digestion of low quality products and reduce nutrient loss through excreta.
8. Helps to increase the usage of feed energy. Enzymes could contribute up to 50-70kcal of ME, 0.1% of Ca and 0.1% of available phosphorus per kilogram of diet.
9. Enzyme is use in reducing environmental pollution from excreta when use as supplement in diets; diminishes Nitrogen/ volatile fatty acid excretion up to 40% and ammonia emission by 30%.
10. Enzyme can be used in therapy in the treatment of digestive problem and other related health issues.

Factors affecting Enzyme action

1. Temperature: Enzymes function at specific temperature i.e. they are temperature specific so that its activity decreases at values above or below that optimum point. The structure or shape of the enzyme is determined by the non-covalent forces (ionic interactions and hydrogen bonds) within it. Hydrogen bonds are easily disrupted by increasing temperature. This inturn may disrupt the shape of the enzyme so that its affinity for its substrate diminishes. Enzyme molecules become denatured at high temperatures.
2. pH: The level of acidity and alkalinity are also specific for the enzymes e.g. the protease, pepsin works best at a pH of 1-2 (found in the stomach) while the protease, trypsin is inactive at such a low pH but very active at a pH of 8 (found in the small intestine as the bicarbonate of the pancreatic fluid neutralizes the arriving stomach contents). Changes in pH alter the state of ionization of charged amino acids (e.g. Aspartic acid which is negatively polar i.e. acidic and Lysine which is positively polar i.e. basic) that may play a crucial role in substrate binding and/or the catalytic action itself. Enzymes such as proteases, that can attack the cell that produce it are inhibited while within the cell due to pH difference e.g. pepsin is synthesized within the chief cells (in gastric glands) as an inactive precursor, pepsinogen but become active only when exposed to the low pH outside the cell during which the inhibiting portion of the molecule is removed and active pepsin produced. Most enzymes works best at a pH of 6 to 7.
3. Concentration of the substrate/ enzyme: The rate of enzyme catalyst reaction is increased when there is an excess enzyme when increasing substrate

concentration. An increase in enzyme concentration when the substrate is in excess would cause an increase in the rate of the reaction provided other factors are present.

4. Presence of Enzyme inhibitors: The action of an enzyme on a substrate could be hindered or disrupted if there are presences of substances that prevent the formation of the enzyme substrate complex (lock and key disruption) e.g. malonic acid inhibits the oxidation of succinic acid by succinic dehydrogenase. Some enzyme inhibitors destroy the site that the enzyme would bind to or occupies such sites thereby making binding site unavailable to the enzyme.
5. Presence of a negative feedback: Negative feedbackcan be sent to the site triggering enzyme production to stop the synthesis of enzyme and this is necessary in the control of biochemical reactions.

Vitamins

Vitamins are organic compounds which are required in small amounts for normal growth and maintenance of animal life. The name vitamin was used due to the fact that they are considered as special (vital) protein (amine) substances that are necessary for life (vital+amine = vitamin). Vitamins are not structural components of the body but functions as coenzymes or cofactors in body metabolism. Each individual vitamin performs particular tasks which cannot be performed in the same manner by another substance. Generally, the animal cannot itself synthesize these natural biologically active agents, which is why they must be supplied with the food. Hence they are essential micro-nutrients. All the vitamins used in animal nutrition, without exception, are produced on an industrial scale by chemical and microbiological methods. Daily amounts of a few milligram, mg or even microgram, µg of vitamins are sufficient to regulate the utilization of nutrients (carbohydrates, fats, proteins and minerals). A few vitamins are obtained by other means than food e.g. intestinal microorganisms (gut microfloral) produce vitamin K and biotin while one form of vitamin D is synthesized in the skin with the help of natural ultraviolet in sunlight. Vitamins are also synthesized from some vitamins precursors they consume e.g. vitamin A is produced from beta carotene and niacin is produced from the amino acid tryptophan. With the exception of cobalamin, water soluble vitamins are not stored in the body tissues in appreciable amounts, hence the need for constant exogenous supply. In ruminants all the water soluble vitamins can be synthesized by rumen microbial action. The use of sufficient vitamin supplements makes it possible to prevent growth disorders, juvenile diseases, fertility disorders and different types of performance impairment and helps to achieve a higher profitability of livestock farming.

Classification of vitamins: Vitamins are classified by their biological and chemical activity, not their structure. Vitamins are classified as either water-soluble (dissolve easily in water) or fat soluble (absorbed through the intestinal tract with the help of

lipids). There are 13 vitamins - 4 fat-soluble (A, D, E and K) and 9 water-soluble (8 B vitamins and vitamin C). In general, water-soluble vitamins are readily excreted from the body. Each vitamin is typically used in multiple reactions and therefore most have multiple functions. Vitamins have diverse biochemical functions, including function as hormones (e.g. vitamin D), antioxidants (e.g. vitamin E), and mediators of cell signaling/ regulators of cell and tissue growth/ differentiation (e.g. vitamin A). The largest number of vitamins (e.g. B complex vitamins) functions as precursors for enzyme cofactor bio-molecules (coenzymes), which help act as catalysts and substrates in metabolism. When acting as part of a catalyst, vitamins are bound to enzymes and are called prosthetic groups e.g. biotin is part of enzymes involved in making fatty acids. Vitamins also act as coenzymes to carry chemical groups between enzymes e.g. folic acid carries various forms of carbon group- methyl, formyl and methylene - in the cell.

Vtamins were first called by a generic descriptor names that are alphabets before they were later assigned chemical names that helped to differentiate the vitamer and are specific to only one vitamer.

Generic Descriptor name	Chemical name
A	Retinol, Retinoid and Carotenoid
D	Calciferol, Ergocalciferol (D_2), Cholecalciferol (D_3)
E	Tocopherol, Tocotrienol
K	Phylloquinone, Menaquinones
B_1	Thiamine
B_2	Riboflavin
B_3	Nicotinamide, Niacin, Niacinamide
B_5	Pantothenic acid
B_6	Pyridoxine, Pyridoxamine, Pyridoxal
B_7	Biotin
B_9	Folacin, Folic acid
B_{12}	Cyanocobalamin, Hydroxycobalamin, Methylcobalamin
C	Ascorbic acid

Names in current and previous nomenclatures

The reason the set of vitamins seems to skip directly from E to K is that the vitamins corresponding to "letters" F - J were either reclassified over time, discarded as false leads, or renamed because of their relationship to "vitamin B", which became a "complex" of vitamins. The German-speaking scientists who isolated and described vitamin K (in addition to naming it as such) did so because the vitamin is intimately involved in the Koagulation of blood following wounding. At the time, most (but not all) of the letters from F through J were already designated, so the use of the letter K was considered quite reasonable.

The following table lists chemicals that had previously been classified as vitamins, as well as the earlier names of vitamins that later became part of the B-complex:

Previous name	Chemical name	Reason for name change
Vitamin B_4	Adenine	DNA metabolite
Vitamin B_8	Adenylic acid	DNA metabolite
Vitamin F	Essential fatty acids	Needed in large quantities (does not fit the definition of a vitamin)
Vitamin G	Riboflavin	Reclassified as Vitamin B_2
Vitamin H	Biotin	Reclassified as Vitamin B_7
Vitamin J	Catechol, Flavin	Protein metabolite
Vitamin L_1	Anthranilic acid	Protein metabolite
Vitamin L_2	Adenylthiomethylpentose	RNA metabolite
Vitamin M	Folic acid	Reclassified as Vitamin B_9
Vitamin O	Carnitine	Protein metabolite
Vitamin P	Flavonoids	No longer classified as a vitamin
Vitamin PP	Niacin	Reclassified as Vitamin B_3
Vitamin U	S-Methylmethionine	Protein metabolite

Provitamins or vitamin precursors are those compound which function as vitamins only after undergoing a chemical change e.g. ß-carotene (provitamin A) and certain sterols. Beta -caroteneoccur naturally in feedstuffs of plant origin, especially green plants, which contain ß- carotene (a precursor of vitamin A) in widely varying amounts. The carotene concentration in green plants is greatly influenced by the time or period of harvesting, the degree of wilting, the preservation method used (drying, ensilage) and the length of storage. The carotene concentrations generally drop to such an extent that in many cases after 3 to 4months they are reduced to less than 30% of the ß-carotene levels present at harvesting time. During this degradation process a structural conversion of ß-carotene into carotene compounds with a lower biological efficacy also occurs. Generally, green foods are excellent sources of ß-carotene and in dried crops the degree of greenness is usually a good indication of the ß-carotene content.

Apart from yellow maize, most concentrates used in animal feeding are devoid of the provitamins. The conversion of of carotene into vitamin A occurs in the intestinal wall/ liver. In theory, one molecule of ß-carotene should form (on hydrolysis) two molecules of vitamin A. It's been recommended by the agricultural research council (ARC) that

Pigs: 11µg of ß-carotene = 1µg of retinol

Ruminants: 6µg of ß-carotene = 1µg of retinol

Poultry: 3µg of ß-carotene = 1µg of retinol
Units: Vitamins A and D are given in International Units (IU)
Vitamins K, C and B are stated in mg
Vitamins B_{12} and B_7 in µg (mcg) per kg of feed
Vitamin A values of foods are often stated in terms of international units (i.u), one i.u. of vitamin A being defined as the activity of 0.3µg of crystalline retinol.

Except for vitamins A and D_3, all the vitamins are tolerated without damage in extraordinarily high doses (100 to 1000times the level of the daily requirements) but are economically undesirable.

Clinical signs of high vitamin A intake in young chicks include loss of appetite (anorexia), poor growth, diarrhea, encrustation around the mouth/ reddening of the eyelids. In pigs excess vitamin A symptoms include rough coat, scaly skin, hyper-irritability, haemorrhages over the limbs/abdomen, periodic tremors and death.
Excessive vitamin D intake causes abnormally high levels of Calcium/Phosphorus in the blood, which result in the deposition of calcium salts in the arteries/organs; this has been observed also in cattle and calves.

Many vitamins are destroyed by oxidation, a process that is increased by the action of heat, light and certain metals such as iron. This fact is important since the conditions under which a food is stored will affect the final vitamin potency. Some commercial vitamin preparations are dispersed in wax or gelatin, which act as a protective layer against oxidation.

Minerals

Mineral salts are compounds of a metal with a non-metal radical. Essential mineral elements are mineral elements which have been proved to have a metabolic role in the body and their absence have a negative effect on the health of the animal. Essential minerals can be classified into two - major or macrominerals and trace or microminerals depending on their concentration in the animal. Normally trace elements are present in the animal body in concentration not greater than 50mg/kg. However, the concentration in which a mineral is required does not give an indication of its relative importance to the animal. Minerals that are required in large amount in the body are referred to as macrominerals. There are seven minerals that have been researched to be nutritionally essential macrominerals, four of these are cations (Ca, K, Na, Mg) while three are anions (Cl, S, P). The minerals required in small quantity by the body are called microminerals and they include Iron, Zinc, Copper, Iodine, Manganese, Cobalt, Selenium and Molybdenum.

Minerals could be obtained from various sources such as soil or earth crust, dust contamination, feed, drinking water etc. Drinking water may contribute about 40% Nacl, 7 - 30% Ca, and 20 - 40% Sulphur requirement of cattle daily. Contamination of herbage with dust/soil also contributes a high percentage of trace mineral requirements. Pulverized bone/shell and inorganic salts are the richest sources of minerals. Also Oyster shell, limestone, dicalcium phosphate and a variety of other sources are rich in Calcium and Phosphorus. In feed formulation, the macrominerals are supplied by bone-ash or bone meal, Oyster-shell or limestone and common salt. The microminerals are usually incorporated as a premix in which form they contain most of the trace minerals in the right proportions as required in the ration formulation for the particular class, age or sex of the animal.

Functions of Minerals

1. Act as constituents of skeletal structures (Ca, P, Mg, F, Si ni bones/teeth and P/S in muscle proteins).
2. Give rigidity and strength to the structure/framework of the body e.g. Ca, P.
3. Acts as soluble salts which help in controlling the composition of the fluid of body cells where they exists as electrolytes i.e. maintenance/regulation of colloidal state, osmotic pressure, membrane permeability/tissue irritability e.g. Mg, K are present in intracellular fluid while Na, Cl are found in extracellular fluid.
4. Helps in the maintenance of pH (acid-base balance) of the body. The physiological activity of the body operates within a narrow pH range of 7- 7.8. Fruits/vegetables contain basic ash containing Ca, Na, Fe/ Mg while cereal grains contain ash made up of Cl/ S. Citrus fruits contain citric acid and potassium. The citrates are neutralized in the body, leaving potassium which form an alkaline in the body (so it is basic).
5. Minerals are essential adjunt (Coenzyme) to many enzymes and protein such as haemoglobin (contains Fe) in enzyme catalyzed reactions. They are needed to activate phosphoreactions e.g. Mg^{2+}. They are components of metalloenzymes and hormones. Cobalt is a structural component of Vitamin B_{12}, while iodine is a component of thyroxine structure.

Minerals maintain their structure in every environment as they cannot be destroyed but can be bound to other substances that may limit their availability.

CHELATED COMPLEXES: The use of organic microminerals has increased due to reports of imporved feed efficiency, growth, reproduction and immune response. Chelation refers to a bonding between a metal ion (mineral) and ligand (protein or amino acid). It is a mixture of the mineral and organic compound i.e. a mineral complex. Complexes or coordination compounds are compounds containing a central metal atom or ion forming coordinate bond with various ions or molecules. These ions or molecules are referred to as ligand. Ligands are chelating agent which can be an organic or inorganic molecule or ion that coordinates a metal ion in more

than one position e.g. monodentate and polydentate ligands. The formation of mineral complexes helps to extend the bioavailability of minerals to animals. Chelated minerals is a way of presenting the essential trace minerals to animals in forms that are more readily absorbed and utilized and not subject to the same interactions commonly experienced with inorganic elemental forms. Organic chelates of minerals are the most important factors controlling trace mineral absorption. Organic micromineral products with the highest amount of insoluble protein is the best choice for ruminant feeds due to their non-susceptibility to ruminal microbial degradation and other reactions as are products with high protein solubilities. High dietary Molybdenum/ Copper in chelated form has an advantage over an inorganic form as it may escape the digestive system complexing among Molybdenum, Copper and Sulphur. Organic microminerals do not react with vitamins in the digestive tract as well as premixes. A ligand with a higher stability constant will displace a metal from a ligand with a lower stability constant. Zinc deficient lambs retained Zinc from Zinc-Methionine better than from Zinc-oxide while Zinc-Lysine has a more bioavailability source of Zinc compared to other Zinc sources.

METABOLISM OF CARBOHYDRATES, LIPIDS AND PROTEIN

Metabolism is a collection of chemical reactions that take place in living cells that either builds up or breakdown substances. There are two types of metabolism anabolism and catabolism. **Anabolism** is the building of complex organic molecules from simple ones in a biological system i.e. combining atoms or molecules to from larger compounds. Energy is usually consumed in anabolic reactions because some forms of energy are required to first break the old molecules before building up the complex ones e.g. formation of glycogen from glucose, protein from amino acids, fats/oil from fatty acids/glycerol, and photosynthesis in green plants. It supports the growth of new cells, maintenance of body tissues, the storage of energy for future use and the transformation of waste products from catabolism into less harmful products that removed from the body through the skin, kidneys, lungs and intestines.

Catabolism (destructive metabolism) is the breakdown of complex organic molecules into simple substances with the release of energy e.g. respiration, fermentation and digestion. It is the process that produces the energy required for all activities in the cells. It helps to breakdown carbohydrates and fats to release energy. It provides energy for anabolism, body heat, muscle contraction and movement. Though, catabolism and burning are used interchangeably because their reactants and products are identical CO_2 and H_2O, they are not the same. This is due to the fact that the body does not burn substances; although the estimation of maximum energy available for body use in substances is obtained form the heat of combustion of the material. $C_6H_{12}O_6 \rightarrow CO_2 + H_2O \blacktriangle H = -673kcal/mol$

$CH_3(CH_2)14COOH \rightarrow 16CO_2 + H_2O \blacktriangle H = -2400kcal/mol$

NB: 1 mole of fatty acids is almost 4 times as rich in energy as 1 mole of glucose. Almost half of the energy is lost as heat during catabolism; the remaining half is incorporated into high energy phosphates. Energy is fixed either by substrate level Phosphorylation or Oxiddative phosphorylation.

Carbohydrates

Carbohydrates are compounds made up of carbon, hydrogen and oxygen, with the name derived from the French "*hydrate de carbone*" (hydrated carbon). It was originally applied to neutral chemical compounds containing the elements carbon, hydrogen and oxygen, with the last two elements present in the same proportion as in water. Although many carbohydrates have the empirical formula $(CH_2O)n$ where n is 3 or more; the above definition is not strictly correct since some compounds with general properties of carbohydrate contain phosphorus, nitrogen or sulphur in addition to the elements carbon, hydrogen and oxygen. Moreover, some compounds e.g. deoxyribose ($C_5H_{10}O_4$) do not have hydrogen and oxygen in the same ratio as that in water. Carbohydrates are polyhydroxyl aldehydes or polyhydroxyl ketones (substances which yield aldehydes or ketones on hydrolysis) or their simple derivatives and any compound that may be hydrolyzed to these. They are the most widely distributed compounds in nature and constitute at least 70% of any animal feed.

Classification of carbohydrates: Carbohydrates are usually divided into two major groups the sugars and the non-sugars.

1. **Sugar carbohydrates:** They are generally restricted to carbohydrates containing less than ten saccharide residues; under this group are the **monosaccharides** (sugars with one saccharide unit) and **oligosaccharides** (sugars with two or ten saccharide units).The nature of a sugar molecule is determined by the type of functional group and the position of the side groups it is found. The orientation of the hydroxyl group on the penultimate C-atom is used to denote a simple sugar with letter D or L e.g. D or L -glucose. Structural formula of a sugar reveals little information on the nature or type of the sugar e.g. $C_3H_6O_3$ represents either of the triose sugars (glyceraldehyde an aldose or dihydroxyacetone a ketose). Sugars with aldehyde functional group are known as aldoses and are often prefix by aldo e.g. glyceraldehyde, aldopentoses (xylose/ribose), aldohexoses (glucose, mannose/galactose). While sugars with ketone functional groups are ketoses, denoted by the prefix keto e.g. dihydroxyacetone (DHA), ketopentoses (xylulose/ ribulose), and ketohexoses (fructose).Oligosaccharide (from Greek oligos, a few) is frequently used to include all sugars other than the monosaccharides (disaccharides e.g. sucrose, lactose, maltose/ cellobiose; trisaccharides e.g. raffinose/ kestose; tetrasaccharides e.g. Stachyose).
2. **Non-sugar carbohydrates:** These are carbohydrates with more than ten saccharide units and complex carbohydrates. They include the **polysaccharides** or glycans (polymers of monosaccharide units) and the **complex**

carbohydrates(glycolipids/ glycoproteins). Polysaccharides are classified into two groups - **homoglycans**, which contain only a single type of monosaccharide unit (e.g. arabinans, xylans, glucans{ starch, dextrins, glycogen/ cellulose}, fructans{inulin/ levan}, galactans, mannans/ glucosamines) and the **heteroglycans** which on hydrolysis yield mixtures of monosaccharides and derived products (e.g. pectic substances, hemicelluloses, exudates gums, acidic mucilages, hyaluronic acid/ chondroitin). The molecular weight of polysaccharides varies from as little as about 8000 in some plant fructans to as high as 100million in the amylopectin component of starch. Hydrolysis of these polymers to their constituent sugars can be affected by the action of either specific enzymes or acids.

Glycosides: If the hydrogen of the hydroxyl group attached to the anomeric carbon atom of glucose is replaced through esterification or condensation with an alcohol (including a sugar molecule) or a phenol, the derivative produced is called a glucoside (similarly galactose froms galactosides and fructose form fructosides). Oligosaccharides/ polysaccharides are classed as glycosides which yield sugars or sugar derivatives on hydrolysis. Some naturally occurring glycosides contain non-sugar residues e.g. nucleosides, which contains heterocyclic nitrogenous base.

Cyanogenetic glycosides release hydrogen cyanide (HCN) on hydrolysis which is toxic to animals. Though the glycoside itself is not toxic and must be hydrolyzed before poisoning occurs. The glycoside is easily broken down to its components by means of an enzyme which is usually present in plants e.g. if wet mashes or gruels containing feedstuffs such as Linseed, Java beans or Cassava (contain the cyanogenetic glycoside linamarin or phaseolunatin) is given to animals, it is advisable to boil them when mixing in order to inactivate any enzyme present. On hydrolysis linamarin yields glucose, acetone and HCN.

In the chemical assessment of food material, carbohydrate is expressed as Nitrogen Free Extract. This term measures the digestible portion of the food after the nitrogen, fat, fibre and ash are removed. This measure, though imprecise, gives a rough idea of the carbohydrate content and the nutritive value of the food. The fibre fraction is measured as crude and comprises cellulose, hemicelluloses, lignin and pectin.

Importance of carbohydrate to the body

1. It is a major store house of chemical energy for carrying out life processes.
2. It is a source of raw materials for chemical synthesis, e.g. milk is synthesized from galactose and glucose.
3. It is an essential component of genetic control of development/growth of living cells e.g. ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) both contains ribose sugar.
4. It is a supportive, structural components of plants e.g. cellulose, lignin/ hemicelluloses.
5. It has components that protects against infections in plants e.g. polyphenols, flavonoids, etc

Carbohydrate metabolism: Involves a series of enzymatically catalyzed reactions in which high carbohydrate units are broken down to smaller units usually by the introduction of high phosphate bonds. Simple sugar such as glucose, fructose, mannose, sucrose and galactose are utilized by living forms as food. The energy contained in them being made available via anaerobic and aerobic processes. Complete oxidation of glucose occurs in three main stages Glycolysis, Pyruvate oxidation and Acetyl-CoA oxidation. The anaerobic process by which glucose is degraded to two molecules of lactic acid is commonly referred to as **glycolysis**. Glycolysis occurs in most microbes, and in cells of most of the higher plants and animals. This is essentially a mechanism which ensures the recovery of some of the energy in glucose molecule as ATP (Adenosine triphosphate). Alcoholic fermentation is a process by which yeast convert glucose into ethanol and CO_2. This process is essentially analogous to the glycolytic sequence up to the pyruvic acid level (the terminal products being ethanol and CO_2 while lactic acid represents the terminal products of glycolysis).

The various pathways of breakdown of simple sugar include the -

1. **Glycolytic** (Embden Meyerhof) **Pathway**
2. **Pentose PO_4 Pathway** (Hexose mono-PO_4 shunt)
3. **Entner-Doudoroff Pathway**
4. **Phospho-ketolase Pathway**

Glycolytic (Embden Meyerhof) **Pathway:** The most important function of carbohydrate is the supply of energy to the body, when they are burnt to carbondioxide and water. The major material for carbohydrate metabolism supplied to the blood from the intestine are the monosaccharides that are presented to the cell, but the major one utilized is glucose while others are converted through one reaction or the other to glucose before utilization.

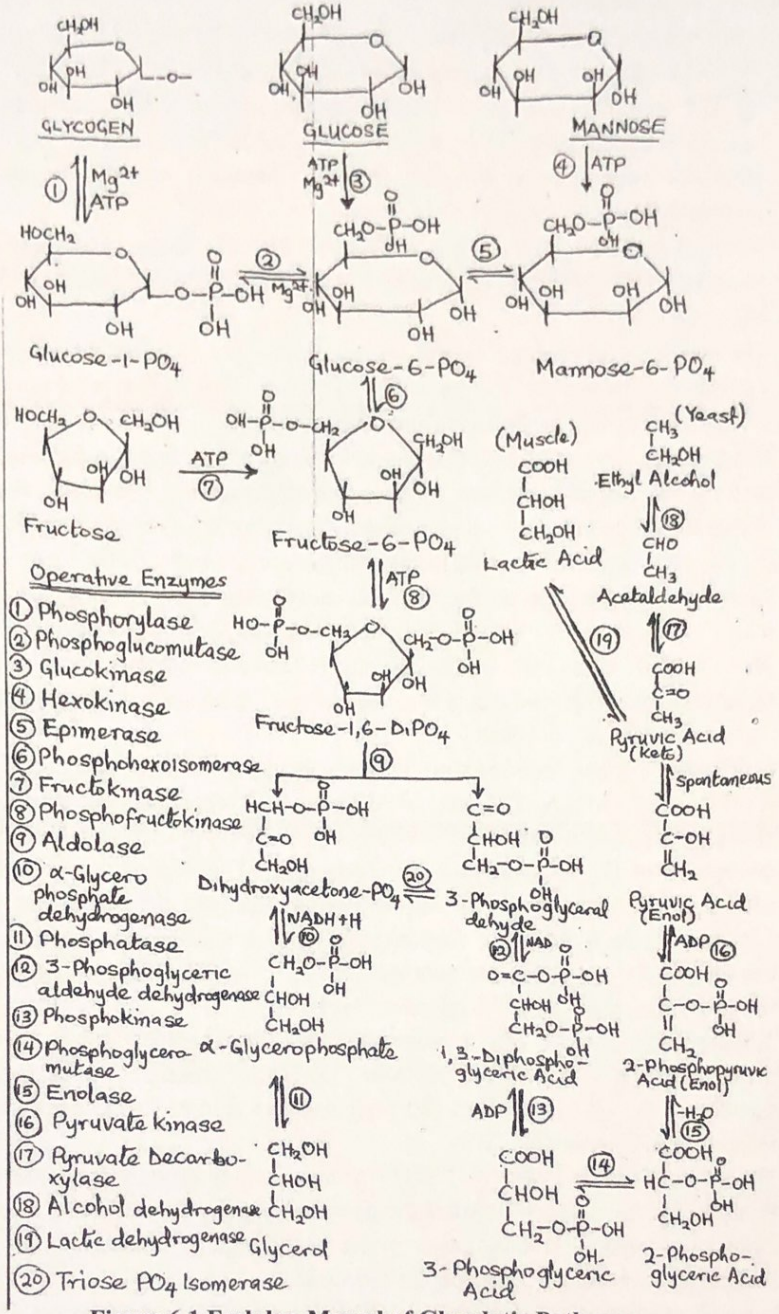


Figure 6.1 Embden-Meyerhof Glycolytic Pathway

Steps of the reactions in glycolysis

(1) Glucose is the primary monosaccharide utilized by the cell during glycolysis. The initial step in the utilization of Glucose in glycolysis is the phosphorylation by ATP to yield Glucose -6- phosphate. The enzyme which catalyzes this reaction is Glucokinase (3). It catalyzes the transfer of phosphate from ATP (i.e. from not only glucose, but also fructose, mannose, glucosamine and 2-deoxyglucose).

(2) The next reaction in glycolysis is the isomerization of Glucose -6- phosphate to Fructose -6- phosphate in the presence of the enzyme Phosphohexoisomerase (6).

(3) The conversion of Fructose -6- phosphate to Fructose -1,6- diphosphate involves the transfer of phosphate unit from ATP to Fructose -6-phosphate in the presence of Mg^{2+} and the enzyme Phosphofructokinase (8).

(4) The next reaction involves the cleavage or breaking of Fructose -1,6-diphosphate to form two triose-phosphate sugars Dihydroxyacetone phosphate and 3-Phosphoglyceraldehyde (or D-glyeraldehyde-3-phosphate) in the presence of the enzyme Aldolase (9). This isomerization reaction between the two triose-phosphates ensures that all the chemical energy in glucose are obtained. The main path continues with 3-Phosphoglyceraldehyde (Glyceraldehyde -3-phosphate). If cells were unable to convert Dihydroxyacetone phosphate to Glyceraldehyde-3-phosphate, half of the glucose molecules would accumulate in the cell as Ketose phosphate.

(5) Oxidative phosphorylation occurs during which Niacin Adenine dinucleotide ion (NAD^+) is reduced to NADH; an aldehyde group in Glyceraldehyde-3-phosphate is oxidized to carbonyl state on to which an inorganic phosphate is attached. The conversion of Glyceraldehyde-3-phosphate to 1,3-Diphosphoglyceric acid is catalyzed by the enzyme 3-Phosphoglyceric aldehyde dehydrogenase i.e. Glyceraldehyde-3-phosphate dehydrogenase (12).1,3-Diphosphoglyceric acid has a higher PO_4 group transfer potential than ATP; it gives a PO_4 group to ADP; the initial investment of ATP is refunded plus 1 ATP.

(6) 1,3-Diphosphoglyceric acid is converted to 3-Phosphoglyceric acid in the presence of the enzyme Phosphokinase (13). The reaction accomplishes the transfer of the phosphate from the acylphosphate formed in the preceeding reaction to ADP to form the ATP.

(7) The enzyme Phosphoglyceromutase (14) catalyses the interconversion of the two Phosphoglyceric acids. It transfers the phosphoryl group PO_4 from one carbon atom to a second carbon atom of the same organic compound i.e. 3-Phosphoglyceric acid to 2-Phosphoglyceric acid.

(8) The next reaction in the degradation of glucose involves the dehydration of 2-Phosphoglyceric acid to produce 2-Phosphopyruvic acid (Enol), the enzyme

involved is Enolase (15). The dehydration of 2-Phosphoglyceric acid converts a low energy PO_4 into the highest energy PO_4 in all metabolic reactions i.e. the PO_4 ester of the enol form of pyruvate.

(9) Pyruvic acid is formed from 2-Phosphopyruvic acid (Enol) through the catalyzing activity of Pyruvate kinase (16). It involves the transfer of phosphate from 2-Phosphopyruvic acid (Enol) to ADP to produce ATP and Pyruvic acid; the loss of a PO_4 group from 2-Phosphopyruvic acid (Enol) creates an instability which drives the reaction.

(10) Pyruvic acid can either be converted to Lactic acid or enters the TCA cycle in the presence of Oxygen as Acetyl CoA to restore the reduced enzyme with NADH at step 5; NADH can pass off H to the respiratory chain. The enzyme responsible for the production of Lactic acid is Lactic-dehydrogenase (19).

Glycolysis must shut down unless the reduced NADH enzyme at step 5 can change back to NAD^+. The change in the absence of Oxygen and the operation of the respiratory chain occurs by the reduction of pyruvic acid to Lactic acid; hence Lactic acid is the end-product of glycolysis under anaerobic condition.

Summary of ATP production from glycolysis

- 2moles of ATP are used in the initial phosphorylation of steps 1 and 3
- Fructose 1,6- diphosphate breaks down to give 2moles of GHD -3-phosphate
- Subsequently an NAD^+ linked dehydrogenation at step 5 is supposed to yield 3 moles of ATP but yields 2moles ATP instead (the need for Glycerol-phosphate shuttle). As a result of the indirect connection to the electron transport at FAD, only 2ATP are made per NAD^+ used in step 5
- 1mole of ATP is produced directly at each of steps 6 and 9
- 8moles of ATP are thus produced from 1mole of glucose; 2moles of ATP are used up giving a net production of 6moles of ATP per mole of glucose.

$C_6H_{12}O_6 + 2NAD^+ + 2ADP + 2Pi \rightarrow 2\ (CH_3(C=O)\ COOH + 2ATP + 2NADH + 2H^+$

The Tricarboxylic Acid Cycle (TCA): The metabolic fate of pyruvate which is aerobically broken down to CO_2, H_2O and ATP is dealt with in the TCA (Tri-carboxylic acid), Citric acid or Krebb cycle. The TCA cycle represents the aerobic phase of carbohydrate metabolism. It is a cyclic process whereby the pyruvate produced during the glycolytic phase is degraded to CO_2 and water with the production of energy in form of ATP. The first phase is the conversion of 3-carbon pyruvate C_3 to a 2-carbon unit C_2 and cabondioxide. Apart from the production of energy, the TCA cycle also produce other carbon intermediates for other synthetic reactions particularly in the synthesis of amino acids such as Aspartic and Glutamic acids.

Under aerobic conditions the end-product of glycolysis is pyruvic acid. Before pyruvic acid enters the TCA cycle it is first converted to Acetyl Coenzyme A (Acetyl-CoA) involving a series of enzymes and co-factors. Acetyl CoA formation is the link between glycolysis and the TCA cycle. It is a process of oxidative decarboxylation and is the most important link to the electron transport chain where most of the ATP needed for energy reactions is produced. The reaction requiring Magnessium and about 5 co-factors such as TPP (Thiamine pyrophosphate, TPP), CoASH, FAD (Flavin adenine dinucleotide), NAD (Niacine adenine dinucleotide) and Lipoic acid.

Pyruvic acid + TPP + NAD^+ → Acetyl CoA + NADH + H^+ + CO_2

The reduced form, NADH, initiates the respiratory chain to regenerate NAD^+. The accumulation of lactic acid in an overworked muscle may be converted to Acetyl CoA and subsequently metabolized via the TCA cycle. The TCA cycle produce more ATP than the glycolytic cycle.

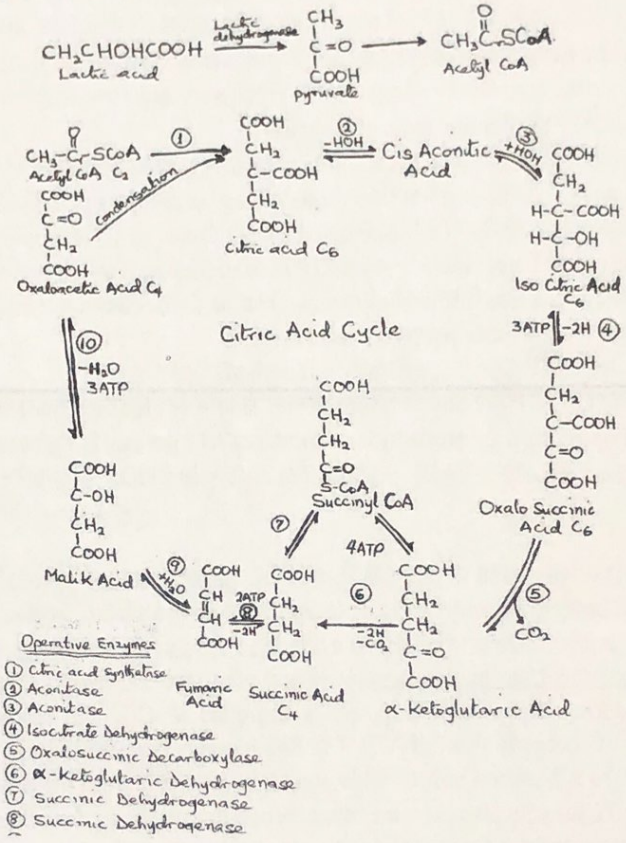


Figure 6.2 The Tricarboxylic acid cycle

Reactions of the TCA cycle

- The initiating step of the TCA cycle occurs when a four carbon compound (oxaloacetic acid) condenses with acetyl CoA (2 carbons) to form citric acid (6 carbons). The source of acetyl CoA is glycolysis or the fatty-acid spiral (lipids).
- As the reaction proceeds, 2 carbons converted into two CO_2 molecules at step 5 and 6.
- The cycle has a series of oxidation reactions which are accompanied by the loss of hydrogen and electrons at four specific places.
- These oxidations are connected to the electron transport chain where many ATP are produced.
- Reactions 4, 6 and 10 involve oxidations of an alcohol group to a ketone group with the coenzyme NAD^+, which result in the removal of 2 hydrogen and 2 electrons.
- NAD^+ is the entry point into electron transport chain (starting with NAD^+, production of 3 ATP results from each use of the electron transport chain).

Production of ATP from one turn of the Tricarboxylic Acid Cycle

ATP from NAD^+ through ETC	**ATP from FAD through ETC**
Steps 4 = NAD^+ = 3 ATP	Step 8 oxidation involving coenzyme FAD
Steps 6 = NAD^+ = 3 ATP	Since FAD is part of the second enzyme complex, only 2 ATP are made with the electron transport chain. Step 8 = FAD = 2 ATP
Steps 10 = NAD^+ = 3 ATP	In TCA cycle, there is only one reaction which directly produces an ATP and this is at Step 7 = 1 ATP
ATP from NAD^+ = 9 ATP	**ATP from FAD = 3 ATP**

Net ATP production = 9 + 3 = 12 ATP

Summary of ATP production from oxidation of Pyruvic acid in TCA cycle

Step	**Reaction**	**H - H**	**ATP**
1	Pyruvate ? Acetyl-CoA	NAD^+	3
4	Isocitrate ? Oxaloacetate	$NADP^+$	3
6	Ketoglutarate ? Succinyl-CoA	NAD^+	3
7	Succinyl-CoA ? Succinate	-	1
8	Succinate ? Fumarate	FAD^+	2
10	Malate ? Oxaloacetate	FAD^+	3
	Total ATP		**15**

A total of 36 phosphate bonds are formed when 1 mole of glucose is oxidized via the TCA cycle. Each phosphate bonds yields approximately 12.5Kcal energy when broken by hydrolysis under physiological conditions i.e. a mole of glucose when oxidized would yield a total of 450Kcal of energy in a utilizable form. Total free energy of glucose at 37°C is 703Kcal/mole, therefore the efficiency of free energy capture by the body is 450/703 x 100 = 64.01%.

Functions of the TCA cycle

1. The primary functions of the TCA cycle is the production of energy in form of ATP
2. The TCA cycle also produces intermediates for other synthetic reactions
3. It provides an opportunity for the complete oxidation of pyruvic acid to CO_2 and water
4. The TCA cycle also provide a ketone acid found in plants particularly the citrus plant
5. The TCA cycle utilizes fatty acid and amino acid for energy production. This implies that there is an interrelationship between Carbohydrate, Fat and Protein metabolism.

Energy Source to the Cell

Glucose metabolism facilitates ATP synthesis in all tissues. Glucose is the primary source of energy in the red blood cell, white blood cell, cells of the eye, kidney medulla, brain, intestines and skin. The rate of glucose absorption is high immediately after a meal. Glucose utilization in the body cells would be increase to maintain normal blood glucose levels. The liver plays a major role in the control and integration of glucose metabolism among tissues. The concentration of glucose in whole blood is fairly constant at a value known as the Blood Sugar Level.

Glucose cannot be made from fatty acids but fat or protein can also be a source of energy. Glucose can be made from most amino acids (but not from Leucine),
Short chain fatty-acids (e.g. proprionate) or glycerol.

Variation in Blood Sugar Level

Hypoglycaemia is the condition where the concentration of glucose in the blood is below the normal fasting level. Hypoglycaemia may starve the brain of energy as it does not store glucose. **Hyperglycaemia** occurs when the concentration of blood glucose rises above the fasting level. The concentration of glucose in the blood above which the kidney begins to transfer excess glucose to the urine is called the renal threshold for glucose.

Factors that raise blood glucose Concentration	Factors that lower blood glucose concentration
• Hunger • Glucose absorption in gut	• Satiety • Glucose diffusion in extracellular fluid (ECF)
• Hepatic glycogenolysis - Adrenaline - Glucagon	• Muscular exercise
• Gluconeogenesis in liver	• Insulin - Increases glucose oxidation - Increases glycogen deposition - Increases lipogenesis - Decreases gluconeogenesis
• Insulin antagonist - Growth hormone - Cortisol • Insulin destroying enzymes	

Blood sugar level at any given time represents a balance between those physiological processes adding glucose to the blood and those removing glucose from the blood. The two processes proceed simultaneously and their relative degree at any given time determines blood glucose levels during starvation, physical exercise, and stress and immediately after a meal. A high blood sugar can damage eye lens and kidney tissues. Low blood glucose concentration will equally cause damage to the brain and eventually death. Usually and in normal subjects, when the blood becomes loaded with glucose after meals a part of it is converted to liver glycogen in the process referred to as **glycogenesis**. Glycogenesis usually involves a host of enzymes such as Hexokinase, Phosphoglucomutase, Glycogen synthetase, Phosphorylase and Amylo-1,4 → 1,6-transglucosidase.

The chief variations or changes in blood sugar level in normal subjects are usually the results in variation of absorption rate from intestine e.g. absorption from the intestine is highest after meals and lowest just before meals. As the blood glucose level rises after meals (alimentary hyperglycaemia) the pancreas is stimulated to secrete more insulin which causes the rates of tissue oxidation and of glycogen/fat formation to increase, thus tending to lower blood sugar level.

When the rate of sugar absorption from the intestine no longer equals tissue demand for glucose, blood sugar level begins to fall towards hypoglycaemic level. In such circumstances the liver increases its rate of glucose addition to the blood by increasing the rate of glycogen breakdown to glucose. Hypoglycaemia usually stimulates the adrenal-medulla to increase its secretion of the hormone epinephrine which increases the rate of breakdown of liver glycogen to glucose in a process called

glycogenolysis. Glucose -6- phosphate is produced by the action of inorganic phosphate and not ATP. Hence, energy production from glycogen could be slightly more efficient than when glucose is the source. Hypoglycaemia in the absence of absorption from the gut stimulates an increase in the production of the hormone epinephrine by the adrenal medulla which stimulates the breakdown of glycogen in muscles and to a lesser extent, the liver. Muscular activity quickly uses stored ATP as the source of energy, hence the need for additional energy.

Glycolysis at the early part of the muscular activity, produces pyruvic acid which is then converted into acetyl-CoA which is metabolized in the TCA cycle ot make ATP using the electron transport chain (ETC). As the muscular activity continues, the availability of Oxygen for use at the end of the electron transport chain becomes a limiting factor after the cells have exhausted the Oxygen available to the muscle. The TCA cycle is inhibited in the absence of Oxygen and pyruvic acid accumulates. Accumulation of lactic acid from pyruvic acid which occurs eventually is the final limiting factor in continued muscular activity. Lactic acid produces muscular pain/cramps that could force discontinuation of the activity. Lactic acid diffuses out of the muscle cells into blood where it enters the liver at the onset of pain and after muscular activity is stopped. The process of recycling lactic acid is referred to as the Cori cycle. In order for most of the lactic acid to be converted to glucose, a quantity of the acid must be converted to pyruvic acid and then to acetyl-CoA. The TCA cycle/electron transport chain must also provide ATP to "fuel" the gluconeogenesis of the remainder of the lactic acid to glucose.

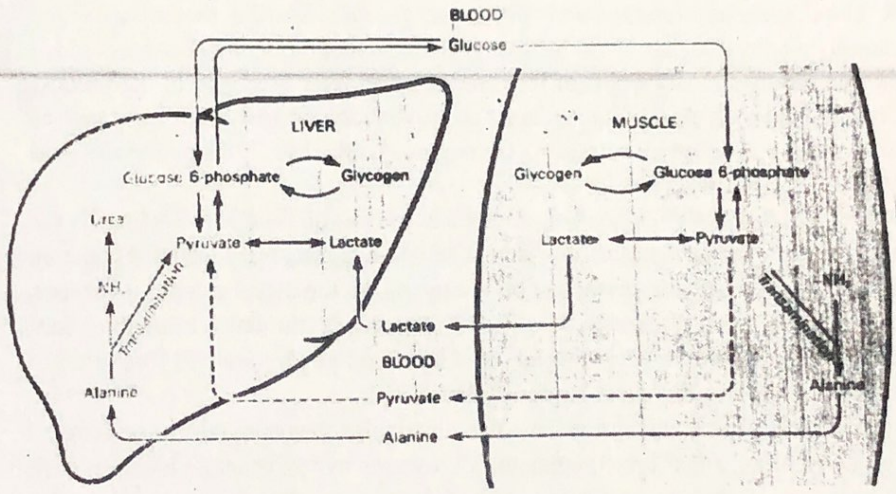


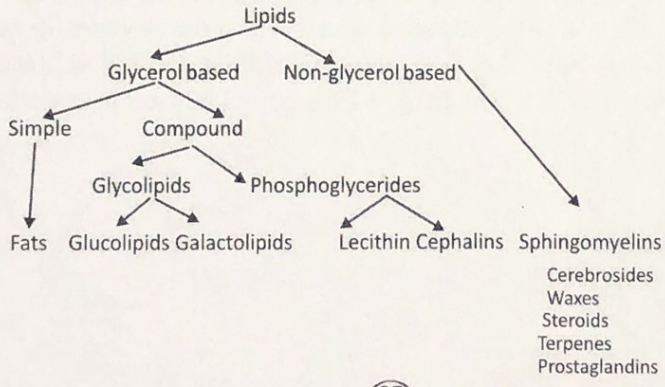
Figure 6.3 Lactic acid (Cori) Cycle

Hypoglycaemic conditions especially as occurs during starvations when supply of food from the intestine is cut-off and glucose available from the liver glycogen is rapidly used up. The supply of blood glucose then depends on the process of **gluconeogenesis** whereby glucose is synthesized from tissue amino acids and other non-carbohydrate sources such as lactates, glycerol, etc. The Islets cell of the pancreas produces the hormone insulin which enhances the utilization of both of the glucose in the tissue. Failure to produce the insulin results to the disease of diabetes. Gluconeogenesis processes from amino-acid is usually increased in diabetic conditions, this result in increased blood sugar during which the kidney threshold (KT) may be exceeded bringing about glucosuria. Although, insulin deficiency causes hyperglycaemia, excessive amount would cause rapid utilization of blood glucose which could exceed the rate of glucose addition to the blood. Such a situation could bring about hypoglycaemia and insulin shock unless extra carbohydrate is provided.

LIPIDS

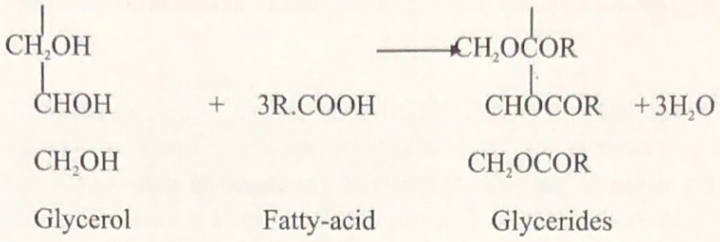
Lipids are organic compounds that are insoluble in water but soluble in common organic solvents such as alcohol, chloroform, benzene and ether. Lipids have a high percentage of carbon atoms in their molecules and are found in plant (as oil in fruits/seeds) and animal tissues (as fats). Fats and oil have similar general structures and chemical properties but differ in physical properties. Oils are liquid at room temperature while fats are solid. Fat and oil are both found in plants and animals but oil is more abundant in plants than in animals.Lipids act as electron carriers, as substrate carriers in enzymatic reactions, as components of biological membranes and as stores of energy.

Classification of lipids - Lipids can be classified as either glycerol based or non-glycerol based lipids or on another hand as neutral lipids or phospholipids. Examples of neutral lipids are acyl-glycerol (fats/oils), hydrocarbons and cholesterol/cholesterol esters; while phospholipids include glycerol, choline, inositol, ethanolamine, sphingomyelin and phosphatidic acid.



Lipids in plants could either be structural lipids or storage lipids. The constituents of various membranes and protective surface layers are made up of lipids, 7% of the dry matter of leaves of higher plants are lipids. Lipids make up the membranes of mitochondria, endoplasmic reticulum and plasma membranes which are mainly glycolipids (40 - 50%) and phospholipids. The protective surface layer lipids are mainly waxes with little long chain hydrocarbons, fatty acids/cutin. Animal tissues structural lipids are majorly made up of phospholipids (0.5 - 1.0% in muscle/adipose tissue and 2 - 3% in liver). The most important non-glyceride, neutral, lipid fraction of animal tissue is made up of cholesterol and its esters (0.06 - 0.09% in muscle/adipose tissue).

Fats are esters of fatty-acids with the trihydric alcohol glycerol called glycerides or acylglycerols



The R can be the same or different fatty-acids which can be saturated or unsaturated. Fatty-acids are said to be **saturated** when they do not contain double bond between hydrogen and carbon and **unsaturated** when they contain a varying number of double bonds (mono-unsaturated one double bond; polyunsaturated - more than one double bonds) e.g. the essential fatty-acids- Linoleic (high in groundnut/soybean), Linolenic and Arachidonic are unsaturated while saturated fatty-acids are high in Palmitic (hexadecanoic- $C_{15}H_{31}COOH$) and Stearic (octadecanoic- $C_{17}H_{35}COOH$)acid (high in butterfat, Lard/Beef tallow). Saturated fats generally have higher melting points and are more stable to oxidation than unsaturated fats. Fats from animal origin are generally more saturated than fats of vegetable origin. Fatty acids can also be described as short chain or volatile fatty acids (has 2- 6carbon atoms), medium chain (8 -12 carbon atoms) or long chain (14-24 carbon atoms).

Table 6.1 Differences between saturated and unsaturated fatty acids

Saturated fatty acid	Unsaturated fatty acid
• Long chain carboxylic acid	• Have one or more double bonds between carbon atoms
• Have no double bonds	• Can be converted to the saturated Forms through hydrogenation
• Saturated with hydrogen and cannot accept more hydrogen atom	• Palmitoleic,Oleic, linoleic, linolenic, and arachidonic acids.
• Acetic acid, propionic acid, butyric acid, caproic acid, caprylic acid, capric acid, lauric acid, myristic acid, Palmitic, and stearic acid	

Oxidised fats are rancid and impart undesirable flavor to feeds and also destroy some fat soluble vitamins.

Importance of lipids

1. Supply feed energy
2. Impart flavor/taste to feed
3. Act as solvents of fat-soluble vitamins
4. Control dustiness in feed mixing
5. Function as heat insulators under the skin
6. Promote utilization of carbohydrates/proteins
7. Act as shock absorbers to visceral organs
8. Promote the transportation of fat soluble vitamins in the body
9. Fats are sources of essential fatty acids (linoleic, linolenic and arachidonic acid) that are necessary for growth/maintenance of skin conditions.

Lipid metabolism: Fatty acids derived from the hydrolysis of triacylglycerol may be the primary source of energy as fatty acids are stored in adipose tissues as triacylglycerol. They are the most concentrated form in which energy is stored with a calorific value of 38.9KJ/g which is twice higher than that of carbohydrate/protein. They have higher proportion of hydrogen ($C_xH_{2y}O_y$). They provide more metabolic water upon oxidation than carbohydrate or protein. Lipid reserves in fat depots can maintain the human body function without food for 30- 40days with sufficient water. In the lumen of the small intestine, triacylglycerols are degraded to free-fatty acids and monoacylglycerol in the presence of conjugated bile acids and pancreatic lipase. The free fatty acids, monoacylglycerols/triacylglycerols are absorbed as micelles (tiny globules of fat/bile salts) into the epithelia cells of the small intestine

(enterocytes) leaving the bile salts behind in the lumen of the bowel. The free fatty-acids undergo oxidation in the liver to form acetyl-CoA which goes into the TCA cycle. All the enzymes involved in the oxidation process are localized in the inner membrane/matrix of liver and other tissue mitochondria. 1mol ATP is required to activate a fatty acid for its complete degradation to acetyl-CoA regardless of the number of carbon atoms in its hydrocarbon chain. The five enzymes required in the process are-

i. Acyl-CoA synthetase for the formation of acyl-CoA
ii. Fatty-acid-CoA dehydrogenase for the dehydrogenation of acyl-CoA
iii. Enoyl-CoA hydrase for the hydration of unsaturated acyl-CoA
iv. Hydroxyacyl-CoA dehydrogenase for the oxidation of hydroxyacyl-CoA
v. Ketoacyl-CoA thiolase for the splitting (thiolyses) of ketoacyl-CoA

The various processes involved in the oxidation of fatty acid is shown in Figure 6.4

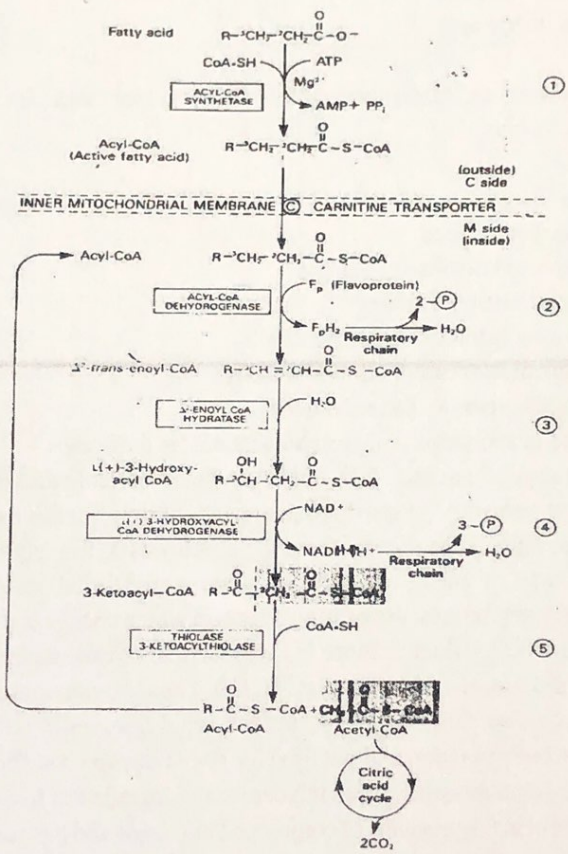


Figure 6.4 Oxidation of Fatty acids

1. **Conversion of Fatty acids to Acyl-CoA** -As in the metabolism of glucose, fatty acids must first be converted in a reaction with ATP to an active intermediate (acyl-CoA) before it can react with the enzyme (acyl-CoA synthetase found in endoplasmic reticulum/mitochondria) responsible for their further metabolism. This is the only stage that requires energy from ATP in the degradation of fatty acid to acyl-CoA.
2. **Dehydrogenation of Acyl-CoA to trans-enoyl-CoA** -Removal of two hydrogen atom from the 2(□) and 3(ß) carbon atoms of the acyl-CoA to form trans- enoyl-CoA. The reaction is catalyzed by acyl-CoA dehydrogenase in the presence of a coenzyme flavoprotein which contains FAD as prosthetic group.
3. **Hydration of unsaturated acyl-CoA to hydroxyacyl-CoA** - Water is added to saturate the double bond and form 3-hydroxyacyl-CoA, catalyzed by enoyl-CoA hydratase.
4. **Oxidation of hydroxyacyl-CoA to ketoacyl-CoA** - The 3-hydroxyacyl-CoA undergoes further dehydrogenation on the 3-carbon to form 3-ketoacyl-CoA in the presence of 3-hydroxyacyl-CoA dehydrogenase. NAD coenzyme is involved in the dehydrogenation.
5. **Thiolyses of ketoacyl-CoA to acetyl-CoA and acyl-CoA derivatives** - Finally, the 3-ketoacyl CoA is split at the 2, 3-position by thiolase enzyme which catalyzes the thiolytic cleavage involving another molecule of CoA. The products of this reaction are acetyl-CoA and an acyl-CoA derivative containing 2-carbons less than the original acyl-CoA molecule that underwent oxidation. The acyl-CoA formed in the cleavage reaction re-enters the oxidative pathway at reaction 2. The acetyl-CoA formed can be oxidized to CO_2 and water via the TCA cycle to complete the oxidation of fatty acids.

Propionic acid catabolism: Propionic acid is produced in the rumen along with acetic and butyric acid during the fermentation of carbohydrates. Its catabolism involves the following steps-

1. Conversion of propionate to propionyl CoA
2. Formation of methylmalonyl CoA through the combination of CO_2 with propionyl CoA in the presence of ATP
3. Changing of methylmalonyl CoA to succinyl CoA
4. Succinyl CoA enters the TCA cycle and is changed to oxaloactetate with the production of 6 mol ATP
5. Oxaloacetate in the presence of ATP yields phosphopyruvate and CO_2
6. Phosphopyruvate is changed to acetyl CoA which is then oxidized via the TCA cycle.

A net production of 18mol ATP (6 + 12) from ADP per mole of propionate oxidized is obtained with each yielding 12.5Kcal of energy on hydrolysis. Normally, propionate produced in the rumen is transported to the liver where it is changed to glucose which is then used as a source of ATP. The yield of ATP is again 18mol per molecule of propionate oxidized.

Ketone bodies: These are ß - hydroxybutyrate, aceto-acetate and acetone. Ketone bodies are formed from butyric acid, one of the three volatile fatty acids (acetic acid, propionic acid and butyric acid) produced by rumen microorganisms. Ketone bodies are also formed in the liver and oxidized in the skeletal/heart muscle and the renal cortex. The brain can adapt to the use of ketone bodies under starvation.

CH_3COCH_3	CH_3COCH_2COO	$CH_3CHOHCH_2COO$
Acetone	Acetoacetate	D ß-hydroxybutyrate

Ketosis is a physiological, condition in which higher than normal concentration of ketone bodies are found in the blood. Ketosis occurs whenever there are high rates of fatty acid oxidation in the liver, particularly when there is an associated deficiency of carbohydrate. This occurs under high-fat diets, and in starvation, diabetes mellitus, ketosis of lactating cattle, and pregnancy toxemia (ketosis) of sheep. Concentration of ketone bodies in well fed animals rarely exceeds 1mg/dl.

PROTEIN

Proteins are complex organic nitrogen bearing compounds of high molecular weight. In similarity to carbohydrate and fats, they contain Carbon, Hydrogen and Oxygen, but in addition they all contain Nitrogen and generally Sulphur or Phosphorus. Every protein contains nitrogen but not all nitrogen compounds are proteins. The true proteins comprise units of amino acids joined together in chain by peptide bonds. Amino acids are produced when proteins are hydrolyzed by enzymes, acids or alkalis. Although over 200 aminoacids have been isolated from biological materials, only 20 of these are commonly found as components of proteins. Structurally an amino acid consists of a basic amino group ($-NH_2$) and an acidic carboxylic group (-COOH) with a side chain (-R). Most amino acids occurring naturally in proteins are of the □-type, having the amino group attached to the carbon atom adjacent to the carboxyl group.

$$\begin{array}{c} NH_2 \\ R-C-H \\ \\ COOH \end{array}$$

The exception is Proline which has an imino (NH) instead of an amino group. The nature of the "R" group, which is referred to as the side chain, is different in different amino acids. It may simply be a hydrogen atom (e.g. Glycine), or a more complex radical containing e.g. a phenyl group

Plants and many microorganisms are able to synthesize proteins from simple nitrogenous compounds such as nitrates. But unlike plants, animals cannot synthesize the amino group, and in order to build-up body proteins they must have a

synthesize the amino group, and in order to build-up body proteins they must have a dietary source of amino acids. Certain amino acids may be formed in the animal's body through the process of transamination (a change of one amino from one form to another) while others are indispensable. Direct amination may take place as in the case of ?-ketoglutarate which yields glutamate, which undergoes further amination to give glutamine. But more importantly may undergo transamination reactions with various keto-acids to give amino acids such as alanine, asparagine and serine.

Indispensable amino acids are amino acids that cannot be synthesized within the body but must be supplied in the animals diet i.e. they are not synthesized in sufficient speed to satisfy the needs of the body. All the twenty amino acids normally found in the body are physiological essentials, ten are dietary essentials. Though the list of indispensable amino acids could vary from animal to animal, the ten dietary essential (indispensable) amino acids required for growth in rats are Methionine, Phenylalanine, Valine, Isoleucine, Leucine, Lysine, Arginine, Threonine, Tryptophan and Histidine (MP VILLATTH). In addition to the above ten essential amino in acids in rats, chicks requires a dietary source of Glycine (MP VILLATTH G) while the essential amino acids in Pig is similar to that of rats with the exception of Arginine and Histidine which can be synthesized by the pig (MP VILLTT). Ruminants on the other hand can synthesize all the 20 amino acids in its body with the help of the microorganisms in its rumen. The rumen microbes can utilize ammonia (NH_3) in the presence of adequate energy to produce amino acids in the absence of dietary source. However, maximum growth rate/milk production cannot be achieved without a supply of dietary amino acids. Rabbits, guinea pigs and horses harbor some microbes in the caecum that synthesize amino acids but the absorption of such amino acids is limited unless the animals practice coprophagy (eating of its faeces) regularly. Corpophagy in the horse is only occasional.

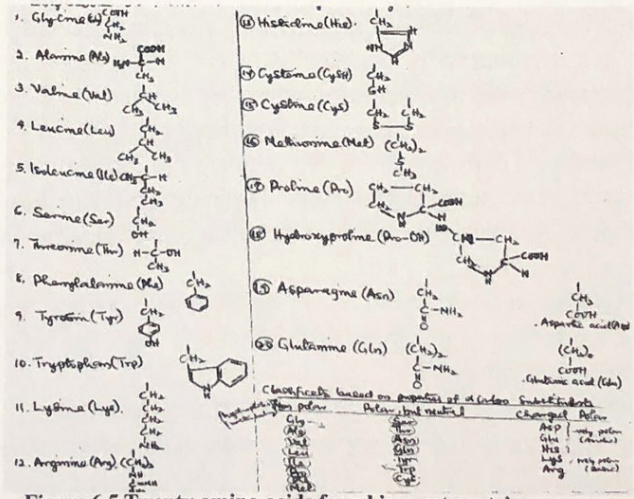


Figure 6.5 Twenty amino acids found in most proteins

Importance of protein to the animal body

- Proteins serve as building blocks of cells/tissues
- They help fight infections e.g. Antibodies
- They catalyze biochemical reaction necessary for metabolic activities e.g. Enzymes
- They regulate biochemical reactions e.g. Hormones
- Proteins transport oxygen to cells e.g haemoglobin
- Proteins are essential for body structure i.e muscles/tendons
- They are necessary for growth of cells/tissue replacement/repair of worn out tissues
- Helps in transmission of messages from parents to offspring e.g. deoxyribonucleic acid (DNA)
- Protein in excess of body requirements are used to supply energy through deamination or build reserves of glucose, glycogen,or lipids.

Classification of protein: Classification of proteins is based on its composition and solubility. Proteins are classified as either **simple protein** which yields only amino acids on hydrolysis or **conjugated proteins** which yield amino acids plus non-protein prosthetic groups.

Protein slightly associated with a nucleic acid is called a **nucleoprotein** (e.g. thymonucleic acid in thyroid gland); Protein slightly associated with lipid (usually phospholipid) is called a **lipoprotein**; **Phosphoproteins** contain covalently bound phosphate groups (e.g. casinogen) and **glycoproteins** contain varying amounts of carbohydrate bound to the polypeptide chain e.g. mucin (saliva/fluids). There are large numbers of **metalloproteins** which have ions such as Cu^{2+} or Zn^{2+} associated with them, and **chromoproteins** which contain coloured heme or flavin prosthetic groups e.g. haemoglobin/ myoglobin.

Derived proteins are produced by the reaction of acid alkali and enzymes. Primary derived protein is produced by denaturation (over heating) and is insoluble in all reagents. Secondary derived protein are produced by hydrolysis, soluble in water but not coagulated by heat e.g. protease, peptin, peptides, etc.

Myofibril(bundle of fibres contained in a muscle fibre formed from filaments of contractile proteins i.e. actin, myosin, tropomyosin, troponin) are insoluble protein meant for rigidity/gelatinized on oxidation while **Sarcoplasmic proteins** are storage proteins e.g. albumin/blood.

Glucogenic amino-acid are amino acids that could be converted to glucose after deamination while **Ketogenic amino acids** are amino aicds that form acetyl CoA, fatty acid after deamination.

Aromatic amino acids are amino acids with a benzene structure e.g. Phenylalanine, Proline and Arginine, unlike the **aliphatic amino acids** which does not have a benzene structure.

- Aromatic/heterocyclic amino acids e.g. Tryptophan, Proline, Phenylalanine
- Basic amino acids e.g. Lysine, Histidine and Arginine
- Mono amino dicarboxylic acid/ amine derivatives e.g. Aspartate and Glutamine
- Sulphur amino acid e.g. Methionine and Cysteine
- Monobasic monocarboxylic acid e.g. Glycine, Serine, Alanine, Threonine, Leucine and Isoleucine
- Limiting amino acids

Properties of protein

1. Precipitation - Soluble proteins can be precipitated with salt solutions.
2. Amphoteric reactions - Proteins act like amphoteric compounds due to the presence of COOH and NH_2 groups on terminal and side chain amino acids.
3. Denaturation- It is a non-proteolytic change of the secondary/tertiary structures of protein from its normal or native state to a more distorted arrangement. Proteins can be denatured by heat, acids or bases and an 8M urea can be used to bring about a reversible protein denaturation. Denaturation changes the physical, chemical and biological properties of a protein and may be reversible or irreversible.
4. Hydrolysis of protein - Proteins/polypeptides can be hydrolyzed with enzyme, acids or alkali to yield its constituent amino acids and the non-protein units.

Properties of Amino acids

Physical properties- they are quite soluble in water and have high melting point. They are amphoteric (basic/acidic properties) compound because of the presence of the amino NH_2 and the carboxyl COOH group. Molecules such as these with basic and acidic groups may exist as uncharged molecules or as dipolar ions with opposite ionic charges, or as a mixture of these. In aqueous solution it exists as dipolar or *Zwitter* ions (*Zwitter* - hermaphrodite). It largely exists as a cation in acidic solution and as an anion in alkaline solution. They act as buffer to resist changes in pH. Iso-electric point is the pH value at which an amino acid is electrically neutral. All amino acids except Glycine are optically active. All amino acids involved in protein structure have an L-configuration of the carbon atom which is determined in realtion to a standard substance (D-Glyceraldehyde).

CHO	COOH	COOH
H - C - OH	H - C - NH_2	NH_2 - C - H
CH_2OH	R	R
D-Glyceraldehyde	D-Amino acid	L-Amino acid

Decarboxylation - Amino acids undergo decarboxylation reaction to release the carboxyl group as CO_2 and form an amine.

.Deamination - Amino acids can be deaminated to produce carboxylic acid and ammonia

Esterification - The carboxyl group of an amino acid can be esterified with an alcohol to from soap and water

Oxidation - The amino group in an amino acid molecule can be oxidized to nitrogen or ammonia with a mild oxidizing agent like Ninhydrin

Transamination - Amino acid can react with a keto acid to release its amino group and change the keto acid to a new amino acid.

Protein metabolism: The metabolism of protein is essentially the metabolism of amino acids. Certain soil microbes (nitrogen fixing bacteria) possess the ability to convert atmospheric nitrogen to ammonia, nitrates/nitrites. Green plants use the soil ammonia or nitrate to synthesize amino acids/proteins which are later consumed by animals. The nitrogen cycle is completed when plants/animal residues are decayed by microorganisms back to nitrates, nitrites and finally nitrogen gas for the air. Food proteins are digested to amino acid in the gastrointestinal tract, and these amino acids are passed into the portal blood stream and to the liver. The liver removes a certain proportion of amino acids to meet its own needs and pass all it has synthesized to the blood. The blood amino acids come from absorption, synthesis and tissue catabolism which all represent an amino acid pool that can be taken from for all purposes of protein metabolism. Each body tissue takes from this pool the specific amino acids in the right proportion and synthesizes them into the kinds of proteins required for growth, maintenance and proper functions.

Non-protein nitrogen that are necessary for tissue operations such as creatine, choline and glutathione are formed from amino acids taken from the pool. Amino acids in excess of the requirements for the formation of structural tissue protein, enzymes/hormones are deaminated in the liver to ammonia and keto acids as protein/amino acids are not stored in the body. Ammonia is converted to Urea, filtered through the kidney and excreted in urine while the keto acids are converted to ketone bodies/ glucose which are metabolized according to the processes of fat/ carbohydrate metabolism.

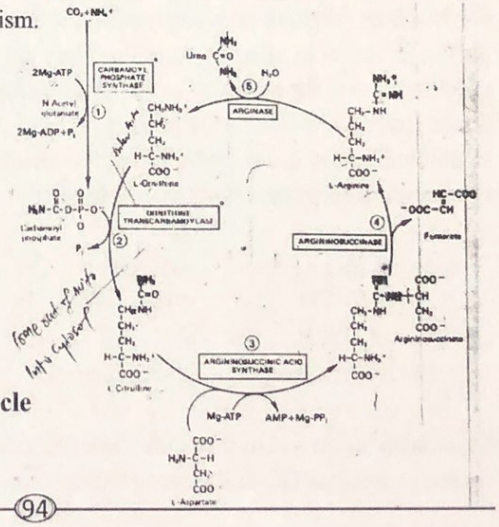


Figure 6.6 Urea cycle

Urea (Ornithine) Cycle: Urea is the end-product of nitrogen metabolism in mammals. In urotelic animals nitrogen is detoxified to urea while it is detoxified to uric acid in uricotelic animals such as avians and reptiles.Ammonia, a product of oxidative deamination is toxic to the body even in small amount and must be converted to the less toxic urea that can be removed from the body. Urea is synthesized in the liver, released into the blood, and cleared by the kidney. Ninety five percent of urea is eliminated by the kidneys and the remaining five percent in the faeces. The urea or ornithine cycle describes the conversion reactions of ammonia into urea

The reactions/intermediates in the biosynthesis of 1mol of urea from 1mol each of ammonium ion, carbondioxide (activated with Mg^{2+}/ATP) and□-amino nitrogen of aspartate are shown in Fig 6.6. The entire process requires 3mol of ATP (2 are converted to ADP+P_i and 1 to AMP+PP_i) and successive participation of 5enzymes catalyzing the numbered reactions. Out of the six amino acids involved in urea synthesis, one (N-acetylglutamate) functions as an enzyme activator rather than as an intermediate. The remaining five (aspartate, arginine, ornithine, citrulline, and argininosuccinate) function as carriers of atoms which ultimately become urea. Two of the amino acids (aspartate/arginine) occur in proteins while the other three (ornithine, citrulline, and argininosuccinate) do not but only function in urea synthesis (ornithine used in reaction 2 is regenerated in reaction 5, hence there is no loss or gain of ornithine, citrulline/argininosuccinate or arginine during urea synthesis. However, ammonium ion, CO_2, ATP and aspartate are used up).

The 5 stages of the reactions are:

1. Synthesis of Carbamoyl phosphate
2. Synthesis of Citrulline
3. Synthesis of Argininosuccinate
4. Cleavage of Argininosuccinate to Arginine and Fumarate
5. Cleavage of Arginine to Ornithine and Urea

1. Synthesis of Carbamoyl phosphate - It starts with the condensation of 1mol each of ammonium ion, carbondioxide, and phosphate (derived from ATP) to form carbamoyl phosphate and catalyzed by carbamoyl phosphate synthase (an enzyme present in liver mitochondria of all ureotelic animals). The 2mol of ATP hydrolyzed during this reaction provide the driving force for the synthesis of two covalent bonds (amide bond and the mixed carboxylic acidphosphoric acid anhydride bond of carbamoyl phosphate) in the presence of Mg^{2+} and a dicarboxylic acid (N-acetylglutamate) which helps to cause the conformational change in the structure of carbamoyl phosphate synthase that affects the affinity of the enzyme for ATP.

2. Synthesis of Citrulline -There is a transfer of a carbamoyl moiety from carbamoyl phosphate to ornithine, forming citrulline + P_i, and it's catalyzed

by L-Ornithine transcarbamoylase of liver mitochondria. The reaction is highly specific for ornithine, and the equilibrium strongly favours citrulline synthesis.

3. **Synthesis of Argininosuccinate-** Aspartate and Citrulline are linked together via the amino group of aspartate in the presence of Argininosuccinate synthase to form Argininosuccinate. The reaction requires ATP.
4. **Cleavage of Argininosuccinate to Arginine and Fumarate -** Reversible cleavage of Argininosuccinate to Arginine and Fumarate in the presence of Argininosuccinase enzyme produced by the liver/kidney tissues. The reaction proceeds via a trans-elimination mechanism. The Fumarate formed may be converted to Oxaloacetate via the Fumarase/Malate-dehydrogenase reactions and then transaminated to regenerate Aspartate.
5. **Cleavage of Arginine to Ornithine and Urea-** This reaction completes the urea cycle and regenerates ornithine (a substrate for reaction 2). Hydrolytic cleavage of guanidine group of Arginine is catalyzed by the enzyme arginase after activation by Co^{2+} or Mn^{2+} (the enzyme is present in the liver of all ureotelic animals but also present in renal tissue, brain, mammary gland, testicular tissues/skin in small quantities). Ornithine and Lysine are potent inhibitors competitive with arginine.

The deficiency of any of the five enzymes of urea synthesis results in metabolic disorders such as vomiting in the infants, avoidance of high-protein foods, intermittent ataxia, irritability, lethargy and mental retardation. Since the urea cycle converts ammonia to the non-toxic urea, all disorders of urea synthesis cause ammonia intoxication which is more severe when the metabolic block occurs at reaction 1 or 2 since some covalent linking of ammonia to carbon has already occurred if citrulline can be synthesized. The rate-limiting reactions of urea synthesis appear to be catalyzed by carbamoyl phosphate synthase (reaction 1), ornithine transcarbamoylase (reaction 2), and arginase (reaction 5). A complete block of any step in the urea cycle is fatal as there is no known alternative pathway for the synthesis of urea. Extensive ammonia accumulation leads to extensive liver damage/death. While persistent elevation of blood urea nitrogen (BUN) level (Uremia) occurs in acute or chronic renal failure, congestive heart failure (leads to low blood pressure and reduced filtration rate) and urinary tract obstruction..

ENERGY METABOLISM

Energy is the capacity to do work; it is an important item in animals' diets. Radiant (Solar) energy of the sun is converted by green plants to produce complex constituents through the process of photosynthesis. Animals consume the plants and break down the complex constituents to release energy that are needed to power bodily activities such as moving (contraction of muscles), thinking (transmission of nerve impulse), growing (synthsis of proteins), maintaining of body structures

(secretion of glands), reproduction (spermatogenesis/oogenesis), responding to the environment (growth/heat generation). Animals derive energy from partial or total hydrolysis of organic molecules in foods. Energy exists in different forms which include potential - energy, chemical energy, heat energy, electrical energy, and radiant energy, which all are interconvertible using appropriate means.

The two laws of thermodynamics are applicable in metabolism-

1. When one form of energy is converted to another, there is no loss or gain in energy.
2. When one form of energy is converted to another a proportion of it is turned into heat.

Heat unit is used to measure the different forms of energy in metabolism. The basic unit of energy is the Calorie. A calorie is the quantity of heat energy required to raise the temperature of 1g of water from 14.5°C to 15.5°C. Calorie is accurately standardized and defined as 4.1855 (International) Joules. However, the calorie is inconveniently too small for use in nutrition as large amounts of energy are involved, hence energy unit in metabolism include

- Kilocalorie = 10^3 Calories
- Megacalorie = 10^6 Calories
- Joules = 0.2389 Calorie
- Kilojoules = 10^3 Joules
- Megajoules = 10^6 Joules

Types of Chemical reactions: The proportion of heat change which is available to do work is called **Free Energy Change** represented as ▲G. The two main types of chemical reactions are **Exergonic** and **Endergonic** reactions.Exergonic reaction is a reaction in which the free energy change is negative while endergonic reaction is a reaction in which the free energy change is positive. Most of the synthesis reactions in the body are endergonic with the energy required to drive the reaction obtained from the catabolic exergonic reactions. The major source of chemical energy in metabolism are carbohydrates and fatty acids, although animals on high protein diet may use dietary amino acids for energy production e.g. during starvation or when the diet is low/restricted in energy.

Role of mediating compounds in metabolism: Mediating compounds help to establish a connection between the two aspects of metabolism (anabolism-endergonic reactions and catabolism - exergonic reactions). Energy released during exergonic reactions cannot diffuse through the cell to take part in metabolic reactions. Certain mediating compounds pick up energy from exergonic reactions and transfer same to endergonic reactions. Mediating compounds include certain nucleotides that take part in the reactions e.g. phosphorylated purines (Guanine/Adenine) and pyrimidines (Cytosine/Uracil).The most important mediating compounds are adenosine monophosphate (AMP), adenosine

diphosphate (ADP) and adenosine triphosphate (ATP).

Substrate-level phosphorylation: phosphorylation reaction in metabolism is the transfer of phosphate group from a phosphate-group containing compound to ADP to form ATP the energy currency of the cell. During phosphorylation a phosphate of high potential gives its phosphate group to ADP.

ADP (substrate) + P_i → ATP; ADP + GTP → ATP + GDP

ATP is universally used by all forms of life as the principal carrier of free energy for body functions as almost every energy-demanding activity consumes ATP - other nucleotides are occasionally used as carriers of free energy. Regeneration of ATP is a principal purpose of catabolism.

Oxidative phosphorylation: The system in mitochondria whereby respiration is coupled to the generation of the high energy intermediate (ATP) is termed oxidative phosphorylation. It enables aerobic organisms to capture a far greater proportion of the available free energy of respiratory substrates than anaerobic organisms. Apart form the phosphate group transfer potential, the body produces ATP from compounds with high electron transfer potential. ATP is generated through the electron transfer/transport chain.

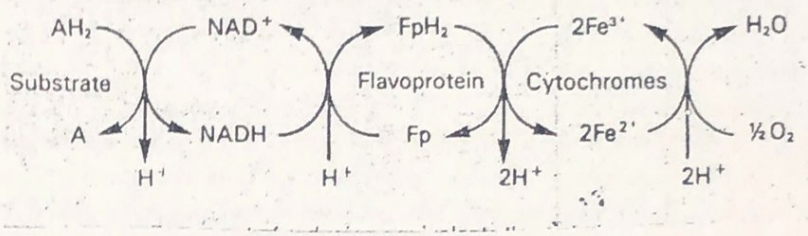


Figure 6.7 Electron transport chain

The electrons and protons come from energy metabolites, intermediate in the catabolism of sugars/fatty acids; electrons of - C-H- bonds are generally used. Respiratory enzymes in the respiratory chain are the chief receptors of hydride group in the oxidative phosphorylation reactions. The chief respiratory enzymes are those having as coenzymes - NAD^+, FAD (a riboflavin linked by- PO_4 to an AMP unit), FMN (flavin mononucleotide linked to a -Po_4 ester of riboflavin) and ubiquinone (coenzyme Q). Respiratory enzymes also include a series of heme-containing enzymes having Fe^{2+} (the last of them holds a Cu^{2+}). The enzymes work together in packages called respiratory assemblies located on the inner surface of the mitochondria (power-house of the cell). Electron acceptors include FMN, ubiquinone, and proteins known as cytochromes. Ubiquinone or Q (coenzyme Q) is a carrier present in the respiratory chain linking the flavoproteins to cytochrome b, the member of the cytochrome chain of lowest redox potential.

Q structure is similar to vitamin K, E and plastoquinone (found in chloroplasts) exists in mitochondrial lipids (predominantly phospholipids) in the oxidized quinine form under aerobic conditions and in the reduced quinol form under anaerobic conditions.

Oxidative phosphorylation contain the electron donors ($NADH + H^+$, $FADH_2$) with the coupled oxidation/reduction represented as

$NADH + H^+ + 1/2O_2 \rightarrow H_2O + NAD^+$

$FADH_2 + 1/2O_2 \rightarrow H_2O + FAD$

The reaction yields free energy. $NADH + H^+$ yield 52Kcal/mol since electrons transfer from $NADH + H^+$ to oxygen yields 3ATP molecule at three sites. $FADH_2$ yields 36Kcal/mol as electrons transfer from $FADH_2$ to oxygen yields 2ATP molecule at two sites.

NB: when substrates are oxidized via an NAD linked dehydrogenase/respiratory chain, 3mol of inorganic phosphate are incorporated into 3mol of ADP to form 3mol of ATP per 1/2mol of O2 consumed i.e. P:O ratio = 3. On the other hand when a substrate is oxidized via a flavoprotein-linked dehydrogenase, only 2mol of ATP are formed i.e. P:O = 2.

$NADH + FMN + H^+ ? NAD^+ + FMNH_2$

Reduced FMN gives up H to Coenzyme Q (CoQ)

$FMNH_2 + CoQ \rightarrow FMN + CoQH_2$

The reduced CoQ passes electron to cytochrome b which later passes electrons to cytochrome $c_1 \rightarrow$ cyt $c_2 \rightarrow$ cyt c_3 and finally to O_2

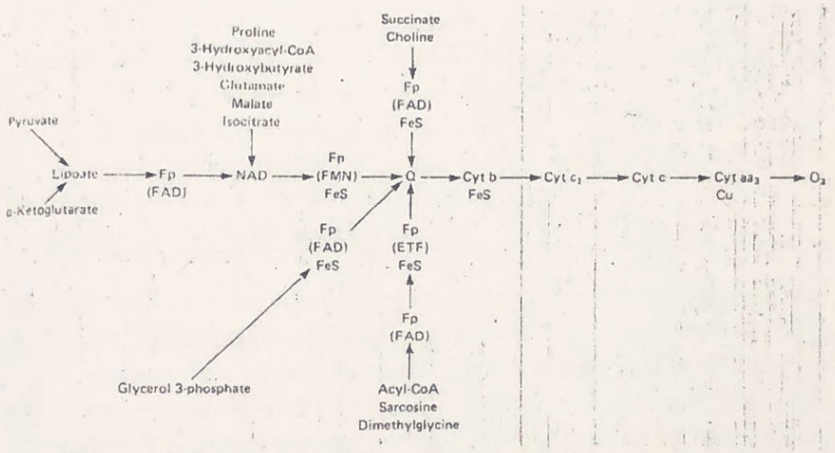


Figure 6.8 Components of the respiratory chain in mitochondria

EVALUATION OF NUTRITIONAL VALUE OF FEEDS

The simplest methods of evaluation of feed are

1. Chemical analysis of feed.
2. Determination of the digestible nutrient in different feed.
3. Comparison of their gross effect as is done in feeding trials

1. Chemical analysis of feed: Feed regulatory laboratories utilize the proximate analysis as quality control of feed ingredients. Though the chemical analysis does not give the information regarding availability of the nutrients present in the feedstuffs to the animals, it gives the information about the quality of the feedstuffs.

   The proximate analysis of feeds developed by Henneberg and Stohmann (1860, 1864) at Weende Agricultural Experiment Station in Germany grouped nutrients with some common properties together so that feedstuffs are analysed in six fractions namely water, crude protein, ether extract, crude fibre, nitrogen-free-extract and ash. The nitrogen-free-extract is determined by subtraction from 100, the sum total of crude protein, ether extract, crude fibre and ash.

Feedstuff Fractions	Components
1. Moisture	Water (and volatile acids/bases if present)
2. Ash	Essential elements Major (Ca, K, Mg, Na, S, P, Cl); Trace (Fe, Mn, Cu, Co, I, Zn, Si, Mo, Se, Cr, F, V, Sn, As, Ni)
	Non-essential elements Ti, Al, B, Pb
3. Crude protein, CP	Proteins, amino acids, amines, nitrates, nitrogenous glycosides, glycolipids, B-vitamins, nucleic acids, Non-Protein-Nitrogen, NPN (urea, NH_3, Creatines)
4. Ether extract	Fats, Oils, Waxes, organic acids, pigments, sterols, vitamins (A, D, E, K).
5. Crude Fibre, CF	Cellulose, hemicelluloses, lignin.
6. Nitrogen-free extractives	Cellulose, hemicelluloses, lignin, sugars, fructans, starch, pectins, organic acids, resins, tannins, pigments, water-soluble vitamins.

i. Moisture content, MC - Moisture content is determined as the loss in weight when the feed sample is oven-dried to a constant weight at 100°C. Significant losses of volatile material may take place with samples such as silage.

ii. Ash - Ash content is determined by ignition of a known weight of the sample at 500 - 550°C in a furnace until all carbon has been removed. The residue is the ash and is taken to represent the inorganic constituents of the food sample. It may contain materials of organic origin such as sulphur/ phosphorus from proteins, and some loss of volatile material in the form of Sodium, Chloride, Potassium, Phosphorus and Sulphur will take place during ignition. The ash content is thus not truly representative of the inorganic material in the food either qualitatively or quantitatively.

iii. Crude protein (CP) - This method determines nitrogen from sources other than protein hence the name crude protein i.e. not the true protein. In this method the food sample is digested with sulphuric acid (conc H_2SO_4) which converts to ammonia all nitrogen present except those in the form of nitrate and nitrite. This ammonia is liberated by adding Sodium hydroxide to the digest, distilled off and collected in standard acid, the quantity so collected being determined by titration or by an automatic colorimetric method. It is assumed that the nitrogen is derived from protein containing 16% nitrogen and by multiplying the nitrogen figure by 100/16 or 6.25 an approximate protein value is obtained.

Assumptions {*All nitrogen of the food sample is present as protein;*All food protein contains 160gN/kg, CP (g/kg) = gN/kg x 1000/160 = gN/kg x 6.25}

Feedstuffs	Nitrogen g/kg	Conversion factor
Cotton seed	188.7	5.30
Soyabean	175.1	5.71
Maize	160.0	6.25
Egg	160.0	6.25
Meat	160.0	6.25
Milk	156.8	6.38
Wheat	171.5	5.83

iv. Ether extract - Ether extract is high in energy, yielding over 9kcal per gramme. It is determined by subjecting the food sample to a continuous extraction with petroleum ether for a defined period. The residue, after evaporation of the solvent, is the ether extract. %EE= (weight of fat / weight of sample) x 100

v. Crude Fibre, CF/ Nitrogen-free extractives, NFE - The carbohydrate of food is contained in two fractions (crude fibre and nitrogen-free extractives). The CF includes the insoluble-cellulose, hemicelluloses and lignin while the NFE includes the soluble cellulose, hemicelluloses and at times lignin, sugar, fructosan, starch, peptines, organic acid, tannins, some pigments and water soluble vitamins. %NFE = 100 - (CP+CF+EE+Ash) after the removal of water.

CF is the portion of the total carbohydrate of a food that is resistant to both acid and alkali treatment. It represents the indigestible portion of the food. The ruminants can take care of this indigestible portion because of the microfloral in their rumen which helps in the production of the volatile fatty-acids (butyric, acetic and proprionic) which the animal use for energy through the tricarboxylic acid (TCA)or Krebb-cycle. CF gives ration an effective bulk since it is highly fibrous. It helps in intestinal motility, the fibre component absorb water and makes the faeces to be moist, causes irritation along the

Van Soest Method of Forage analysis: Nutritionists has criticized the proximate analysis procedure as being archaic and imprecise due mostly to the CF and NFE fractions, and alternative procedures using detergents have been proposed by Van Soest.

Fraction	Components
Cell contents (soluble in neutral detergent)	Lipids, sugars, organic acids, water soluble matter, pectin, starch, non-protein nitrogen, soluble protein
Cell wall constituents (fibre insoluble in neutral detergent)	
1. Soluble in acid detergent	Hemicellulose, Fibre-bound protein.
2. Acid-detergent fibre	Cellulose, lignin, Lignified Nitrogen, Silica

The neutral detergent fibre (NDF), which is the residue after extraction with boiling neutral solutions of Sodium lauryl Sulphate and ethylene-diaminetetracetic acid (EDTA), consists mainly of lignin, cellulose and hemicelluloses and can be regarded as a measure of the plant cell wall material.

The acid detergent fibre (ADF) is the residue after refluxing with 0.5M Sulphuric acid and Cetyltrimethylammonium bromide, and represents essentially the crude lignin and cellulose fractions of plant material but also includes Silica. The determination of ADF is particularly useful for forages as there is a good statistical correlation between it and digestibility.

2. Determination of the digestible nutrient in different feed: It is obvious that the quantity of carbohydrate, fat and protein helps in measuring the usefulness of feedstuffs but this (chemical composition) gives only the potential value of feed and does not give the actual nutritive value of the feedstuffs until losses of nutrients in faeces, urine, gases, etc from animal during digestion, absorption and metabolism are taken into consideration.**Digestibility of a feedstuff is the portion or percentage of feed or of any single nutrient of feed which is not recovered in faeces or that is acted upon by the microbes/ digestive enzymes in the digestive tract and is absorbed by the body system.**

When digestibility is expressed in percentage it is known as **digestibility coefficient**e.g. if a Cow ate 15kg of hay containing 12kg of dry matter and excreted 5kg of dry matter in its faeces, the digestibility of the hay dry matter would be (12 - 5)/12 = 0.583; Digestibility coefficient = (12 - 5)/12 x 100 = 58.3%.

A digestion experiment with a bullock may show that out of 80g of protein in a feed eaten by the animal, 48g are apparently digested and absorbed.

The digestibility coefficient of the protein in this case would be 60% (48/80 x 100), meaning that the protein is 60% digestible.

Digestibility coefficients could be calculated in the same way for each constituents of the dry matter. The term digestible nutrient means that portion of nutrient which is digested and taken into the body. The term refers to Digestible Crude protein (DCP), Digestible ether extract (DEE), Digestible Crude fibre (DCF), and Digestible nitrogen-free-extract (DNFE). The losses of nutrients in the faeces are of considerable importance and economic value to the livestock owner and the nation.

Determination of Digestibility: The percentage digestibility of feedstuffs or its nutrient is determined by feeding trials with the animals. These tests are called digestion experiments. Digestion coefficients are determined by means of these digestion or balance experiments where in addition to faeces, urine is also collected. In determining the digestibility coefficients of feed or its nutrients the following procedure is adopted-

(a) Analyze the feed sample to determine its chemical composition (proximate analysis)

(b) Place the animal in a metabolism cage or stall where there is an arrangement for separate collection of faeces and urine.

NB: urine collection is not required for determining digestibility but for determining the balances of nitrogen, calcium, phosphorus, etc. Losses of nitrogen in urine are also taken into consideration. In metabolism stalls faeces bags are harnessed on the animals to collect the faeces.

Four to Six adult, apparently healthy animals of the same species, age/sex, preferably males should be selected to avoid animal to animal variation.

(c) Pre-experimental feeding- Feed the animals with the test feed for a period of 1 to 2 weeks for ruminants and lesser for monogastics to remove previous feed from the digestive system and establish a uniform rate of feed passage and excretion of faeces.

(d) Experimental feeding-Weighed feed are fed to the animals for about 7-10 days (with longer days giving greater accuracy) during which daily record of weighed feed offered, residues left and faeces voided are kept on a 24hour basis. During this period representative samples of feed offered, residue left and faeces voided are taken daily and kept in hot air oven for drying. After drying, the samples are kept in polythene bags where each day sample is kept so that at the end of collection period all the samples are composited and analyzed for chemical composition.

(e) Chemical analysis of samples.

The basic procedure involved in a digestion trial simply consists of measuring the quantity of nutrient consumed and the quantity excreted during experimental period. From the amount and chemical composition of feed

and its various fractions can be computed.

Digestibility = Quantity consumed - Quantity excreted in faeces

Digestibility coefficient = Intake - Output in faeces x 100

Intake

e.g. if intake is 20g and output is 12g

the digested = 8g; digested coefficient = (8/20) x 100 = 40%

from this we can get the digestible nutrients; if from analysis of feed, the CP is 12% and CF is 18%

CP in feed sample = 12/100 x 20 = 2.4; CF = 18/100 x 20 = 3.6; Since you must have analyzed for the faeces, if its CP is 6% and CF is 10%, the CP in faeces i.e output = 6/100 x 12 = 0.72; CF in faeces = 10/100 x 12 = 1.2

For accurate feeding of the weighed amount of feed/collection of faeces, the following factors must be considered-

1. Accurate feeding of the animals
2. Provision of drinking water
3. Collection of the faeces
4. Separation of urine from faeces
5. Type of animal used ie. Male or female
6. Comfort of the animal i.e. avoid stressful condition, space should be comfortable for animal to face only one direction.

Factors Affecting digestibility

1. Feed intake level
2. Chemical composition of feed
3. Stage of maturity
4. Addition of easily digestible carbohydrates such as starches, sugar, molasses, etc
5. Feed processing

1. **Feed intake level:** An increase in the quantity of food eaten by an animal generally causes a faster rate of passage of digesta, thus allowing less time for digestion/absorption hence decreased digestibility. The rate of passage of food through the GIT is accelerated by food intake hence less time for enzyme/microorganism to act on feed. Experiments have shown that larger farm animals digest a large percent of the nutrient in their feed when fed in scanty ration than when they receive the full ration. It has also been observed that the bulkiness or physical form of chopped or long hay fed alone may prevent animals from eating enough, so depressing digestibility.
2. **Chemical composition of feed:** The apparent digestibility of a feed is influenced by the proximate analysis. This means that feed of the same name but differs in chemical make up will show different digestibility. Diets with increased CP

content but equal in caloric content have greater digestibility of both the protein and energy. The digestibility of nutrients tends to decrease as percent of protein in ration decreases. In ruminants, the addition of protein or nitrogen compounds to feed increases the breakdown of CF. This inturn makes other nutrients more digestible. Percent of CF affects the digestibility of feed, the greater the amount of fibre, the lower the digestibility of other nutrients. CF tends to exert a protective influence against the digestibility of other nutrients. Amount of CF that is desirable in ration depends on animal species because size and anatomy of GIT varies. Too much bulky food reduces the consumption of digestible nutrients. High fat rations are more digestible than rations low in fat. The nature of EE depends on the sources. Seeds and their by-products consist largely of true fats which are the digestible esters of the fatty acids. The EE of roughages contain large proportions of pigments such as chlorophyll which is non-saponifiable and non-lipid substance.

3. **Stage of maturity:** Stage of maturity affects the digestibility of forages because of the change in chemical composition. As plants matures its CF content increases and becomes less digestible than the fibre found in the younger green plants. This results in the older plants becoming less palatable so that animals eat less, thereby influencing the digestive intake because of the change in plane of nutrition.
4. **Addition of easily digestible carbohydrates:** Ruminants digest ration equally when there is a large proportion of easily digestible carbohydrate such as starches, sugar, molasses, etc. This is due to the fact that rumen microorganisms utilize the more readily available carbohydrate for energy instead of attacking the resistant cellulose/hemicelluloses which are left unfermented or less fermented. CF digestibility is not the only one lowered, but also that of CP, NFE and other nutrients because the undigested cell wall protects the nutrients contained in them.
5. **Feed processing:** Changes in the physical form of feedstuffs may influence the digestibility of the feed products. Feed processing such as drying, if it is possible to dry leaves without fermentation will not result in any significant decrease in digestibility; but if some leaves are lost and fermentation/leaching occurs it will lead to decreased digestibility. In order to obtain maximum digestibility cereal grains should be crushed for cattle and ground for pigs, or else they may pass through the gut intact. Sheep can generally be relied upon to chew whole cereal grains, so mechanical pre-treatment may not be necessary.

   Grinding/ chopping seem to increase consumption of roughages which are of low quality and palatability. Decreasing intake of poor quality roughage may not always be beneficial to high production in animals but the rate of passage of feed residue through animals fed finely ground feed is greater than the one fed

coarsely ground feed leading to less rumination and decreased digestibility with the more rapid passage of the feed in the GIT.

In pelleting, since a given weight of pelleted feed takes up less space, animals may eat more pelleted feeds than ground feed. It has been found that pelleting of complete ground ration consistently and significantly lowers CF digestibility because the length of stay in the gut is short.

Treatments like alkali treatment increases digestibility because it breaks the lignin bondage making cellulose/hemicelluloses available for microbial digestion.

Heat treatments are most effective in improving digestibility when used for the specific purpose of inactivating the digestive enzyme inhibitors that are present in some feeds.

6. **Animal factors:** Digestibility is more a property of the food than the consumer, but this is not to say that a feed given to different animals will always be digested to the same extent. The most important animal factor is the species of the consumer. Food that are low in fibre are equally well digested by ruminants and non-ruminants, but more fibrous foods are better utilized by ruminants. Apparent digestibility coefficients for protein are frequently higher for pigs because their excretion of metabolic faecal nitrogen is lesser than that of ruminants. Differences in digestive ability between Sheep and Cattle are small and of little importance with most diets. However, highly digestible foods such as cereal grains tend to be more efficiently digested by sheep, and poorly digested foods such as low quality roughages tend to be better digested by cattle.

TOTAL DIGESTIBLE NUTRIENTS

The chemical composition of feedstuffs does not give the true nutritive value since losses of nutrients in the animal body are not taken into consideration. The energy value of feeds are usually calculated using the total digestible nutrients (TDN)

TDN = %DCP + %DCF + %DNFE + %DEE x 2.25; where DCP is digestible crude protein, DCF - digestible crude fibre, DNFE - digestible nitrogen free extract and DEE - digestible ether extract. It should be noted that the ether extract is multiplied by 2.25 because the energy value of fats is approximately 2.25times that of carbohydrates and proteins.

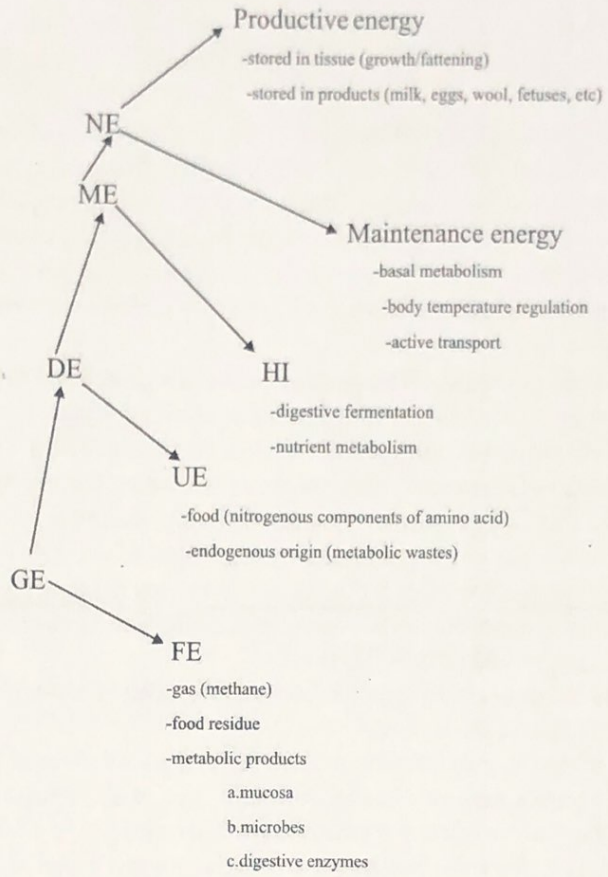
This system of energy expression is very simple but it suffers from accuracy as it fails to take into account that the efficiency with which the digested energy-yielding nutrients are metabolized and made available to the animal varies from one feed to another. It over-estimates the energy value of roughages and underestimates that of concentrates.

PARTITIONING OF FEED ENERGY

The energy value of feeds may be considered under the following

1. Gross energy, GE

2. Digestible energy, DE
3. Metabolisable energy, ME
4. Urinary energy, UE
5. Heat increment, HI
6. Net energy, NE
7. Faecal energy, FE



The total potential energy of any given feed represents the **gross energy**. This is usually determined by combustion of a given feed in a bomb calorimeter or it can be determined by summing the average heat of combustion of the three energy yielding components of food such as carbohydrate, lipid and protein. During digestion and absorption the gross energy is broken down and a part of it escapes the body via the large bowel or intestines in form of gas chiefly methane, undigested feedresidue and energy yielding metabolic products that have originated in the digestive system.

The solid faecal residues can easily be recovered and their energy determined chemically. The gas/heat of fermentation frequently escape without record and hence the digestible energy DE = GE - FE is frequently too high since not all of the unused energy is recorded.

The portions of the absorbed nutrient that have served their purpose must be eliminated, usually through the kidneys. Some of these materials could be directly of feed origin such as the nitrogenous component of amino-acids while some could be of endogenous origin (derived from metabolic processes i.e. within the body) arising from metabolism of some of the tissues of the body. These wastes are largely voided through urine.

The metabolisable energy (ME), which is infact the useable portion of the ingested energy is computed as ME = GE - FE - UE. While it is difficult to arrange the possible uses of ME in order of importance, it is obvious that one constant requirement for metabolisable energy is for the maintenance of the animals body. An animal is in a state of maintenance when its body composition remains constant, when it does not give rise to any product such as milk and does not perform any work in its surroundings.

The maintenance energy consist of two main parts, the first is the **basal metabolism (BM) which may be defined as the state of minimum energy expenditure by the animal in post-absorptive condition**. The basal metabolic rate (BMR) is a direct and constant function of the metabolic size of the animal which is given by BM_{24hr} = 70W $^{3/4}$kg) kcal. The second part of the metabolisable energy is used for the maintenance or sustenance of a certain amount of unavoidable activities by animals that are not using energy for work or for the production of any tissue or product. The maintenance energy requirement can be computed as BMR increased by one third

$$BMR_{maintenance} = 1.33\ (70)\ (W^{3/4}kg)\ kcal$$

After BM and maintenance ability requirement has been satisfied, most of the rest of feed energy is available for production.

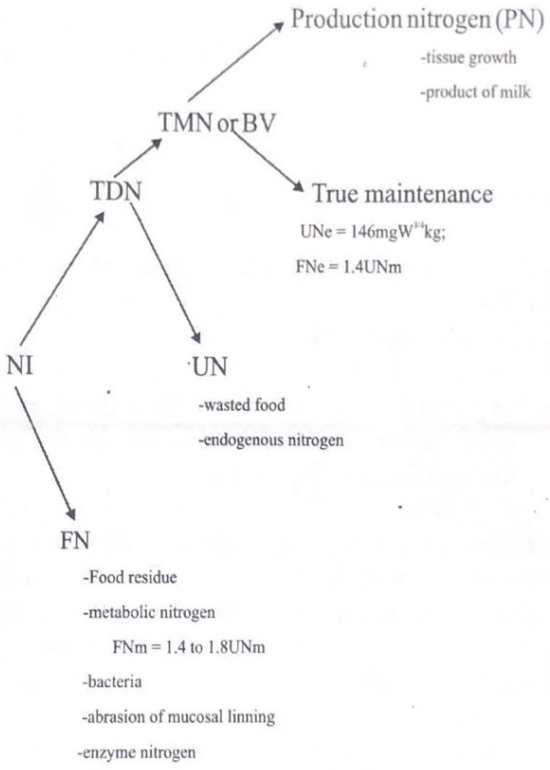
The productive energy may be stored in products or in tissues such as in growth or fattening. Such energies may also be stored as milk, egg, wool, fetuses, etc. The energy contained in such products that are lost to the body such as egg, milk, fetuses, etc must be replaced. The other portion of productive energy is that required for increased activity of the body as in work or pleasurable endeavour that exceeds minimum activity of maintenance. The energy expenditure is irreversible and should the animal persist in activity requiring energy in excess of maintenance without adequate replacement in the diet it results in body weight loss.

The heat increment is the amount of energy spent in chewing, mastication, absorption, utilization, etc of the feed. The secretion of digestion juices and the microbial breakdown of crude fibre (heat of fermentation) require energy. Similarly, energy is required during absorption/metabolism of nutrients.

It is believed that heat increment represents a decrease in the efficiency of energy metabolism of feed eaten as compared with that occurring under basal condition. It is influenced by the proportion of energy yielding nutrients in the ration. Heat increment is a possible reflection of the degree to which the ration eaten fails to meet the exact nutrient need of the body at a given time. Heat increment is variable and ranges from 3 - 20% of the gross energy of feed. GE - FE = DE; DE - UE = ME; ME-HI = NE (Net energy). It should also be known that GE- UE - FE = ME.

Partitioning of dietary protein

In the same way that feed energy is partitioned, it is also possible to partition feed protein. For every 100g of feed protein we have 16g of nitrogen.



where NI - total nitrogen intake; TDN - true digestible nitrogen or true biological value; FN - faecal nitrogen; UN - urinary nitrogen.

The requirement for protein in the diet is determined largely by the losses the body suffers in nitrogenous end-product. Therefore, for the animal to be maintained in nitrogen equilibrium, the intake must be sufficient to balance for lost ones. In this regard the losses of protein from the body of an adult non-producing animal are -

1. Undigested/ unabsorbed digestive protein residues

2. Nitrogenous residues from the intestinal microfloral
3. Spent digestive fluid nitrogen
4. Urinary excretion of the nitrogenous waste from intermediary protein catabolism

Consequently, animals storing protein such as in growth will have requirement for tissue anabolism, and animals producing protein containing products such as eggs, milk, and wool will have further requirements to meet this needs. To maintain an animal in protein equilibrium these losses must be replaced. Their sums represent the protein requirement of the animal. The nitrogen or its protein equivalent of the first 3 categories above appears in faeces. Some of this do not represents undigested protein of the diet and they constitute the chief component of metabolic faecal nitrogen.

By definition therefore, **apparent digestibility of a protein is the percentage of the intake that is not recovered in the faeces**. Because all of the faecal nitrogen is not an unabsorbed diet residue, the calculated apparent digestibility of a protein will be greater than the true digestibility.

$$\text{Apparent Digestible protein, AD} = \frac{(NI - FN)}{NI} \times 100\%$$

Where NI is Nitrogen intake and FN faecal nitrogen

True Digestibility, TD ensures the correction of the proportion of feed intake that is not recovered in the faeces.

$$TD = \frac{NI - (FN - FNm)\ (UN - UNm)}{NI - (FN - FNm)} \times 100$$

The latter expression has practical limitation because of the difficulty in measuring endogenous urinary nitrogen, hence it has been customary to measure endogenous urinary nitrogen of animal using the following equation-

$$UNm = 146\ W^{3/4} kg$$

True digestibility takes care of requirement for maintenance and production. Where no other factors come into play, the higher the percentage of protein in the diet the higher the apparent digestibility. Increase in fibres tends to depress the digestibility of a protein. The protein which is eventually digested and absorbed may be used entirely to meet the protein requirement of the body or under special circumstances may be used largely for energy.

The proportion of the digested protein that is actually used to meet the protein needs of the body is referred to as the biological value of the protein. BV is therefore a proportion of the absorbed nitrogen that is retained within the animals' body.

$$BV = \%\ \text{absorbed N retained}$$

The two major factors that appear to regulate the BV of protein in a diet are the level of energy and the amino-acid composition.

If the energy requirement of the animal is not fully met by non-protein sources, then most of the digested protein will be diverted to meet the energy deficiency. On the other hand, if the energy requirement is adequate from non-protein sources, the chief factor controlling the proportion of digested protein used to meet the protein need in the body is the amino-acid composition. Essential amino-acid are amino-acids that the body cannot synthesized in sufficient amount to meet the body is requirement e.g. Valine, Isoleucine, Methionine ↔ Cystine, Lysine, Tryptophan, Phenylalanine, Tyrosine, Leucine, Histidine while the non-essential ones are Glutamic acid, Aspartic acid, Alanine.

Protein Amino acid complementality i.e. what one protein is deficient in is made up for by another e.g. blood meal is deficient in methionine and when mixed with fish meal which has methionine, it serves as complement. That is adding two ingredients which make-up for each others deficiency.

Requirement of protein for growth: The tissues of the young animal are highly proteinaceous hence protein remains an important consideration in the rations of growing animals. The protein content of the ration of a growing animal will be affected by the size of the animal and by the rate at which new protein tissues are being synthesized. It has been established that energy and protein requirement bears a definite relationship to each other for adult animals, a situation which could also be true for growing animals.

Protein requirement for lactation: It is usually much easier to compute a protein requirement for lactation than for growth. This is because lactation represents the direct loss of protein to the body which needs to be replaced, and the extent of this loss can readily be computed. There is ample indication that animals can adjust themselves to lactation over a relatively wide range of protein intake, which seems to range from 1 to 6 times the quantity of protein that has been secreted in the milk.

Requirement for Vitamins and Minerals

Vitamins: Unlike the other nutrients previously discussed, vitamins as a group have a few characteristics common to each other. They are organic compounds not synthesized by the body and are needed in a very small amount in the diet. Vitamins are no major structural component of the body and they most commonly functions as coenzymes or regulators of metabolism. Birds for example have an absolute requirement for about 13vitamins which include the so called fat soluble vitamins such as A, D, E and K, and the so called water soluble vitamin which include thiamine, riboflavin, niacin, folic acid, biotin, panthotenic acid, B_6, B_{12} and choline.
The body can generally synthesize vitamin C and therefore has reduced requirement. All the above vitamins are needed for the efficient growth of the chicken. Egg normally contains sufficient vitamins to supply the needs of the developing embryo,

for this reason eggs remain one of the most important sources of vitamins in human diet. There is usually a large specie difference with respect to the vitamin requirement. For example, little attention is given to the B-series of vitamins in herbivores (or ruminants) as rumen microorganisms are capable of synthesizing this B-series of vitamins.

Minerals: Mineral elements required by poultry include Calcium, Phosphorus, Sodium, Potassium, Magnesium, Chlorine, Iodine, Iron, Manganese, Molybdenum, Cobalt, Zinc and Selenium. Calcium, Phosphorus, Potassium, Sodium and Chlorine are usually designated as a major element since they must be present in a relatively large amount in the diet. Calcium should be present in 1% level for the growing chicken and over 3% for the layers. Magnesium should be 0.03- 0.05% of the diet. Although, the remaining minerals are required in trace amount in the diet it must be emphasized that their deficiency could be detrimental to the normal health of the animals as the deficiency of the major minerals.

Specific requirement for Ca, P and Mg: Ca, P and Mg are important bone constituents. The ash of bone contains about 25% Calcium, 12% Phosphorus and 0.5% Magnesium. Insufficiency of these minerals could result in poor bone formation. The major mineral need in the diet of the laying hen is Ca. For every large egg the hen lays it requires or uses about 2g Ca for egg shell formation. Egg quality characteristics are largely influenced by the dietary Ca level. Eggs laid at the end of the production year tend to have thinner egg shells than those laid at the start of the laying year. High environmental temperature causes the deposition of thin egg shell by causing lower intake of feed, so more calcium must be added to the feed to enable the uptake of Ca for every single feed. However, the most important cause of thin egg shell formation is Ca deficiency. Feed consumption is also important in determining Ca requirement when expressed as percentage of the diet. For old layers in hot weathers 4 - 4.5% Ca is recommended for good egg shell formation.

In addition to their roles as structural constituents, Ca and P have other functions, for example P is essential in energy metabolism, functioning as a constituent of nucleic acid and for the activity of several enzyme systems. Ca is also important in blood clotting and muscle contraction. Much of the body Mg is found in the bone, and also as an important activator of some enzymes involved in energy metabolism.

Chickens are especially very sensitive to imbalances in Ca to P ratio in the diet. Ratios of 1.5: 1 and 2: 1 of Ca/P is essential for optimum performance. An imbalance will result in very poor utilization of Ca or P. Vitamin D must be present in adequate amount for proper utilization of dietary Ca and P.

Sodium, Potassium and Chlorine

These are principally inorganic ion of the body fluid. Na is found in the extracellular

fluid while K occurs mainly in the intracellular fluid. This mineral is important in the maintenance of acid, base and fluid balance in the body tissue. Chlorine is an important component of the Hcl found in the proventriculus in the chicken, and the stomach in monogastric animals. Deficiency of any of these results in poor growth, dehydration and death while excess may result in excessive retention of body fluid.

Trace minerals

These are generally considered to be components or activator of several enzyme systems. Iron is an important component of haemoglobin and of muscle in form of myoglobin. It is also a component of the cytochrome system.

CHAPTER SEVEN
MANAGEMENT OF FARM ANIMALS

Livestock production systems: There are two distinct systems of livestock production, namely the traditional and the modern system.

1. The Traditional System: It represents the extensive system of livestock production and can be divided into two- Traditional pastoralist and Traditional Rural farmer.
   a. Traditional pastoralist: This deals mainly with cattle and some sheep/goat. The system develop as an adaptation to environmental and historical factors faced by animals with the problems of seasonal variation, forage availability, and water demand and social interaction with arable crop farmer. Thus the traditional pastoralist has evolve a range of husbandry practices to suit the prevailing condition of its environment. The traditional pastoralist sees his animal as a source of wealth, social security and source of milk production rather than beef production. This makes milk a major source of income in the domestic economy. Appropriate management schemes have therefore been evolved to ensure all year round milk production from the herds. But production is low because of the failure of the producers to take advantage of available production technology and inputs so as to get an increase in their output. However, various degrees of settlements are now emerging among the pastoralist and these settled groups show improvement in their management practices through the adaptation of improved production technology with improved supply, provision of feed supplement and health improvement packages from extension services. These developments have resulted in substantial increase in yield and productivity.
   b. Traditional rural farmers: In this system the livestock is usually made up of household chickens, sheep and goats, and at times pigs. This play an important role in the socio-cultural life of the community, and at times provides a source of cash to meet the immediate financial need. In this type of system, the animals are left to fend for themselves, roam about the villages, browsing on forages and scavenging on domestic wastes.
2. Modern system:This includes the semi-intensive and intensive system. This system has been successfully employed for high productivity in livestock industries. Productivity in this system is many times higher than the traditional system yet few impacts are made on the generality of the population.
   a. Semi-intensive system: Under the semi-intensive system, livestock are partly confined. They are kept in areas demarcated with wire-netting, barb-wire or chain-links. The animals moves about in this areas during the day and they

have the chance to look for their natural food. Very often supplementary food is given. At night they are confined within a shed provided. This system is intermediate between the intensive and extensive system. It is common with cattle production where there are established paddocks.

b. Intensive system: Under the intensive system, livestock are kept in-door all the year round, feed and water are supplied and animal health care is also provided. There are specialized ways of disposing the faeces and urine, as well as other effluents. This system is common with commercial pigs, poultry and dairy cattle.

Modern Production and Management for Beef cattle

In the modern system of production the animals are not sedentary, so

1. Shelter must be provided and this ranges from ordinary trees to complex structures.
2. They have to be provided with feeds
3. A disease control program is highly necessary.

Types of beef production program

i. Cow-calf: This is the production of beef calves and raising them to weaning. In this program, good cows are needed to produce the calves which are weaned at 3 - 6 months before they are sold.

ii. Feedlot/ Fattening: This involves the general improvement of the animal body to produce good quality meat. The animals are supposed to put on more flesh to meet the market demand.

iii. Stocker Operation program: Here young cattle are fed from cow-calf program either as replacement heifers or as fattened beef animals.

iv. Combination of the three programs: This program is practiced in many farms combining program 1 to 3 (Cow-calf, feedlot/fattening and stocker operation).

Choice of foundation stock

1. Age: The age of bulls and cows should be considered as it is a well known fact that too old animals are not always fertile/ good for breeding purpose.
2. Performance record
3. Freedom from diseases
4. Cost of the animals

Building and Equipment required in a beef Cattle enterprise

Building/ equipment is required in modern livestock production for the three reasons-

1. It serves as protection in the form of shelter or shade form weather/ predators.
2. It serves as storage facility for feed and equipment.
3. Provides comfortable environment for the farmer.

The type of building to be provided depend on the type of system e.g. for ranch system, there may be natural shelter such as trees and artificial shelter like small barns. For the intensive system, building should be more permanent. In such permanent structures the following compartments or units must be available-

1. Housing unit for animals to eat and rest
2. Maternity unit
3. Calve housing unit
4. Isolation unit where sick and new animals are kept
5. Store for feed/drugs and other equipment

Reasons for equipment on the farm

1. To make farm work easier
2. To save labour

Examples of equipment

1. Feeding equipment:
   a. Racks and Manger - They are use for feeding roughages, silages, etc. Racks are off the ground while mangers are placed on the ground.
   b. Troughs and Bunks- for feeding grains and concentrates, they are self feeders
   c. Mineral feeding box
   d. Silos - for storing grains
2. Watering equipment: Water troughs and tanks must be provided, the troughs can be made of concrete or metals and should be scattered all over the range to reduce competition among animals. Animals may also get their water from stream, lakes, dam, etc.
3. General equipment:
   a. Loading Ramp - This is useful when bringing new animals or taking animals away from the farm. They are structures that have a platform and an inclined surface.
   b. Cattle squeeze - It restrains the animal from struggling when performing operation or during milking.
   c. Dipping tanks- It is a tank for dipping animals against ectoparasites.
   d. Spray race - This is used for spraying animals against ectoparasites.
   e. Corrals - It is for the same use as the cattle squeeze.
   f. Weighing balance or Scale - This is necessary for taking the weight of the animals.
   g. Fences - This is necessary to separate the pasture into paddocks.
   h. Veterinary cupboard - For storage of medicine, bandages, plasters, needle/syringe, bolus applicator, forceps, etc.

Feeding and Management Practices

1. Calf to Weaning
2. Weaning of heifer to 1st calving

3. Weaning to slaughter
4. Bulls and Cows

Before calves are born management starts right from when the fetus is inside the dam, the dam is given steam up feed which helps in milk let-down, production of more antibodies (colostrum), helps the calve to develop properly.

Cow or heifers that are approaching parturition usually undergoes the following-

i. Nervousness
ii. Watery discharge from vulva.
iii. Tail-end will be extremely soft

After calving the young is licked up by the dam. Iodine solution should be applied on the navel to prevent infection and the nostril of the young cleaned by the farm attendant. After about 30 minutes post-natal the calf will search for the teat and may be assisted to locate it. The calf should suckle before 36 hours because the intestine is permeable to protein molecules to pass into the body (by-pass protein). Colostrum has a high feeding value than ordinary milk, it contains antibodies which protect the calves from diseases, rich in vitamins A and D, it has a laxative effect on the digestive system which helps to remove meconium or foetal dung. If the calve loses its dam or if a calf is removed from the dam at birth, colostrums should be provided from foster mother. At times calf are allowed to run with the dam, but with dairy cattle the calf should be removed so that the dam will not have digestive problem. About a week after calving, solid concentrate feed should be given, this is known as calf-starter which should contain 18% crude protein and 2 - 3% crude fibre. After the introduction of calf starter, creep feed which is made up of 50% corn, 30% groundnut cake, 20% cotton seed cake and mineral salt should be given. After feeding for about 4 - 5 weeks, hay or grass is gradually introduced and this help in the development of the rumen. Other management practices before weaning include -

1. Identification: Animals should be identified for record purposes. The various identification methods include
   a. Hide branding -This can be done by using paints on the tail, hide or other parts of the animal's body.
   b. Hot branding in this case hot metal is pressed on the body of the young calve.
   c. Ear tag - This is done by using metal or plastic. It has the disadvantage of being susceptible to being broken or lost.
   d. Neck chain - It has to be changed as the animal grows up and should not be too loose.
   e. Tattooing - This is done on the ear and body
2. Castration: Bull-calf which is not wanted for breeding can be castrated. It should be done early 2-4 months of age to reduce the pain or when the animal is 18 months old. Castrated bull is referred to as bullock.

Advantages of castration

a. It controls breeding i.e. a form of contraceptive
b. It prevent poor breeders reproducing themselves
c. It eases management problems e.g. steers are calmer and less vicious and easy to handle in large numbers than bulls.
d. Steer fatten more quickly and produce better quality meat in relation to tenderness.

Methods of castration -The Open or Surgical methods: here the testicles are removed by simple incision using a sharp knife or blades, cut the cord, remove the testicle and tie the cord.

Advantages

I. The farmer is very sure that the animal is castrated
II. It is less painful

Disadvantages

I. It may constitute a site of infection

Close or Non-surgical method: In older animals, castration is done by crushing the spermatic cord that connects the testicle to the penis. This is done with a strong elastic rubber ring (elastrator) or with burdizzo. The elastrator, which is the best method for young calves, stretches a strong rubber ring around the scrotum and must be done on the first day of the calf's life. The burdizzo crushes the cords which go to the testes, and is used mainly on older animals.

3. Dehorning: This is done with a hot iron which burns off the horn-buds or dehorning can be done by the application of caustic soda to the horn, it corrode the horn area and the horn will not emerge.

Breeding herd

1. Heifer: Heifers are matured female cattle that have not given birth, they are supposed to replace adult cow and so must be properly managed. They are fed properly so that they are not too fat or thin. They should not be bred until they are about 18- 24 months old (150 - 200kg), so that they will give their first calve at about 2½ to 3 years of age. Cows are expected to calve every year for a maximum of 10years. Heifers should be reared separately in a paddock far from cows or bull. They can be fed grasses during the wet season, hay and silage during the dry season which could be supplemented with concentrate and mineral salts, etc. Steam up the female 3- 4 weeks before calving. Dehorn to prevent injury to others by sawing-off the horns.
2. Adult Cow: A mature adult female cattle that has been giving birth are reared separately by leaving them on the grass for ready access to feed. They are fed in a similar way to heifer and should be supplemented with concentrate. Cow should be serviced in such a way that they calve during the wet season.

- Calving rate - this is the number of live calves produced by hundred cows exposed to the bull. The calving rate is influenced by the condition of the bull and proper management and environment of the bull.
- Calf crop - this is the average weight of weaned calves produced per cow per year. The higher the value the greater the production per year.

3. Bull: Bulls are matured male cattle and should be given good feed; allow access to exercise to maintain good body condition. They must not be too fat or too thin. Excess body fat may discourage mounting (reduced libido). Bulls should not be overworked and should be allowed access to concentrate feed especially during the breeding season.

Characteristics to look for when selecting bulls

1. Physical soundness- the animal should be physically active, with good rear legs.
2. Check for libido i.e. aggressiveness
3. Check for good rate of growth
4. Check for good fertility
5. Check the testis

When the bull is about 1- 1½years it could be used for light services, but when it is old enough and as acquired mating expertise, it should be use for about 2 times a week. In natural service one bull is recommended to mate 20- 25 Cows.

Health aspect: this is a very important aspect of management, two major agent must be controlled- i. parasites ii. Microbes (Bacteria, Virus, Fungi, Protozoa). Metabolic problems are not common in beef cattle but in dairy cattle.

Control of bacterial infection is by good sanitation. Keep pens and water trough very clean, isolate new animals i.e. a sort of quarantine. Vaccinate animals at scheduled period and treat sick ones.

Vaccines	Min. age to vaccinate	Duration of immunity
1. Anthrax Spore vaccine	6 months	1 year
2. Black Quarter	4 months	1 year
3. Contagious Bovine Pleuro-pneumonia	6 months	1 year
4. Haemorrhagic septacemia	6 months	3 - 6 months
5. Rinderpest vaccine	6 months	1 year

Vaccinate against prevalent diseases, vaccinate at the right time according to manufacturer's instructions. Ectoparasites include house fly, mite, ticks, tse-tse fly, etc which causes losses in terms of death and reduced performances if not controlled. Tse-tse fly and ticks can cause reduced performance and the death of an animal as a result of blood loss and irritation. Ticks can provide routes for bacteria and can serve

as vector for East-Coast fever, heart-water, tick fever, red-water, etc. Trypanosomiasis is transmitted by tsetse fly in hot and humid areas of the tropics. The fly carries small organisms known as trypanosome which enters the blood stream when the fly bites and it destroys the blood cell and weakens the animal.

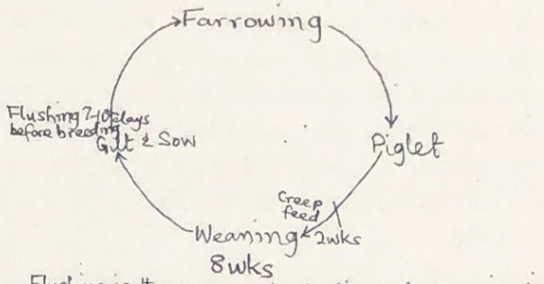
Control of Ectoparasite: Flies can be controlled by sanitation

Tse-tse fly is controlled by i. clearing surroundings of bushes, ii. Removal of wild or game animals which serves as secondary host, iii. Chemical control, iv. Biological control by using sterile males of tse-tse flies.

Ticks are controlled by i. regular clearing of infested pastures, ii. Dipping or spraying of cattle with acaricides.

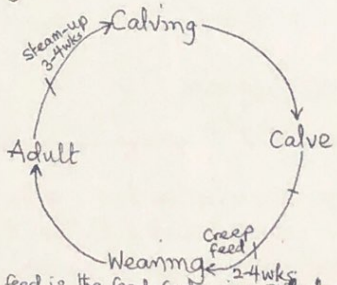
Endoparasites include round worm, flukes, cestodes etc. Conditions that enhance parasitism include i. warm/ humid environment, ii. Heavy stocking rate, iii. Poor nutrition, iv. Grazing animals of different ages together, v. Poor sanitary condition particularly around feeders and watering area.

Ectoparasites can be controlled by i. proper management practices, ii. Supplement proper management with antihelminthes. Deworm tactically and regularly. Pregnant cows should be dewormed 2months before calving, after calving deworm every 3 months e.g. Piperazine, Thiabendazole, Panacur, etc. iii. Practice pasture rotation, iv. Chemical sterilization of grazing area.



Flushing is the increase in feeding rate of an animal before mating in order to increase the number of ova produced.

Steam up is the increase of feed some month before parturition in order to increase the birth weight of the offspring



Creep feed is the feed containing ~~a~~ high quality protein meant to be a close substitute to the mothers milk. It is very digestible and consist of milk and milk by-products.

The Pig Enterprise

Pig lives under extremely divergent condition; however its concentration occurs only where a number of favourable factors combine to support their production. Such factors include

1. Abundance of suitable feeds
2. Good climate
3. Capital
4. Equipment
5. Suitable market
6. Adequate skills on the part of the operator

Selection of foundation stocks

This can be made on one of the following basis

a. Individuality of the animal
b. Pedigree (ancestor)
c. Progeny

Consideration in selection:

1. Litter size: Ability to produce large litters is inheritable; consequently prospective breeding animals should be purchased from at least 8-10 piglets.
2. Weaning weight: Heavy weaning weight is an indication of the mothers nursing ability, so select pigs from gilt litres that weighs 10kg at 42 days, or a range of 11 to 12kg at 42 days.
3. Age of pigs at 100kg (market weight): Weight for age is an index of gaining ability, gilts that is to be used for foundation stock should be 100kg at 165 days and boars in 150 days or less.
4. Body conformation: Select animals that are meaty, good body length, good depth and curves (shapes).
5. Mammary development: At least 12 well spaced teats should be on the animal.
6. Feed conversion: Record of feed intake should be taken and animals that can put on 1kg live weight for every 3.2kg of feed should be selected.
7. Carcass quality: Consumers demand for pork is for lean meat than fat, as a result selection of pigs in relation to meat as being an important criterion for evaluating pigs. Some of the criteria are-
   a. Back fat thickness, BFT- this is known by taking measurement from the 1st rib, last rib and last lumber vertebra.
   b. Loin eye or muscle area - It is the area between the 10th and 11th rib. In a 100kg pig the area should be at least 4inches^2 (4 square inches).
   c. Yield or Dressing percentage - This is measured by ½ of the carcass weight over ½ of the live weight multiplied by 100. For every good meaty pig, dressing percentage should be at least 70%.

d. Percentage Ham and Loin: Weight of ham and loin over carcass weight multiplied by 100. A good meaty type of pig should have at least 40% ham and loin.

8. Freedom from diseases: Animals should be free from diseases and parasites. There are four pathogenic parasite pathways :- cuts/wounds, digestive tract, respiratory tract, and reproductive system.

Pig management can be treated under the following categories -

1. Breeding herd
2. Pregnant Sow
3. Sow and her litter
4. Growing and fattening pigs

1. Breeding herd: This offers a great reward for management because it is from this that all other demands are made yet it is the most carelessly managed, either through lack of dedication or ignorance. Two principal function of breeding herd are i. to produce pigs for fattening/ finishing; ii. To provide a replacement for breeding animals.

Pigs to be used for breeding are separated from those to be sold at about 4 to 5 months or 150 to175 pound live weight. Pigs should have at least 8 functional teats. Gilts usually show 4 signs of heat when they are about 6 months of age but must not be bred at this time because the number of ova shed are very small for large litters to occur. Gilts should be at least 8 months old or weigh 250 pounds before they are bred. The time of sexual excitement in sow or gilt (heat period) should be understood. It is at this period that it produces large ova and accept boar, it last for 2 - 3 days.

Signs of heat include: a. Restlessness, b. Enlargement of vulva, c. Mucus discharge, d. frequent urination, e. Frequent mounting of other animals, f. the animal gives some occasional large grunt.

Gilt (sexually matured female pig that has never given birth) should be mated twice within the heat period. First mating should occur on the second day of heat period when ripe ova is shed and on the third day when the ripe ova has been shed and those not fertilized during the first mating is available for fertilization during the second mating. Deworming and spraying of gilt and sow before they are bred is recommended and sanitary measures should be followed to prevent real infection. Flushing - a term used to describe the increased feeding rate of animal with high protein diet to increase ova production, is recommended 7-10 days before breeding and this should be maintained until the animals are bred. Under no circumstances should flushing exceed 28days. In boar sexual maturity is gradual, some produce few spermatozoa at 4months of age but should not be used for mating because

maximum fertilization will not occur and it shortens live-span. Boar should be about 6months old before it is used for service. Usually the sperm volume of sexually matured ones is 150 - 400ml and much more in older boars. A young boar may settle for 7 to 8 gilt per week or maximum of 3 in 2days while a matured boar can handle 12 to 14 gilts per week. Boars will not perform satisfactorily when constantly subjected to frequent use and they should not be used when fully fed. Exercise is of paramount importance and this is achieved by running them on pasture. Animal should not be used for breeding when sick.

Methods or System of mating:

a. Herd or pasture mating by allowing the boar to run with the sow for part or all of the day. It has the advantage of i. not requiring individual attention of the farmer, ii. Boar derives a lot of exercise by running around hence fat-laying or putting on weight is reduced, iii. Chances of missing heat are reduced because the boar is the heat detector. It has the following disadvantages i. Uncontrolled mating of the boar. The boars may mate more females in a day than the recommended level, ii. When there is more than one boar, the litters sire may not be easy to trace, iii. There is difficulty of keeping records of days of mating, hence dates of farrowing cannot be easily predicted, iv. There is additional risk of preferential mating of the boar i.e. leaving some Sow un-served even when on heat.

b. Hand mating - this involves bringing out the Sow to the boar in the pen for mating. Its advantages include i. facilitate record keeping of all services made together with dates and consequently the expected date of farrowing is known, ii. It is possible to regulate sexual action of the boars and to ensure desired crossing, iii. Sows are settled more promptly since controlled mating practices allow for the maintenance of quality and quantity of boars semen

2. Pregnant Sow and Gilt: Once the sow and gilt has been bred, the management is practically that of feeding. The nutrient fed to a pregnant sow or gilt must take care of its maintenance, growth and development of the foetus. The nutrients that are important in terms of quality and quantity are protein, vitamins and minerals. There is greater demand for nutrient during gestation (period of pregnancy). It is known that in the last trimester of pregnancy approximately two third (2/3) of the growth of the foetus takes place at the last trimester, hence there is an increase in feed intake. This means that demand for food during pregnancy will increase during this period. There is also the need to feed the animal well for abundant milk production after parturition. Mature sow is expected to gain about 34 - 45kg during pregnancy while gilt is expected to gain 45 - 56kg. To achieve this growth rate animal must be fed concentrate at the rate of 1½ to 2% of their body weight.It is good management to keep

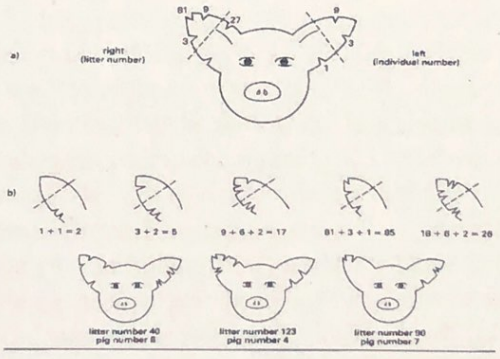
pregnant pigs on open pasture (i) for exercise which prevent laying down of body fat, (ii) source of protein, vitamins and minerals, (iii) they have access to iron in the soil and this helps to prevent body anaemia, (iv) it prevents foot and leg diseases.

It is generally recommended that gilt and sow should be kept separately during gestation and boars separated from gestating animals. Pregnant sow and gilt should be given a clean ride into the farrowing pen a week before farrowing so that they can get used to the environment. Regular but moderate exercise should still continue. Farrowing pen must have been thoroughly cleaned/ disinfected and equipped with the following equipment- (i) farrowing crate, (ii) guard rails, (iii) feeding/ water troughs, (iv) light bedding should be provided, the more unfavourable the weather the greater the bedding materials used. Farrowing pens should be maintained at a temperature of 55 - 65°C and should be well ventilated. Heat lamps can be provided.

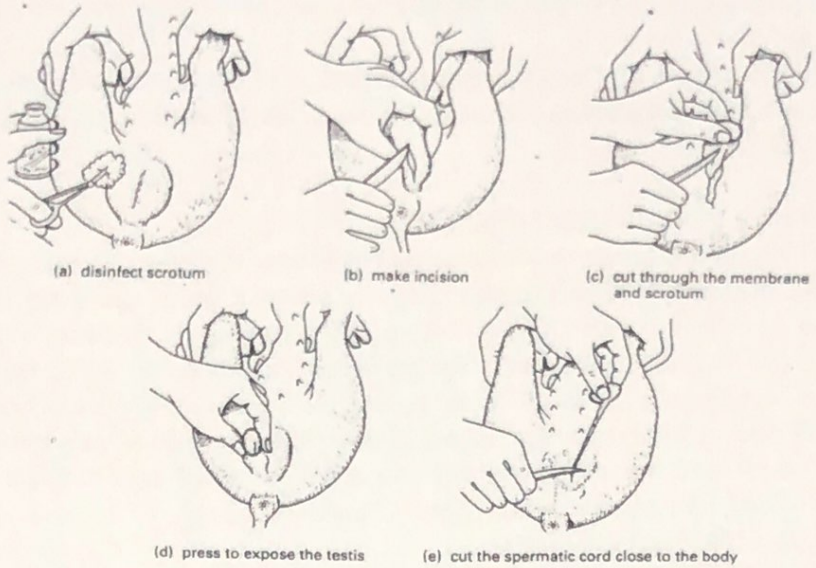
3. Sow and Litter management: At farrowing time, an attendant must be around to help in difficult delivery (like piglet legs coming out first - breech presentation). As soon as pigs are born they should be wiped dry so that they will not die of cold, membranes covering the nostril should be removed to prevent suffocation. Piglets entangled in the navel cord should be freed and the weak ones should be helped to suckle from their dam. The navel cord should be treated with Iodine solution to prevent infection. The second day after farrowing, the needle teeth should be cut or clipped to prevent injury to the teat of the dam when suckling and to prevent injury to other pigs during the process of struggling.

   Administration of iron injection: Since the pigs have been removed from their natural environment there is need for supplemental sources of iron to piglets, otherwise they will suffer from piglet anaemia. To prevent piglet anaemia give iron-dextran injection in the first 2 - 3days of live or give ferrous-sulphate orally. A second dose should be given 2 to 3weeks later.

   Identification of piglets (Ear notching): This is done on both ears; the right ear is for litter number while the left ear is for individual pig number



Castration: This is the removal of the testis from the boar and it should be done at least 2 weeks before weaning. It is important because - (i) it prevent uncontrolled breeding, (ii) reduce boar odour, (iii) helps in the production of meat of better quality



Creep feeding: It's a high protein quality type of feed meant to be a close substitute for the mother's milk. This feed is very digestible and consist of milk and milk by-products. Creep feeds should be introduced to piglets at 2 weeks before weaning. Piglets are normally weaned after 8 weeks of birth. The best way is to remove the sow from the piglets. Before farrowing and weaning, death of piglets can occur from- (i) Overlaying, (ii) Still birth, (iii) Cold, (iv) Starvation, (v) Anaemia.

4. Growing and Fattening Pigs: Feeding is mainly recommended here and about 70% of the total cost of feed occurs here. From weaning to 75pounds, percent protein to be fed is 20 - 25%; at 75 - 125pounds crude protein need is 15 - 20% while at 125 to market weight it is 12 - 15% crude protein. Pigs should be dewormed soon after weaning and the process can be repeated thereafter before market weight.

Types of Swine Production System

1. Pasture system
2. Pasture/ confinement
3. Total confinement

Advantages of Pasture System: (i) Greater flexibility, (ii) Easier to construct, (iii) Capital investment is low, (iv) Animals get more exercise.

Disadvantages of Pasture System: (i) It is difficult to supervise animals especially at farrowing time; (ii) To supply warmth during cold season is difficult, (iii) Overhead cost per animal is higher.

Advantages of Total confinement: (i) More convenient and efficient than others, (ii) Easier to give close attention at farrowing time, (iii) Easier to control the environment in the house, (iv) It can easily be cleaned, (v) Overhead cost per animal is low.

Disadvantages of Total confinement: (i) It has high initial cost.

Diseases of Pigs: Diseases can be the cause of a considerable economic loss in any pig enterprise.

Control of diseases: (i) Good managerial method, (ii) There should be a system of controlling endemic diseases, such as application of anti-helminthes against internal parasites.

MANAGEMENT OF SHEEP AND GOAT

Practically all tropical sheep are maintained on improved grazing. They are often grazed extensively alongside cattle. Sheep are selective grazer and prefer short grasses. As they thrive best in drier climates where feed supply fluctuates both in quality and quantity, supplementary feeding is important especially during the dry season. Roughages are obtained by grazing while concentrate is supplied in pens to furnish nutrient for maintenance and production. During grazing animals have the opportunity of selecting the grass they like and their faeces/ urine increase the nutrient level of the soil. On the other hand these animals are exposed to diseases and trampling of the grass in the pasture.

Good feeding is very important just before the breeding season begins; this practice helps to improve prolificacy. Good feeding is also important during the later part of pregnancy. Salt should be given to the animal and they should have access to clean water everyday. Castration, if practiced may be carried out using a knife or elastrator. Docking of tail is desirable in wool breeds. Weaning of sheep is usually done at 4- 5 months of age but early weaning can be done in 3 months. Average age at puberty depends on breeds but varies between 5- 10 months.

Flushing makes the animal to superovulate and improve the body condition. **Steam-up** helps the mammary gland to produce milk, improve the body condition of the ewe and development of the foetus and it also eliminate pregnancy toxaemia i.e. weakening of energy of the dam. The normal feeding after **tupping** (copulation) reduces still birth caused by the narrowness of the pelvic girdle while the normal feeding after weaning prevent fatness of the female which can cause reduction in fertility. Housing is important to protect animal from rain and heat. Excessive moisture without proper shelter leads to greater incidences of diseases such as pneumonia. Housing of sheep and goat should not be very expensive and should be clean and easy to make. There are three types of sheep production systems - extensive, semi-intensive and intensive. Extensive system allows for free range, requires large area of land, especially in areas where the land is unsuitable for

agricultural production. Intensive system is expensive but provides protection against adverse condition. Semi-intensive system combines the advantages of the extensive and intensive production.

Diseases and Parasites: This can be combated with the aid of good management, proper feeding, and strict sanitation: Some of the diseases affecting sheep include - Rift valley fever, Sheep pox, Heart-water, and Foot- rot.

Goat reach sexual maturity between 4 to 6 months of age but the best in management practice is to delay mating until the does are near matured body weight so that pregnancy does not coincide with the period when the does are actively growing. Duration of oestrous cycle (interval between one heat and another) is 18 - 21 days, and the duration is about 24 - 36 hours, the same for sheep. Gestation (period of pregnancy) length is about 145 - 14 8 days, although two kidding is possible yearly the most common is to have three kidding in two years. Kids should be given colostrums since it stimulate the alimentary canal, provide vitamin A, contains antibodies that confers immunity against disease.

Energy requirement for maintenance of goat is the same as for sheep.

POULTRY PRODUCTION

Poultry is used as a general name for several kinds of birds that are useful mainly as food for man. They include the domestic fowl, ducks, geese, turkey, guinea-fowl and quail. Poultry can be classified as

1. Egg type
2. Meat or table type
3. Breeders

1. Egg type: The egg types are the layers reared for table-egg production. They are reared through three main stages- the chick stage, the pullet stage and the layer stage. The chick stage starts from the day old to 8weeks and it is fed with chick mash. From 8 weeks to 20 weeks it is called a pullet and is given a grower mash. When it starts laying after 20 weeks it is called a layer and it's given a layer mash.
2. Table bird type: These are kept for the production of poultry meat and are mainly broilers. They are fast growing birds which reach market weight of 1.6 to 2.0kg within 12weeks. From day-old to 4 weeks, they are fed with Broiler-starter mash and from 4weeks to slaughter they are fed finisher-mash. Other sources of poultry meat are Spent layers and Roasters i.e. by-products of the pullet chick production and they are reared for about 20 weeks.
3. Breeders: These are birds reared for the production of hatchable or fertile eggs.

Classification of Poultry feeds

Poultry feed are made mainly on the basis of the protein requirements of the birds aside other factors such as energy requirement, grit size calcium/phosphorus level

etc, so classification is based on protein content.

Chick mash contain 20% of crude protein

Growers mash contain 16% of crude protein (Roasters - higher calcium/phosphorus)

Layer mash contain 15% of crude protein

Broiler-Starter mash contain 22% of crude protein

Broiler-Finisher mash contain 18% of crude protein

The young birds require more protein than the adult ones because they are actively growing.

Poultry Management Systems

The performance depends on environment and the genotype. The system of management determines the environment to which the poultry is exposed to. In the extensive system, exposure is practically limitless with natural advantages in terms of vitamin A gotten from the pasture and vitamin D from sun/ pasture. Simple inexpensive and movable shelter is primarily provided. Feeders and drinkers are placed on pasture at some distance from shelter. In the intensive system, birds are kept in cages or on deep litter floor. This is more popular in commercial production. Deep litter is used mainly for rearing chicks, raising of broilers and for managing layers while the cage is primarily for layers. The two systems are not different from each other in efficiency and capital investment under good management. Both the cage and deep litter system are characterized by fixed wire mesh covered open-sided buildings. Birds are confined and prevented from sunshine and pasture, so nutrient must be provided to cater for the deprived nutrient. In the deep litter system, the floor is covered with materials like wood shavings, maize cobs and pea-nut shells, these materials are water-absorbent whereas in the cage system birds are housed one or two in different compactment. The advantage of the cage system is that birds are prevented from contact with droppings and pecking-order does not occur because they do not have colony. The deep litter on the other hand has the following advantages it helps in reducing the concentration of dropping, and because the litter is diluted it controls the outbreak of diseases, it also absorbs water from droppings hence it prevents the growth of pathogenic organism. The deep litter system, feeders/ drinkers are placed inside the houses. The number of feeder is related to the size of the house and number of birds to be fed. Drinkers should not be far away from feeders.

Age	Floor Space
8 - 12weeks of age	0.06- 0.07m^2/bird
12weeks- point of lay	0.125m^2/bird
At point of laying	0.15m^2/bird

In the cage system, the feeders/ drinkers are component parts of the cage. The number of bird per cage is according to the manufacturer's specification. Overcrowding of

birds can lead to reduced egg production as birds will be stressed.

Rearing of birds: The objective of rearing is to provide environmental condition that promotes satisfactory growth, feed conversion rate and low mortality. Broilers should be 1.5 - 2.0kg at market weight (12weeks). Pullet should be 1.0kg. Birds at point of laying should be 1.5 - 2.0kg depending on strain. Layers are not allowed to grow very fast as broiler because of sexual preciosity or else they will produce small size eggs and have short life span.

Brooding: This is the provision of heat, water/ feed but most especially heat. It can be performed by

1. Natural method: Here hen is used in breeding but the system is not efficient.
2. Artificial method: Here we use the brooder; we have different types or model paraffin, electric, gas and coal type. It is very important that the source of heat should be constantly available and easy to operate with minimum risk of fire outbreak.

For preparation for arrival of birds, you clean the house with disinfectant; allow drying, putting litter and installing brooding equipment. Brooder should be switched on 24- 28hours before the arrival of chicks. Inspect chicks on arrival and remove deformed or dead chicks. The environmental temperature in which chicks are exposed to decreases with age.

Week	Temperature, °C
1	32.2 - 35.0
2	29.7 - 32.2
3	26.6 - 29.7

The area of play of the birds should be watched, if they cluster around the brooder light it means the temperature is too low and should be increased. But if they move close to the guard rail, it means the temperature is too high and should be reduced. In addition to temperature control the amount of floor space should increase with the increase in age of the birds. This is achieved by moving the guard backward every two days. After 10days the guard should be removed. During the first few days chicks are fed on flat feeders. They are also provided with small water fountain which are regularly washed while some use automatic feeders. Large feeders/ drinkers are used for adult birds. Birds are debeaked using debeaker when they are 2 - 6weeks old to prevent pecking. Pullet chicks are sexed at a day old to prevent precocious mating and social friction. Broiler chicks need not be sexed because they will be slaughtered very early, and because at 8weeks the male and females are still very compatible. Sex linkage or plumage may be used for sexing.

Management of Adult birds: The adult birds are either layers which are maintained to produce table eggs or breeder which produce hatchable eggs. When birds reach point of laying they are moved to the laying house which must have been well cleaned. One feeder is recommended to serve 25 birds.

Birds must have completed their vaccination before movement including deworming/ delousing. Movement of birds should take place during the cool time of the day. Breeders and layers are managed by providing water/ feed *ad libitum* (free unrestricted access to feed/ water). But if birds tend to laydown fat, feeding should be restricted. Sick and unproductive birds should be culled (removal of unproductive animals). These unproductive birds can be identified through external features such as-

1. Small and dull comb
2. Parrot-like beak
3. Dull and sunken eyes
4. Small and dry vent

Those that produce good eggs have -

1. Short and stumpy beak
2. Bright and large comb
3. Large and moist vent

Characteristic features of a good layer

- Broad and square head
- Short beak
- Bright and bulging eyes
- Smooth and lean face
- Large fine comb
- Bright red comb and wattles
- Soft and pliable abdomen
- Absence of cannibalism tendencies/ aggressiveness
- Broad flexible pelvic bones
- Wide, moist cloaca
- Pale coloured shanks
- Absence of broodiness
- Glossy plumage

Egg collection: This is done at 12 noon and between 3, 4 and 5 PM after which birds tend to lay eggs. As for the breeders, male should be introduced to the female about 6weeks after point of lay. Fertile eggs should not be stored in a cold and dry place because the embryo tends to develop. Store eggs for only few days after which hatchability decreases by around 4%. If eggs are to be stored for more than 6 days, turn thrice daily to prevent embryo sticking to shell walls. Eggs collection from breeders should not be done until after 7 days of introduction of males to female to allow for fertilization. Mating ratio of 1male to 10 females for light breeds and 1male to 8 females for heavy breeds should be practiced.

Feeds: This accounts for about 60 - 70% of production cost and it's the major constrain to poultry production. The major ingredients are maize, groundnut cake, soybean meal or cake, fish meal, Oyster shell, bone meal, etc. Maize is the main energy source; groundnut cake is the plant protein while fish meal is the animal protein. Oyster shell supplies calcium, bone meal provides calcium/ phosphorus. Di-calciumphosphate also provides calcium and phosphorus. Other ingredients include vitamins/ mineral premix. All these are ground into sizes depending on the ages of bird and mixed in proportion suitable for the birds in terms of providing protein, energy and other essential nutrient.

	Protein, %	Metabolizable Energy, Kcal/kg	Calcium, %	Phosphorus, %
Broiler Starter (0-5weeks)	23 - 24	3,000 - 3,200	1.5	0.8
Broiler Finisher (5 8weeks)	20	3,000-3,200	1.5	0.8
Pullets (0 8weeks)	20	3,000-3,200	1.5	0.8
Grower	15 - 16	3,000-3,200	1.5	0.8
Breeder/ Layers	15 - 18	2,850	3.5	1.2

Broilers consumes about 3 to 4kg of feed to market age with a feed efficiency of about 0.5 - 0.6 (weight gained/ feed intake). A Pullet consumes about 10kg to the point of laying.

Special Operations	Age of bird
1 NewCastle Disease Vaccine intraocular(NDV $_{i/o}$)	Day old
2 Toe clipping	2weeks
3 Fowl pox vaccination	2weeks
4 NewCastle Disease Vaccine (repeated)	3weeks
5 Debeaking	4weeks
6 Vaccination against Typhoid, Cholera, Newcastle disease	6weeks
7 Deworming	7weeks

The days of vaccination are spread out to minimize stress on the birds

Poultry can be raised under three management systems i.e. extensive, intensive and semi-intensive.

Extensive system (free range): In this system of poultry management, the birds are

allowed to roam about and are exposed to sunshine and pasture; they obtain little or no care. They are exposed to danger, theft and predators. Egg may also be laid in the bush and therefore not available for human use. They may be provided with a nest where they would spend the night. This system cannot be practiced commercially and it is usually practiced for home consumption especially in the rural area.

Semi-intensive system (fold system): In the semi-intensive system the birds are kept in houses provided with grass-runs i.e. they are partially confined. The runs are fenced, the birds are able to obtain enough exercise and also some green feed and sunlight. In this system, some food is given to birds, this system combines the advantage and disadvantages of both intensive and extensive system.

Intensive system: In this system the birds are totally confined and because of the confinement the birds require a highly balanced diet therefore the cost of feeding is very high but the cost of their products usually offset the cost of production. There are two sub-divisions under this system:

i. Battery cage system: This is the most popular intensive system used mainly for layers in which the birds are kept in small cages. The cages are made of galvanized wires and are linked in rows arranged in tiers. The floor slopes forward to enable the egg roll on to the cradle. Each hen is confined to a cage just large enough to permit very limited movement and to allow her to stand and sit comfortably.

Advantages of battery cage system

1. Birds make little contact with one another and with the faeces, so little disease outbreak is experienced.
2. Birds are easier to manage i.e. saves labour
3. Sick birds are easy to locate.
4. Enable easy record keeping of each bird and thus facilitates culling of unproductive birds
5. Birds are able to feed and take water in comfort.
6. Feeding/ watering troughs cannot easily be contaminated, hence minimize the spread of diseases.

Disadvantages of battery cage system

1. Capital cost is relatively high.

ii. Deep litter system: This is an intensive system in which the birds are continually confined to a well ventilated house of concrete floor covered with litter of absorbent materials such as saw-dust, corn-cob, straw, dry grass or wood shavings. Roofing can be of asbestos or iron sheets. Feeding and watering troughs as well as laying nest boxes are provided for the birds. The litter is stirred up with a fork at frequent intervals to encourage microbial multiplication within it. These microorganisms assist in breaking down the poultry droppings and convert the litter into a mass of fine, dry odourless material.

Advantages of deep litter system

1. It increases efficiency in poultry management.
2. Facilitates the management of very large flock.
3. It maximizes the use of land.
4. It increases rate of land
5. It maximizes the use of labour.
6. Reduce loss of eggs to vermins, snakes and thieves.
7. Birds are protected from harsh weather conditions
8. Facilitates the ease of identification of sick birds.

Disadvantages of deep litter system

1. High cost of construction of deep litter house
2. Requires a large quantity of litter which adds to the cost of production.
3. There is wastage of feed by birds.
4. Cannibalism and pecking of eggs are common.
5. High rate of disease/ parasite spread.
6. Litters make eggs dirty.
7. Difficulty of determining unproductive birds.

Disadvantage of using saw-dust as litter in deep litter house

1. Due to its fineness, it is not durable as litter.
2. The birds inhale the dust which creates chest congestion, leading to respiratory problems.
3. Cakes up easily.
4. Harbors more bacteria than other system.
5. Also contains more foreign bodies like nails, etc than any other systems.

Poultry housing orientation

Any type of housing should provide protection against rain, wind, sunshine and cold. The housing unit should also protect against predators such as dogs, cats, thieves, etc. The size, shape and height of the building are often determined by the size of operation and the farmers taste.

- The building should be far away from heavy traffic since birds are disturbed by frequent noise.
- The land should be well drained to avoid flooding.
- An East - West axis is preferred to avoid excessive entry of sunlight into the house.
- The building axis should be away from the direction of the wind.
- Future developments should be borne in mind when designing buildings e.g. future incorporation of incubators, feed-mills, etc.
- Standard houses can be 10m wide and 70m long, about 2.4m high at the eaves

and 4m high at the ridge.

- Walls can be made of blocks or wood and can be 1m high.

Preparations for receiving day old chicks for rearing

- Clean and wash brooder house
- Repair broken/ damaged floors, roofs, windows
- Disinfect brooder house
- Spread wood shavings to a depth of 6 - 8cm in brooder house
- Provide adequate floor space/ provide reliable heat source
- Stock chick starter feed
- Wash and dry feeders and drinkers
- Keep handy a supply of vital medicants e.g. anti-stress
- Net the windows to keep away flies, rodents, etc.
- Ensure a dry brooder house before chicks arrive
- Warm up brooder house to 35- 39°C before chicks arrive
- Make a small shallow trench filled with water or engine oil around brooder house to deter soldier ants invasion
- Place foot dip with disinfectant at the entrance of brooder house.

Sanitation in intensive poultry management

- Feed only clean diet and water
- Cull off all sick birds promptly
- Restrict visitors to farm
- Avoid keeping different age group of birds together
- Provide footbath at the entrance
- Purchase foundation stock from accredited breeders
- Vaccinate animals regularly against notifiable diseases as and when due
- Remove and bury of all dead birds promptly
- Screen windows against wild birds and insects
- Ensure adequate ventilation of the house
- Maintain a dry litter if deep litter system is practiced
- Deworm at regular intervals
- Spray or dust birds at regular intervals against ectoparasites
- Clean all equipment thoroughly before use
- Avoid bringing in recycled bags of feed from outside
- Clear the surrounding bush/ weeds around the poultry house

Feeding of birds under intensive poultry management

- Feed with balanced diet fortified with minerals and vitamins
- Feed birds *ad libitum* for good growth
- Feed birds according to age

- Feed according to purpose of production
- Provide feeds in feeding trough
- Supply clean drinking water always

Common diseases of poultry

- Newcastle disease
- Aspergilosis
- Coccidiosis
- Fowl typhoid
- Chronic respiratory disease (CRD)
- Fowl pox
- Fowl cholera
- Favus
- Infectious coryza
- Marex
- Pullorum/ bacillary white diarrhea
- Gumboro/ infectious bursal disease

The Poultry Enterprise

The keeping of poultry depends on the purpose of keeping them and it often influence the type of bird to use as the foundation stock. The various poultry enterprise we have include

- Hatchery (rearing of breeder stock with the aim of hatching the eggs - hatchable-egg production in an incubator for sale as day-old chicks),
- raising of broilers for supplies to industries, restaurant and during festive periods,
- raising of layers as point of lay or for table-egg production,
- feed production (feed mills),
- cold stores/ trading in chicken parts.

MANAGEMENT OF CHICKS: The management of chicks involves the following three operations:

1. Procurement of the chicks i.e. placing order for chicks.
2. Making preparation for brooding
3. Brooding

1. Procurement of the chicks: Placing order for chicks is important for the following reasons;

- Chicks are not available in most hatcheries daily. Hatching is done usually once or twice in a week.
- Most hatcheries set eggs according to projected demands usually indicated from previous bookings.
- Serious business cannot afford the risk of disappointment if chicks become unavailable on hatcheries especially where large number of chicks is needed.

Factors to consider in placing order for chicks

1. The time chicks are needed i.e. hatching period, layer replacement schedule.
2. Number of chicks needed.
3. Choice of breeds (of chicks).
4. Source of chicks
5. Type of chicks.

1. The time chicks are needed: For chicken it takes a minimum of 3weeks for eggs to hatch. Ideally it is good to place order for chicks giving at least 3months notice to meet demand (a minimum of 3weeks). When placing order for chicks from abroad at least 6weeks notice should be given - for hatching and for communication. You determine layer replacement schedule for the flock. If you have a flock of layer birds and you want to rear the replacement stock by yourself you bring in the chicks 5 - 6 months to the end of lay because it takes 5 - 6 months before the chicks start to lay. It means that you place order for the chicks 3months ahead of that time i.e. before the 5 - 6months to the end of laying. For example, if the month laying started is January. Anticipated laying period is 12months (for some 10months while others are up to 15months). The month, the replacement is due will be = (Jan. + 12months) 6months (to rear bird to laying) = July. Therefore, the month to order for chick will be = July - 3months (notice for supply) = April. Prepare a chick replacement ordering chart (chick ordering chart) especially for broilers if cropping is weekly, fortnightly or monthly.
2. Number of chicks needed: Having gone through the time chicks are needed, we then consider the number of chicks needed. The number of chicks needed depends on (i) the available space for brooding, and (ii) the number of layers to replace. You buy as many as can be taken care of. (a) Provide 0.046m^2 per chicks' space from day-old to 8 weeks. For example, if the length of the brooder house is 15m and its breadth 10m, the Area = 15 x 10 = 150m^2, therefore the number of chicks that can be housed = 150 ÷ 0.046 = 3,000 chicks (for 8 weeks). In the cage we usually provide 277cm^2 per chick i.e. more chicks are needed in the cage than on the floor. When placing replacement for layers, give 10% allowance for mortality (5%) and sexing error, runts/deformities (5%). These allowance varies with the experiences that occur in individual farms e.g. if the farm is hygienic and mortality is low, the allowance could be low. For example to replace 5000layers, provide 10% allowance, i.e. 5,000 x 10/100 = 500 chicks. So place replacement order for 5,500 chicks. Fine method of calculating layers replacement stock to replace 2000layers, let □ represent the number of chicks needed, □- 10% □ = 2000, □ - 0.1□= 2000, □ - □/10 = 2000, 10□ -□ = 20,000, 9□ = 20,000, □ = 20, 000/9 = 2222.2 = 2223day-old chicks. If buying unsexed or straight-run chicks (the ratio of male to female after hatching is 1:1) multiply

whatever you get by 2 to allow for the males. So if the above is calculated for unsexed chicks, the number of chicks required will be 2223x2.

FORMULA FOR STOCKING

$1m^2$ for 5 Layers

$1m^2$ for 10 Broilers/Growers

$1m^2$ for 20 Chicks

e.g. suppose a room measures 10m by 8m, the stocking rate = Area = $10 \times 8 = 80m^2$; for Broilers = $80 \times 10 = 800$ broilers; for layers, divide it by 2 = 400; for chicks, multiply it by 2 = 1,600 chicks.

3. Choice of breeds: This is another factor to consider when ordering for chick. Breed is a group of birds which are developed from some carefully selected common ancestors. Therefore birds belonging to one breed have certain common characteristic which distinguishes them from other breeds within the same poultry species. Some of the distinguishing characteristics are;

(i) Liveability
(ii) Age at sexual maturity or onset of lay
(iii) Egg laying ability
(iv) Colour and size of eggs
(v) Colour of feathers/ shanks
(vi) Type of combs
(vii) Resistance to diseases, parasites and other stressors
(viii) Freedom from known vices
(ix) Shape and size/ average body weight of growing and adult birds
(x) General appearance of birds during and after ceasation of lay
(xi) Feed consumption rate

You can find breeds with one or two of these characteristic the same but differs in others. No breed is the best because each is developed to manifest some particular characteristics. Therefore in choosing a breed it is better to seek the advice of successful farmers who have been using various breeds. The hatchery is not the best place to seek advice in choosing a breed because they will naturally want to sell what they have. Specific characteristics of a breed are usually provided by the breeders for various hatcheries. The hatchery can make such information available to interested customers. The following are names of some breeds-

	Layers	**Broilers**
i.	Warren	Ross
ii.	Babcock	Hubbard
iii.	Harco	Cobb
iv.	Shaver	Anak

	Layers	Broilers
v.	White leghorn	Starbro
vi.	Rhode Island red	Indian River
vii.	Hyline	Lohmann 75
viii.	Hisex	
ix.	Yarkon	
x.	H & N	
xi.	Ranger, etc.	

The name that is given to a breed depends on the breeders; there is nothing special about the names. The names of the breed can be the name of a town or country where the breed was developed e.g. Rhode Island Red in USA (Rhode Island) or the breeders' personal name or the name of some people, places or objects as he wishes.

4. Source of chicks: Chicks should be bought from reputable hatcheries or chick dealers. A reputable hatchery would be well managed, free from diseases and will have good breeds of chick. A chick dealer or agent is one who buys large quantity of chicks from the hatchery and distributes them to the farmers. He stands as the middle-man between the hatchery and farmers. Some chick dealers sometimes import chicks which an average poultry farmer may not have the priviledge of doing. A reputable chick dealer must have good chick handling equipments and reliable services which will prevent the chicks from dying or been over-stressed. Such a dealer must be able to keep his dates with the farmers. To do this he must have a reliable contact with the hatcheries and must not be over involved with other businesses at the expense of keeping his dates with the farmers.
5. Types of chicks: Chicks can be classified into types under three categories- (i) the purpose for which the chicks are kept, (ii) the sex, (iii) the age.

i. Purpose for which the chicks are kept: Chicks can be kept for three main purposes as broilers to provide meat, as pullets to provide eggs, and as cockerel to provide fertilized egg for hatcheries. Therefore when ordering chicks, you state clearly whether it is pullet chick, broiler chick, etc.

ii. Sexing: Hatched chicks can either be sexed ones (in which the sexes are determined already) or unsexed or straight-run chicks (in which the males/females are not separated). Although if one says he needs pullet chick the sex has already been identified, so the chick needed will be the sexed ones. Chicks sex could be determined through any of the methods below-

a. Wing feather development (variation in length of the primary and covert feathers). The covert feathers are on the surface of the wing whereas the primary feathers are on the underside of the wing. In female chicks covert feathers are about one and a half times longer than the primaries i.e. early feathering. While in male chicks coverts are as long as or shorter than the primaries i.e. late feathering.

b. Barring character (Bb)(Sex-linked gene): Male chicks have white head spots at

the occipital region while female chicks are without white spots.

iii. Age: Chicks can either be day old (around 1 day or more old, but has not started feeding) or starter chicks which are those that has started feeding. Day old chicks are not fed, and note that chicks can survive without feed for 3 days. Starter chicks are those that have not been raised to about 1 or 2 weeks or to the point of lay. They have the disadvantage of being costly and farmers that raise starter-chicks can easily classify starter-chicken of the same age but different sizes into different ages to attract higher price from buyers. You can always design your chick order form

.2. Making preparation for brooding: Necessary preparation for brooding involves the following operations:

i. Provision of suitable brooder house
ii. Assembling and testing brooding facilities
iii. Cleaning and disinfecting brooder house and equipment
iv. Setting up brooding facilities
v. Collecting or receiving the chicks

i. Provision of suitable brooder house: An ideal brooder house would have the following characteristics (a) Good location - the house should be located at least 100m away from the adult birds to reduce danger of disease transmission. It should be located in such a way that air or wind moves from the brooder house to the adult birds and not otherwise. This arrangement entails providing a separate house for brooding especially where it involves large number of chicks. Where residential houses are provided for the attendants of the farm it is advisable that the brooder house be fairly close to the attendant house because the chicks may need attention at odd times e.g. at night if some heaters turned off or bring out smoke. If the poultry house is not fenced, it is necessary to fence round the brooder house to keep off or reduce traffic to the house in preventing disease transmission. (b) Adequate building specifications the house should have adequate space to accommodate the chicks through the 8 weeks brooding period. There should be window or vent which can be closed to conserve heat and prevent draught (fast moving air) while brooding, and opened for added ventilation when chicks have outgrown the need for supplementary heat. The materials for building the house should be able to conserve heat during the cold period. Block wall is preferred to the use of roofing sheets as wall. It is important to concrete the floor of the brooder house so that it will be easier to clean up later, wash and disinfect. There should be no crevices on walls and floor through which rats can invade. The roof of the house should be free from leakage because of the rain. At the entrance of the house there should be a footbath for disinfecting soles of shoes.
It is also useful to have a shallow gutter of water round the house. Inside the water you put oil droplet to prevent mosquitoes from breeding. The water usually serves as barrier for soldier ants.

ii. Assembling and testing brooding facilities: The following facilities are necessary for floor brooding

a. Heater

b. Brooder guards
c. Hovers or brooder boxes
d. Feeders
e. Drinkers
f. Litter material
g. Litter cover
h. Feed and water
i. Drugs and vaccines
j. Supporting facilities

a. Heater: There are different type of heaters which vary according to size, construction and source of energy for heating. For example gas, kerosene, electricity, coal, firewood and biogas are sources of energy for heating. These generate energy for lamps, lanterns, stoves, bulbs, plates, etc. Gas, biogas and kerosene heaters can be lamps, lanterns, stoves and gas-plates attached or unattached to hovers. Electric heaters may be electric bulb or electric plates. Coal and firewood may be ignited in heating chambers within the brooder room to heat the whole room. Hot-water pipes can also be laid within the brooder room for heating. In some places in temperate countries such pipes are also laid under the deep litter floor. Many heaters especially those attached to hovers (conical-shaped structure to make heat concentrated) usually have heat regulators/ thermostats. The number of heaters to provide for a brooder house depends on -

1. Method of brooding: Partial house or total house brooding. While heat is provided within the brooder guard in partial house brooding, the whole pen is uniformly heated in total house brooding. More heat is therefore needed in the latter.
2. Number of chicks in the house: The greater the number of chicks the more heat needed because larger space will be required to accommodate them.
3. Size or heating capacity of the heater one stove depending on the size is equivalent to 3 or more lanterns in terms of heat output.
4. Weather conditions less heating is needed during the hot season than during the cold periods. Generally when weather conditions are average 2-big or 3-small lanterns are needed per 100 chicks during the first few days of brooding. Similarly about 1-watt of electricity is needed per chicken.

Where heater is attached with hover, the stated capacity of the hover will determine the number of chicks it can brood. The capacity is usually about 500-1000 chicks per hover. If electric brooders are used for brooding it is advisable to have some other types of brooders as stand-by in case of power failure. There would be no fear of power failure if electricity supply is stable or if the farm has stand-by generator. All heaters must be tested to ensure that they are

working satisfactorily.

b. Brooder guard: This is the material used to provide a confined environment within the pen for the chicks during the first 1-2weeks. This is important for the following reasons -

1. The circular guard helps to keep chicks within a confined environment where they would be readily accessible to heat, feed and water.
2. It helps to concentrate heat within a limited area (partial house brooding) thereby reducing the number of heaters as might be needed in total house brooding.
3. Chicks are prevented from piling in corners which is often the case in rectangular pen.
4. Attendants find it easier to work in the pen because the risk of stepping on frail chicks is reduced.

While a few other materials can be improvised in constructing the guard, foldable ceiling boards have been found very suitable. A ceiling board usually measures 240 by 120cm, this is halved into 240 by 60cm.The 60cm height (2ft) can be easily hurdled over. Many halves are lapped together to construct the guard. Lapping can be done by using cloth hanging pegs or clips or improvised wire clips or the laps can be drilled and tied with rope. Three halves lapped together with a diameter of about 2m will adequately accommodate 100-200 chicks for 1week. Four halves will accommodate 300-400 chicks while five halves will accommodate 600 chicks, etc. Sometimes where brooder guards are provided there may be no need for hovers.

c. Hovers or brooder boxes: These are shields designed to provide environment where brooder heat is most concentrated. When chick feel cold they usually take cover and keep warmer under the hover. Hovers and brooder boxes differ in designs and construction material but they basically perform the same function. Some of them are designed to be placed on the floor and some are hung on the roof. Some have cloth curtains between their edges and the floor. Some are designed to allow electric bulbs to be fixed under them and some have gas or electric plates connected to them. If the hovers are placed high enough above the floor, stoves, lamps or lanterns can be placed under them. A brooder box or hover is usually provided for about 500 chicks. Manufacturers of hovers usually specify the brooding capacity, how many chicks could be brooded under it.

d. Feeders: In the first week chicks eat more conveniently from flat trays. They crowd inside the tray to eat. One tray of 60 by 30cm can be provided for about 100chicks for one week. Care must be taken to prevent feeders and drinkers occupying the whole floor. Long or conical shallow feeders can be provided after the first week. The depth of the feeder will be 5-10cm. Long or conical feeders can also be provided after 2days of brooding along with tray feeders. The numbers of feeders needed can be calculated by providing 5cm feeding space per chick. Often a

feeder is provided for 50 chicks and above for the 6 - 8 weeks brooding period depending on the size of the feeder. E.g. if a feeder is 90cm long, how many of the feeder will you need to brood 500 chicks? Answer: Each chick will need 5cm space. Since it is 90cm long, both side will be 2x90 = 180cm, therefore 180cm will be needed for 180/5 = 36 chicks; for 500chicks, the number of feeder will be 500/36 = 14feeders. NB: for circular feeder, use $2\pi r$ to calculate the circumference.

e. Drinkers: In the first 3weeks 100 chicks will require 1drinker of 3litre capacity, thereafter, until the 8th week 2 drinkers of 3litre capacity should be provided i.e. for the first 3 weeks you provide 1drinker for 100 chicks. Thereafter due to their size they'll need more drinkers i.e. 1drinker per 50 chicks. If the big automatic hanging drinker is used, one of such drinker is adequate for 100 chicks till 8 weeks.

f. Litter material: This is the material spread on the floor to act as insulation against cold and to act as absorbent for faecal moisture. Litter materials include wood shavings, sands, chopped corn cobs and chopped straw. Among these, wood shaving is the most common. One jute sack of wood shaving is adequate for a 4m2 area. With four halved ceiling boards lapped together to form a brooder guard the quantity of wood shaving required for the space is 2 full bags of the 25kg feed bags.

g. Litter cover: It is usually desirable to spread paper to cover the litter for the first 2 4 days of brooding to prevent chicks from eating the litter. If they eat the litter in large quantity they may have stomach compaction. Litter is mostly fibre (cellulose) which is not digestible by chicks. Old newspaper or empty paper bags are suitable as litter cover. Glossy paper is not good because it can be slippery if wet and this can cause sprawling of the chicks legs.

h. Feed and water: It is important to ensure that there is fresh feed and clean water at least 1 or 2 days before chick arrives. Chicks eat starter mash. Each chick will consume about 2kg of starter mash during the 8weeks brooding period. One bag of feed normally weighs 25kg.

i. Drugs and vaccines: The following drugs are important to procure

1. Fortified antibiotics (antibiotics with vitamins) e.g. Medic aid, Floxaid, Chick formula, etc. Each of this drugs is good as anti-stress as well as antibiotics. Some also contains vitamins which are of nutritive value to the chicks. You should not use more than one of them at a time, and any of them that is used should be use according to specification or as prescribed by the veterinarian.
2. Coccidiostat e.g. Amprolium or Amprol. This is a drug used prophylactically (preventive) or therapeutically (treatment) of coccidiosis.
3. Dewormer e.g. Phenothiazine
4. Disinfectants e.g. Detol or Izal often used for disinfecting poultry houses/ equipment and in foot-bath to disinfect shoe-sole
   Detergents e.g. Bar-soap or powder-soap or liquid-soap which are used for washing equipment. Sponge and brush can also be provided with this.

Vaccines to procure include the following-

1. New-castle disease vaccine (NDV) e.g. $NDV_{i/o}$(intra-occular if not applied in the hatchery), Lasota (orally through water) and Kamorov (intramuscularly).
2. Gumboro vaccine
3. Fowl-pox vaccine
4. Fowl cholera vaccine
5. Fowl typhoid vaccine

The last two vaccines are not often needed except where there is the prevalence of the disease.

j. Supporting facilities: These are facilities that support brooding operation. They include the following-

1. Water tank for water storage.
2. Wheel barrows for carrying heavy materials such as chicken crates, litter, feed bags, etc.
3. Feed bin for storing feeds from opened bags.
4. Feed scoops for packing or scooping feed from bin into feed containers and troughs.
5. Catching guard or hurdle for driving chicks into confinement when catching them.
6. Chicken crate or Coop for conveying grown up chicks. Small chicks are usually conveyed in chick boxes.
7. Incinerating drums for burning dead chicks. Going along with these are matches and kerosene.
8. Drinker stand and grills. The stand is just like a platform on which drinkers are placed. Grills are net or wire-netting usually shaped to cover open drinkers to disallow chicks from jumping into it.
9. Buckets for conveying feed from bin to feeder and for conveying water.

iii. Cleaning and disinfecting brooder house and equipment: Brooder pen and equipment should be washed and disinfected before use. Disinfection helps to kill pathogens that can be hiding in crevices and corners of pens and equipment. This practice helps to prevent the occurrence of diseases. Disinfection should be completed at least 2 - 5days before chick arrival. The following procedure can be followed in disinfection -

1. Move out all equipment from the pen.
2. Pack the litter out.
3. Sweep the floor of the pen and remove all cob-web from wall and roof.
4. Add disinfectant such as Izal or Detol freely and generously in water or according to specification.
5. Sprinkle or spray the disinfected water generously on the walls/roofs. If the walls are painted with gloss (oil) paints, they can be washed with

broom or bush using the disinfected water with a detergent like powder or liquid soap.

6. Wash the floor with disinfected waters taking special care of the corners.
7. Wash every washable equipment carefully with detergent and disinfected water. Equipment to be washed are hover or brooder boxes, feeders, drinkers, drinkers stand, drinkers grills, heaters such as lamps or stoves and brooder guards if any of them is used.
8. Allow the pen and equipment to dry.
9. Test the drinkers after washing against any leakage.
10. Pack in the equipment and set them up for brooding.

iv. Setting up brooding facilities: Having assembled the required number of necessary facilities and disinfected the pens/equipment, the facilities can then be set up in the following sequence

1. Fix the brooder guards the halved ceiling boards should be lapped in circles. The circumference depending on the number of chicks it will accommodate. When there are many chicks each guard can be made to accommodate 500-1000chicks.
2. Spread litter within the guards dry wood-shavings should be spread uniformly to the depth of about 3 - 5cm.
3. Cover the litter with dry non-slippery paper.
4. Place or hang the brooder box or hover at the centre of the brooder guard. If hover is hung, it should be at a level of about 15- 30cm from the floor, high enough for the chicks to go under. The height can be raised as chicks grow.
5. Place the heaters if hover has no heater or if no hover or brooder box is used, heaters should then be placed orderly, well spread out within the guards.
6. Place feeders and drinkers containing feed and water respectively at least 6 hours to chick arrival. Spread feed also on the paper covering the litter. For the first 1week shallow tray feeders can be used, thereafter this should be replaced with conical or long feeders which can be placed on the floor initially and after 1week raised from the floor by hanging or by placing them on short stands. Some people use inverted paper egg tray as tray feeders for the first one week. Depending on size, 1tray feeder is adequate for 50 chicks. The most common chick drinker is the 3 litre capacity plastic drinker. For the first 3 weeks one of such is adequate for 100chicks. If the birds have been exposed to stress, an anti-stress and/or antibiotics is usually added to the drinking water for the first 3-5 days in the recommended doses. Some people also add a little glucose to the drinking water for the first day to supply instant energy to the chicks if they have undergone much transportation/handling stress before arrival.
7. Shut the windows or vent in the brooder pen to reduce ventilation draught or draft and to conserve heat within the pen.

8. Fix record charts in appropriate places provided for them in the pens. Daily record charts are usually hung on the wall/door outside the pen.
9. Put disinfectant in the footbath at the entrance of the pen. Ensure the footbath is located where it cannot quickly dry out or be flooded by rain. It is good for the bath to have a canopy.
10. Six hours to chick arrival switch on the heaters to keep the pen or brooder-guard area warm especially during the cold season. The heaters could be switch on earlier if the whole pen is to be uniformly warm and if heater capacity is fairly low and during the cold season. If during the hot season the pen is already warm by the sun's heat and chicks arrives during the hot daytime, the heaters may not be switched on until the chicks have arrived.

v. Collecting or receiving the chicks: Between the time chicks are collected from the hatchery and when they are set for brooding on the farm the following 3 important operations are involved;
   1. Inspection
   2. Transportation
   3. Delivery

1. Inspection: In some hatchery the chicks are usually packed labeled for collection in such a way that any inspection is almost impossible. This is more so with agents who import and deliver chicks to the farmer. In such cases extra chicks are usually given, some up to 5% to compensate for any misnormal. Where inspection is however possible before accepting the chicks the following should be taken note of during inspection -
   a. That the chicks are given necessary day old vaccinations such as NDV (Newcastle Disease Vaccine) or Marek Disease Vaccine. Such vaccination is usually a courtesy service by the hatcheries but some hatcheries do not render it. Where they don't render it the buyers should arrange to give the vaccination.
   b. That the chicks are correct in number. A quick count or random counting can be done if possible.
   c. That the chicks are all healthy; weak, dead and deformed chicks should be removed. Deformed chicks include those with crooked legs, crossed beaks, sticky down-feather and blind eyes.
   d. That the chicks are correctly sexed; all wrongly sexed chicks if found should be replaced.
   e. That the chicks are of the desired breed and type.
   f. That extra chick is given; usually hatcheries provide between 1 - 5% extra chicks to compensate for transit losses.
   g. That the chicks are not overcrowded in the chick boxes i.e. the right number of chick is in each compartment of the chick box.

2. Transportation: The following precautions should be taken while transporting chicks-
   a. Chicks should receive adequate ventilation during transportation. If large vehicle is use in transporting chicks such vehicle should not be covered completely with tarpaulins to prevent suffocation.
   b. The vehicle should be clean and disinfected.
   c. Chicks should not be exposed to draught, direct sunshine and rain. Vehicles that are completely opened on tops and sides are therefore not adequate. Air vents in the vehicles should be reduced if air is windy or if weather is cold.
   d. When possible it is better to transport chick before sun rises or when sun is setting to avoid heat stress which is usually responsible for transit loss. Avoid frequent stopping during transportation.
   e. If there is a vehicle breakdown during transportation, chicks should be kept in warm area. The chicks can remain in the vehicle provided there is no suffocation. The chicks will generate enough body heat in the vehicle to keep them warm except during severe cold weather or draught. Chicks can survive without food and water for 3days after hatching if there are no other stresses like cold, diseases and parasites.
3. Delivery: When chicks arrives on the farm they should be settled down as soon as possible preferably immediately they arrive. Certain weak chicks which would have died due to heat and transportation stresses are helped to survive if they are settled immediately after arrival. Sometimes chicks arrives at night and there are no attendants to immediately take delivery, such chicks can be left till the following morning without harm if they have not stayed for more than 3days after hatching and if they are kept in a fairly warm environment free of draught.

   When unloading chicks from their boxes to the brooding apartments (floor or cage), they should be counted and the number recorded on the record chart in the pen. They can be counted in two or three or more but usually not more than five per handful to prevent injury to the chicks. Weak, sick, deformed and dead chicks should be removed. Weak chicks can be assisted to drink and eat by dipping their beaks in water/feed. Very sick/deformed chicks should be killed and burnt along with the dead ones in an incinerating drum. The burnt carcasses should be buried. If chicks go through long transportation stresses it is useful to add to their drinking water glucose or anti-stress drug e.g. Floxaid,Teramycin chick formula or any vitamin supplement. If chicks have not been given day old vaccine they should be vaccinated with NDVi/o or intranasal vaccines while they are being settled. Debeaking can also be done at this time especially if the breed of the chicks is that notorious for toe-picking/cannibalism. Chicks should be provided a floor space of 0.046square

metre per bird (about 20 chicks per square metre), and 0.020 - 0.028 square metre per bird (30 - 50 chicks per square metre) in the cage for the 6 - 8weeks brooding period.

After settling chicks in the brooder guard the chick boxes should be discarded by burning so as not to constitute litter around the brooder house. Some people improvise this chick boxes as brooder guard for about 5 days before chicks develop enough wings to fly or jump over. After such use the chick boxes should be discarded by burning.

3 Brooding: Brooding is the management (provision of heat and other necessary care) given to chicks during their early growing periods, usually from day old to 6- 8 weeks.

Management practices during brooding

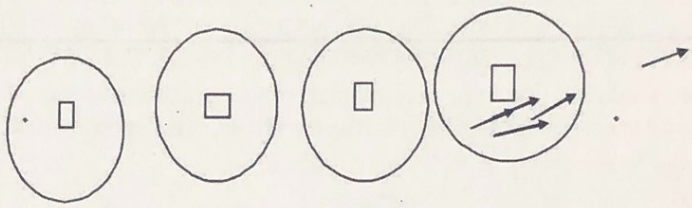
These are divided into (i) daily routing, and (ii) occasional routing practices

Daily routing practices include-

1. Daily observation of the birds
2. Provision of feed and clean water
3. Sanitation practices
4. Daily record keeping

1. Daily observation of the birds: It is important to observe the general welfare of the chick 2 or 3 times daily. The following should be taken note of during observation-

a. The comfort of the chicks: they will be uncomfortable if there is too much heat, cold or draught as expressed in the following illustrations.



Comfortable Too hot Too cold Draughty

If chicks are comfortable they would spread out evenly within the brooder guard. When they are hot they would move as far away from the heater, heat should then be reduced. On the other hand if they are cold they would crowd around the heater, heat should then be increased. If there is draught the chicks will pile together away from the direction of the draught, the vent allowing draught should be closed.

b. Activity of the chicks: healthy chicks should be seen to be actively moving about, eating and drinking.

c. The colour and consistency of the droppings: if faeces are bloody it is a possible indication of coccidiosis; if greenish a possible bacterial infection; if

watery and frequent it may be diarrhoea. When normal the dropping is greyish with small white cap. When abnormal adequate treatment should be promptly given.

d. The condition of the litter: spillage of water from drinker makes the litter wet which can cause cold and disease outbreak. If litter is wet it should be packed out and replaced with dry litter. Caked and damp litters should also be replaced.

2. Provision of feed and clean water once or twice daily except where the systems are automated. Drinkers should be washed daily.
3. Sanitation practices: This includes keeping passages within the pen clean by sweeping, removing spider webs on the walls/ceilings. Keeping poultry house surroundings clean by picking papers and putting all equipment inside the house, sanitation also include renewing or topping disinfectant solution in the foot dip and consciously preventing many people from entering the pen except on business.
4. Daily record keeping: There are daily and occasional records that are necessarily kept. Daily records are the pen record charts and the farm diary. The pen record charts usually have column for date, number of chicks, age of chicks, and if necessary feed consumption, average weekly live-weight and remarks.

Date	No. of chicks	Age (Days)	Feed consumption	Average weekly liveweight	Remarks
1/1/15	1000	1			
2/1/15	1000	2			
3/1/15	998	3			2dead(pecked or accident)

The diary is a record of information that might not have been kept in any other record chart or book e.g. occurrence of national happenings and spectacular activities on the farm like heavy rainfall, flooding, wind damage, weeding, hosting of special guest; travelling, some special purchases, decisions, projections, plans, meetings, etc.

Occasional routen practices include the following-

a. Extension and removal of brooder guards
b. Removal of heaters
c. Change of tray feeders/drinkers to bigger ones
d. Debeaking
e. Deworming
f. Other medication and vaccination
g. Culling
h. Purchase of feeds, drugs and equipment
i. Periodic or occasional record keeping
j. Maintenance of surrounding

a. Extension and removal of brooder - this is usually done after one or two weeks. At 2weeks the chicks will start

b. Removal of heaters - the weather conditions usually determines when the heaters should be removed. During the hot season heaters can be removed as early as 2 weeks whereas during the cold seasons (harmattan or rain) supplementary heat may be needed up to 6weeks. Most of the time heaters are removed after 3 or 4 weeks.

c. Change of tray feeders to bigger ones done after 1 week and the drinkers after 6 weeks.

d. Debeaking - the upper beak or both beaks can be cut. This is done at day-old or between 6 - 8weeks.

e. Deworming when birds are brooded on the floor, worm infestation can be a problem. Deworming can be done any time between 6-8 weeks using any suitable dewormer (anthelmintics) such as Piperazine.

f. Other medication and vaccination - the following drugs can be given prophylactically - antistress e.g. Floxaid or Tetramycin chick formula, antibiotics or a vitamin. Supplement anytime birds are stressed from activities like debeaking and much handling. These drugs can also be given when chick appears dull and sick. Coccidiostats is usually provided to prevent or treat coccidiosis. It can be given at 4 weeks of age for prevention. Birds are normally vaccinated for diseases that are heritable from their parents and those that are prevalent in the locality where they are being raised. It is therefore unnecessary to vaccinate birds for all diseases for which vaccines are available hence schedule of vaccination differs from place to place and from one veterinarian to another. The vaccines most commonly administered during brooding are

1. Newcastle disease vaccine (NDV intraocular or intranasal) between 1 5 days of age.
2. NDV Lasota (water administration at 2- 4 weeks)
3. NDV Kamorov (intramuscular injection at 6 - 8 weeks)
4. Two doses of Gumboro vaccines at 2 weeks and 5 weeks of age (in water)
5. Fowl pox vaccine at 2 -5 weeks of age through wing web jab
6. Fowl cholera and typhoid vaccine between 6-8 weeks of age (administered by injection)

Birds should not be vaccinated if they are sick or under a stress.

g. Culling - this is the removal of undesirable birds from the flock e.g. sick ones, deformed birds and birds that are showing cannibalistic traits.

h. Purchase of feeds, drugs and equipment feeds should be bought every 2 - 4 weeks. If feeds are kept for too long they can become stale and unpalatable. If they are kept under humid and unsuitable conditions they can grow moldy, caked up, loose taste and go bad. Drugs and equipment should be bought in

bulk and preserved in the store.

i. Periodic or occasional record keeping records kept occasionally include store record books (purchase and disposal), equipment inventory book, medication/treatment record, pen record chart analysis book and weekly/monthly/quarterly/annual report.

j. Maintenance of surrounding cutlassing or mowing surrounding, mending of roads and other maintenance of the surrounding are necessary

POSSIBLE CAUSES OF MORTALITY DURING BROODING AND HOW TO PREVENT THEM

1. Poor quality chicks
2. Inadequate feeding and watering
3. Inadequate housing
4. Early pecking
5. Cold and high humidity
6. Brooder trouble
7. Poor sanitation
8. Bad exposure
9. Diseases

1. Poor quality chicks: The quality of chicks may be poor if they were not selected, improperly selected or purchased from a bad hatchery. Such chicks are usually deformed, weak, dull and sleepy. Some chicks also become weak and sick due to transportation stress. If such chicks are not settled as soon as they reach the farm they can die. Poor quality chicks usually die during brooding. To avoid having poor quality chicks, selection should be done if possible at the hatchery. Chicks should be obtained from reputable disease free hatcheries and the chicks should be quickly settled as soon as they reach the farm to help the weak ones affected by transportation stress to survive.
2. Inadequate feeding and watering: Feeding and watering becomes inadequate if- (a) the quality of feed is poor in nutrient, (b) the feed is spoilt e.g. moldy due to humidity or old age, (c) if water is dirty or contaminated, (d) if drinking/watering troughs are insufficient in number such that there is overcrowding and stampeding while eating or drinking. This also causes trampling, suffocation, pecking and death. Insufficient feed/water can cause starve-out and dehydration; (e) if drinking troughs is wide, deep and opened type such that chicks jump into the water and get drowned. Open drinking troughs that are unprotected with grills encourage chicks to defaecate in the water thereby contaminating the water. For prevention good quality feed and clean water should be provided always, as well as enough feeders/ drinkers. The use of fountain drinkers or protection of open drinkers with wire grills is also helpful.

3. Inadequate housing: Overcrowding can be caused by inadequate floor space in the house. This often leads to trampling, suffocation and pecking. Poor housing can also cause draught. Houses should be well constructed with good orientation to prevent draught and adequate floor space to prevent overcrowding.
4. Early pecking: All conditions may be adequate and the chick may still develop the bad trait of pecking. Such trait can cause mortality if not quickly checked. Apart from hereditary, inadequate salt in feed can cause pecking. As soon as pecking is noticed the chicks should be debeaked. Breeds of birds notorious for cannibalism should be avoided.
5. Cold and high humidity: This can be caused by the followings - (a) season e.g. harmattan and raining season, (b) draught, (c) wet litter due to leaking roof and water spillage from drinker, (d) lack of supplementary heat or heaters going off. This can be prevented by building brooder house with materials that provide adequate insulation. Windows and vents should be covered when necessary to prevent draught. Ensure that the roof is free from leakage and prevent water spillage from drinkers. Protect open drinkers with wire grills and raise them on drinker stands (platforms above the floor). Use reliable heaters that will not go off during brooding.
6. Brooder trouble: The following can cause brooder trouble - (a) heaters may go off due to electrical power failure or lack of kerosene or gas and chicks may die of cold, (b) heaters may overburn if not well regulated or if thermostat is faulty. This may provide excess heat which may overheat the chicks especially if chicks are within the brooder guard; (c) smokes may develop especially with faulty kerosene lamps, this usually suffocate chicks causing mortality; (d) there may be fire outbreak while brooding if heater catches fire due to any fault. This is prevented by the use of reliable heaters that has been tested properly to ascertain their quality. Visit the chick house as many times as possible during the day and if possible at night.
7. Poor sanitation: This normally leads to disease outbreak. To maintain good sanitation the following practices must be observed - (a) provide foot-dip at the entrance to the chick house, (b) keep passages within the pen clean and do not litter the house or surrounding with any material e.g. equipment or empty drug sachets, (c) disinfect the house properly before moving in chicks, (d) keep litter dry. Remove and replace wet litters; (e) do not use moldy feed and contaminated water, (f) wash drinkers daily, (g) prevent birds from defaecating inside the water or feed as much as possible, (h) prevent stray birds as well as unwanted visitors from entering into the brooder house, (i) prevent attendants and other people from moving from the adult bird house to the chick house.
8. Bad exposure: Birds reared under extensive and semi-intensive systems are usually highly exposed to attacks by hawks, snakes, rats and other predators.

They are also exposed to flood and some other disasters. If windows of the brooder house have wire cover which is too wide apart or no wire cover at all, straying wild and game birds can enter the house to eat some of the chicks' feeds and possibly transmit diseases. Cats and big rats can also prey on chicks if brooder house is not well protected. As prevention, chicks should be brooded in well protected environment.

9. Diseases: Disease is the commonest cause of mortality during brooding. Disease can arise from the following sources - (a) poor sanitation, (b) poor nutrition, (c) lack of vaccines and necessary vaccination, (d) delayed treatment of diseases or injury, (e) infection from hatchery, (f) infestation by parasites e.g. lice and fleas, (g) brooder house infected before brooding thereby needing disinfection, (h) infection from visitors, rodents and from attendants moving from adult bird house to chick house, (i) use of infected equipment.

Common diseases during brooding include-Newcastle, Gumboro, Coccidiosis, Fowl-pox and Pullorum. Sometimes fowl typhoid and fowl cholera are problems but this are more common during the growing stages. Every effort must be made to prevent diseases through good management practices.

MANAGEMENT OF GROWERS

Growers are chickens between 8- 20weeks of age, the female are called **pullet** and the males' **cockerel**. They are not as delicate as chicks and not as important as layers, therefore people often think that they don't need much management. Good management must however be provided for the following reasons -

1. To maintain good health and vigorous growth.
2. To maintain fairly uniform growth within a small average body weight range in the birds e.g. 1.0 - 1.5kg weight range, not 1.0- 3.0kg
3. To have low mortality of about 5% maximum throughout the growing period (8 - 20 weeks).
4. To make pullets start laying at the expected age (20 ± 2 weeks).
5. To raise them in such a way that while they are laying eggs they will -

a. Peak at as high rate as possible in egg production - 85% and above, and also reach the peak in good time (30 - 36 weeks of age).
b. Maintain the peak for fairly long period (at least 3 months).
c. Maintain an entire circle of high egg production at least 200eggs/bird/year.
d. Lay an acceptable egg size during the entire laying period of about 12 months.

Housing and floor space requirements: Growers can be reared in fenced runs under semi-intensive systems, deep-litter houses or in cages. When on the run an area of $6m^2$ can be provided for each pullet. On the floor of a deep-litter house $0.1m^2$ floor spaces is needed for 8 - 16weeks, from 16 - 20weeks this can be increased to $0.14m^2$

Per bird, especially if the birds are being raised in the same pen for laying. The birds are usually transferred to their laying pens at 16 weeks. In the cage 300cm² can be provided for each bird before they are transferred to the laying cages at 16 weeks. There are the following two possible systems of housing for growers -

a. **Single stage housing** where only growers are raised in the house from 8-16weeks.

b. **Multiple stage housing-** (i) Brooding/growing house - where a house is used for raising the bird from day old until the end of growing period.

(ii) Growing/laying house the house used for raising the growers is also kept as deep-litter house for laying. The litter can be changed and laying nest provided between 16 - 20 weeks. (iii) Brooding/growing/laying house- this is an all purpose house used for keeping the three stages of birds.

Feeder and drinker spaces: Every grower should be provided a feeder space of 7.5-10cm when the birds have grown bigger, usually after 10weeks. This space enables all the growing pullets to eat at the same time when feed is served. This allows for more uniform growth because the more timid birds then now have more space to feed.

A drinker space of about 5cm per grower is adequate. The drinker space is less than the feeder space because birds spend less time drinking than eating. Secondly birds do not scramble for water as for feed. The number of feeders and drinkers required depends on their various sizes i.e. the size of feeders/drinkers. A feeder is good for 25 birds while a drinker of 8-10 litres capacity is good for 40 growers. A grower consumes about 7kg of grower mash during the growing period.

Routen management practices

1. Provide adequate feed regularly
2. Wash drinkers daily and supply fresh clean water
3. Keep daily record of feed intake, bird population and health conditions
4. Remove dead birds promptly, burn and bury carcass
5. Isolate sick birds and promptly provide adequate treatment
6. Turn litter with rake periodically e.g. weekly, especially during raining season to prevent caking
7. Add to the litter when found necessary
8. Do weekly culling of runts and deformed birds, if any
9. Debeak at 10-12 weeks if pecking is noticed. It is not advisable to debeak when it is too close to laying period especially anytime after 16 weeks, except when pecking is noticed.
10. Control rats/mice by blocking their tracks using rat poison or traps.
11. Place laying nest in the house before the end of growing period usually between 16 - 18 weeks.
12. If birds are raised on the floor, deworm prophylactically using anthelmintics

such as piperazine once in two months. Similarly provide prophylactic treatment against coccidiosis.

Growth restriction for growing pullets

Objectives of growth restriction

1. To allow sufficient time for gradual development to sexual maturity thereby preventing them from starting to lay egg too early.
2. To prevent birds from laying small size eggs for too long after commencement of lay.
3. To make birds more persistent in lay with higher peak.
4. To save feed and reduce feeding cost.

Methods of growth restriction

1. Feed restriction: this is done by providing insufficient quantity of feed per day for the birds. This method as a disadvantage of preventing timid and less vigorous birds from eating. It can also encourage cannibalism.
2. Feed control: this involves reducing the quantity of nutrient in the feed thereby reducing the quality. This is the most popular method of growth restriction. The feed usually contains more fibre and less protein. This is why growers mash is the cheapest among the poultry feeds.
3. Skip-a-day method: it is a feed restriction method whereby feed is provided every other day with feeds not provided for the day between the provision of feed. Mortality can be high when using this method due to stampeding and trampling over one another when feed is served. Hunger can also promote cannibalism.
4. Control of photoperiod: this is a method of providing less hours of daylight for the birds. By so doing the effect of light in stimulating growth of their reproductive system is reduced. This method is more practicable under the environmentally controlled conditions.

CHAPTER EIGHT
AGRIBUSINESS

Agribusiness is the business of agriculture and it entails the process of producing crops and animal and all other aspects before the product gets to the final consumer. All other processes that are involved in the transformation of agricultural products to a finished product for its final consumer are all part of agribusiness as well as the marketing of agricultural products. Factors determining agri-business establishment include the following -

1. Closeness to source of raw materials
2. Availability of labour i.e. both skilled and unskilled
3. Nearness to market
4. Availability of infrastructures e.g. good roads, light, water, school, hospital, etc
5. Nearness to financial institutions e.g. banks, insurance, etc
6. Personal values
7. Government policies
8. Norms and values
9. Availability of land

Management of Agri-business

Management is the ability to do the right things at the right time, asking the right questions, deciding logically and making judgment without sentiment. It deals with stating and working toward the achievement of an objective. It permeates all human activities home, factory, farm, spending, etc.Management can be defined as getting things done through other people (Druker Peter). Management is relevant wherever there is an organization where objectives are to be met.

Silk (1979) define management as **the coordination of resources through the process of planning, organizing, staffing, leading and controlling in order to achieve predetermined goals and objectives**. The five processes are known as the management functions or process of management. Management is also the coordination of both human(skilled/unskilled) and material (equipment, machines, capital,etc) resources in order to meet predetermined goals.

The broad objective of agri-business can be stated as:

- To maximize profit
- To stay in business
- To provide a service
- To clean up the environment

As a distinct process, management consists of planning, organizing, actuating (mobilizing people to work i.e. staffing/ leading) and controlling.

Objectives of management: Managerial objective represent the intended goal and encompasses the scope and direction of action.

1. Management objectives must be in clear statement and unambiguous (well defined/ understandable)
2. Must not be lost in the process of achieving it
3. Must agree with societal norms
4. Must not be deliberately harmful or injurious to anyone unless absolutely necessary as in situation of war
5. Objectives help to stimulate effort and ensure clear paths of action and avoid misunderstanding. They may come simply and easy to comprehend or may be complex or multiple objectives in which case the achievement of one depends on another
6. Managers must formulate their own objectives, no manager can succeed if he tries to achieve the objectives he has not carefully formulated
7. The ease with which objectives are set depends on background experience, intelligence/ sharpness of manager
8. A good manager uses subordinates to identify objectives through the process of brainstorming. Very deep thinking and coordination are vital to objective formulation
9. Close observation to decide similarities/ differences between problem at hand and other problems arising are necessary
10. Memory to recall or call to aid previous examples of alternative courses of action must be processed. Good reasoning to be able to judge differences and finally good emotion. Very problematic situation helps to stimulate management to greater achievement. If there are no challenging problems the thinking faculty may be reduced to mediocrity.

Process or functions of management

1. **Planning:** Planning is determining where to go in advance and how to get there fast. In planning, objectives are set, forecasting - predicting or projecting some future occurrence is made. The objective can be to make specified profit, earning per share, large market share, share price, etc. Forecasting is prediction based on extrapolation.
2. **Organizing:** Organization takes place when people come together to achieve goals. It involves creating departments, setting of roles, delegation of authority, establishing channels of authority and communication, coordinating the work of subordinates.
3. **Staffing (Personnel):** Determining what type of people should be hired, recruiting prospective employees, selecting employees, setting performance standards, evaluating performance, training and developing employees.
4. **Leading:**Involves actuation, directing, motivating subordinates, maintaining

morale, establishing the right psychological climate using management theories such as Maslow's, Vroom, Herzberg, Goal path, Mcgregor leadership theory of X &Y whereXassumes that average person has an inherent dislike for work and will avoid it if he can, so they needed to be forced, controlled, directed and threatened with punishment to get them to put forth adequate effort toward the achievement of organization objectives and that the average person prefers to be directed, wishes to avoid responsibility, has relatively little ambition, and wants security above all. Theory Y assumes that the expenditure of physical/ mental effort in work is as natural as play or rest and that man will exercise self-direction and self-control in the service of objectives to which he is committed and that commitment to objectives is a function of the rewards associated with achievement, that the average person learns under proper conditions, not only to accept but to seek responsibility and lastly, that the capacity to exercise a relatively high degree of imagination, ingenuity and creativity in the solution of organizational problems is widely, not narrowly, distributed in the population.

Classical theory can also be applicable, using force to use someone to work, and neoclassical theory which believes that people should be motivated.

5. **Controlling:** Involves setting standards such as sales quotas, quality standards, or production levels, checking to see how actual performance compares with these standards and taking corrective measure or action as needed.

Characteristics of management

- Purposeful
- Exert real influence on human existence
- Associated with group effort
- Accomplishes objectives through people with other peoples effort
- Activity not a group of person

Management activity: Every business organization has various branches at which the organizational goal is carried out. These are the activity points. All activity points must be created when going into business formation, though it can still be divided into sub-departments.

- Production
- Finance
- Marketing
- Personnel

Communication: There is always serious need for communication when dealing with management activities. Communication is the transfer of information from a sender (encoder) to a receiver (decoder) with an accompanying response from the receiver to the sender. It is not a one way but a two way process. It is the process of encoding and decoding. It is the act of imparting a common idea or understanding to another person. The manager may develop his plans, procedure/ organization

by himself that he needs to communicate his desires to others when he needs to implement

Communication is passed from the encoder to the decoder and the decoder gives a feedback to the encoder.

Communication cycle

TV, radio, writing, verbal, symbol or sign

medium

Encoder → → **Decoder**

(Sender, reader, speaker, giver, writer) **information** (receiver, listener, learner, etc)

← ←

Feedback

Communication is effective when encoder gives information and decoder is able to interpret it according to the desire of the encoder.

Factors militating against effective communication are

- Bias
- Technical jargon
- Ladder of abstraction i.e. not teaching at listeners level of understanding
- Personality of speaker
- Noise
- Plateau of knowledge
- Communication environment
- Block mindedness

For effective communication, the effect of these factors should be reduced. Agribusiness communication is mainly PIW (put into writing) to make it genuine and documented, to forestall denial/ forgetfulness. There are two basic form of communication in writing, viz

1. Memo- for inter organizational communication
2. Letter- for communications between organizations
3. Reports
4. Minutes of meeting
5. Circular
6. Communique

THE FORMATION OF A COMPANY

The formation of a company begins with promotion or incorporation of a company. A number of important steps must be taken by promoter (entrepreneur), he must decide on the following:

1. The name of the company, the objects of the company, the place of business, the liabilities of the members for losses (whether limited by shares, guarantees or unlimited) and the capital of the company.
2. Prepare the memorandum or an article of association, whether it is a public or private company.
3. Enter into preliminary contract if necessary.
4. Register the company.
5. Raise the working capital.

The promoter must consult a solicitor with all necessary information. It is the business of the solicitor to prepare the necessary document and to register the company.

Registration: After a solicitor has prepared all incorporation documents on the instruction of the promoter, the document are presented to and filed in the companies registry (at Abuja), where they are carefully shelved. The incorporation document consists of the following:

1. Memorandum (deals with public relation i.e. external) and article of association (internal regulation).
2. Statement of nominal capital.
3. Notice of situation of the register office of the company (location of company).
4. Particulars of director.
5. Statutory declaration of compliance with statutory requirement.
6. For status or statements in lieu (in place or instead) of prospective.
7. Consent of directors and lists of directors.

At least two directors are required in respect of the public company. If the entire document is in order the company is registered after payment of stamp duty and registration fee.

Memorandum of association: The memorandum of association is one of the two constitutional instruments of a company. The memorandum of association of a company limited by share must take the following;

1. The name of the company with limited as the last word in its name e.g. Divine Farm Limited.
2. The situation of the register office of the company (location of the company).
3. Objects of the company.
4. That liability of members is limited (to percent or amount of shares not yet paid).
5. The amount of shared capital with which the company proposes to be registered and the divisions thereof into shares of a fixed amount.

Articles of association: This deals with internal affairs of the association. Anything here is ultravire (beyond the powers or authority granted by law). The article of association is the other constitutional document of a company (beside the memorandum). It regulates the right of members of the company and the manner in which the business of the company shall be conducted. Matters which are dealt with by the memorandum may also be contained in the articles, but whenever there is a conflict between the provisions in the memorandum and those in the article of association, the memorandum prevails.

CHAPTER NINE
LIVESTOCK DISEASES AND CONTROL

Health: Is a condition associated with a sense of physical and mental well-being in which all the body structures and organs are anatomically and physiologically normal. When there is deviation from this condition, the body becomes unhealthy.

Maintenance of health: Factors essential for maintenance of health include-

1. Well balanced diet.
2. A healthy environment and hygiene.
3. Good housing.
4. Good management i.e. in terms of stocking density/ feeding time.
5. Vaccination in some cases.
6. Site security or quarantine.
7. Routen hygiene.

How to maintain good health - this can be done through preventive medicine which entails -

1. Early detection and treatment of diseases.
2. Awareness to situation or conditions that may lead to the development of diseases.
3. Good management skills i.e. knowing the signs that animals show when ill.
4. Vaccination against very prevalent diseases.
5. Avoidance of air and water pollution.

Disease: The word disease is formed from the prefix dis - (deviation or change) and ease (comfort). It is a discomfort or deviation from normal or comfort. It is a state of ill-health. With the advancement in science, curiousity arose about diseases, its causes, its treatment and this attitude heralded the modern aid of medicine. The anatomist dissects the body and describes it; Pathologist examines diseased tissue and characterized it; Physiologist describes the normal function of the organ when in good health and the malfunction in illness; Microbiologist studies and identifies the organism that causes disease; Pharmacologist studies drug and their action on the body.

Animal diseases may be classified on the basis of the causative agent as:

- Bacterial diseases
- Fungal diseases
- Viral diseases
- Parasitic diseases
- Hereditary diseases
- Environmental diseases
- Nutritional diseases, and

- Nutritional diseases, and
- Congenital diseases

For a disease to develop, there are stages it has to undergo. Progressive stages in the course of a disease are-

- Per acute
- Acute (quick and short-lived)
- Sub-acute
- Chronic (slow and longer-lasting)

A disease is described as acute when the condition is quick and shortlived. It is chronic when it is slow and longer-lasting. In any diseases the acute form may last a few days and may be followed by death or recovery while the chronic form may last one month or more, there is usually no fixed time for this comparison. Also this terms do not per say indicate the seriousness of the disease. An acute or chronic disease can be very serious or even fatal. On the other hand it can be mild. Sometimes the chronic form follows the acute phase. There are times when the reverse may occur whereby a condition that is chronic takes a sudden acute form when the resistance of the animal becomes lowered by sudden stress. Peracute is the terminology used to denote a very rapid and usually fatal course e.g. the case of Anthrax in cattle which is very fulminating (Note that Anthrax in pig is not peracute but may be acute or chronic). Subacute means a condition between acute and chronic.

Predisposing factors of diseases

It is not in all cases of microorganism invasion that the body comes down with a disease. Predisposing factors plays a major role in the cause of a disease unless the disease causing agent finds a suitable environment their development is not favoured. Using Trypanosomiasis as an example, three (3) factors will be necessary before the disease can be established in an animal, these are -

1. The organism, Trypanosome must be present in the environment.
2. The carrier agent Tsetse fly must be present in the environment and also carry the raising organism
3. The animal to be infected must be such that it can support the development of the disease agent.

In summary therefore, the Trypanosome is the **initiating factor,** the vector is the **contributing factor** while the bodily condition of the animal which renders it susceptible is a **predisposing factor**. There are many conditions or factors that may predispose an animal to a disease, this include -

1. Management - (a) Poor or sub-optimal nutritional status, (b) Poor husbandry practices e.g. feed, water, shelter, protection from predators, etc.
2. Stress - This may arise as a result of (a) management, (b) environmental drawback (cold or hot weather, high humidity), (c) calving or parturition stress e.g. breech presentation, (d) fatigue as in trekking long distances.

3. Tolerance factor - Some disease organisms has been associated with their host for many generations. These animals are the normal host and they suffer less from the effect of the disease than animals which have not had long contact with the disease organism. The latter are called abnormal host. The normal host suffers less because in the course of evolution it has become adapted to that organism and the organism has become adapted to the hosts reaction against it. Such adaptation between the two is called **tolerance**. It can be seen for example in N'dama and Muturu cattle breed of West Africa, both of which shows a marked though different degree of tolerance to Trypanosomiasis, and the numerous Zebu breed which shows a variable but quite distinct tolerance to Rinderpest. With this two diseases, temperate climate breed of cattle do not have these tolerance. Therefore they are much more predisposing to them. For this reason attempts to introduce temperate breeds to the tropics to improve yields have often failed. The factor that accounts for the existence of tolerance is associated with the theory of natural selection.

Aetiological Factors of Diseases: The factors may be primary or secondary and under both factors we have intrinsic (internal) and extrinsic (external).

Primary factor -

Intrinsic: Aberrant genes, aberrant metabolism and aberrant behavior. All these are congenital.

Extrinsic: This may be inanimate or animate. The inanimate ones include physical factors, chemical factors, poisons, allegens, etc. while the animate are endoparasites in general and exoparasites.

Secondary factor -

Intrinsic: age, sex, species, conformation, hormonal status, nutritional status fatigue and behavior.

Extrinsic: husbandry, climatic stress, trauma, other diseases and vaccination.

Portal of Entry of Disease Agents

1. Alimentary canal
2. Conjuctival
3. Respiratory tract
4. Urogenital tract
5. Skin - pre-existing breaks i.e. when skin breaks before infection or preinfection break
6. Blood stream
7. Lymphatic stream

The route of infection may be variable or specific. Some organisms can be ingested and also through the conjunctiva e.g. rabies; tuberculosis can be by ingestion or through air route, so they are variable. Specific ones are trypanosomiasis (*Trypanosome equiperdum*) which is through coitus.

Multiplication of Disease Agents

(a) Locally e.g. in abscess for example vibrio

(b) Locally with excretion of exotoxin e.g. tetanus

(c) Local and then generalize e.g. tuberculosis

(d) Generalized - this is spread by blood stream e.g. virus (viraemia) or bacteria (bacteraemia)

(e) Can be generalized and then localized as is seen in Brucella where the lymph node is involved. First the organism (Brucella) is in the blood but later spread to all the organs and finally in the lymph node

Exit of Disease Agents

Exit of disease agents may be through the following routes -

1. Nasal, oral and occular secretion
2. Urine or faecal discharges
3. Veneral discharges
4. Mammary secretion
5. Parenteral (body system) humours - when administering drugs you have per Os (through mouth) and per enteral (injection into body system). It can either be lymphatic or blood secretion.
6. Per cutaneous (Per - through, cutaneous - the skin) through the skin.

Modes of Disease Transmission

This may be (a) Horizontal or (b) Vertical

Horizontal one is the transmission between hosts which are not genetically related. This can be through contact directly or indirectly. The direct one may be through intimacy or aerosol. The indirect one may be through milk, semen, bedding, etc without multiplication outside the host. Usually the host in this case is a fomite. It can also be indirect as is seen when it happens through an intermediate host. For example (a) biological - where developmental phase in the intermediate host is necessary as typified by vector borne intermediate host usually an invertebrate i.e. vector-borne invertebrate intermediate host; (b) it may be mechanical where the vector transmit passively and no developmental stage is required.

Vertical transmission is the transmission between the parent and the offspring. The gene, the placental and the colostrums are involved.

NB: Contagion is an infection spread by direct contact;Fomite is an inanimate object which acts as an indirect carrier of infection;Vector is an invertebrate intermediate host which is usually an essential phase or stage in the lifecycle of a parasite;Zoonosis is an infection transmitted between animal and man; Epidemiology is the study of the natural history of diseases i.e. the aggregation of fact that determines the occurrence and distribution of that diseases.

Factors that can Influence the Success of Transmission

a. Organism factor - this include (a) Quantity (number) or weight of infection- some organisms in very little number can be dangerous while some are only dangerous in large quantity; (b) Physical Stability - some organisms can withstand either physical or chemical materials e.g. the physical ones we have dessication or ultraviolet light (irradiation), chemicals such as disinfectants may have no effects on some organisms. Competition with other organisms (physical material) whereby the stronger one overcomes

b. Host factor (a) availability of suitable host. Some host may be accidental in which case the disease organism dies in them, (b) availability of suitable vector.

Disease Control

1. Break the transmission cycle either directly or indirectly
2. Reduce the number of organisms
3. Reduce the effects of secondary factors
4. Raise the level of immunity
5. Chemotherapy i.e. the application of chemicals

How can the transmission cycle be broken -

1. By direct means (a) by preventing contact between infected and uninfected animals; (b) by movement control or segregation between (i) groups of animals on farm using fences/ pens, (ii) farms using fences and quarantine, (iii) segregation of area using stock route and market, (iv) between countries using boarders and port; (c) by detecting and removing disease carriers which are either sold or destroyed.
2. Indirect means (a) by controlling the movement of fomite, (b) removing animals from infected areas, (c) by disinfection.
3. Vector control - opportunist pathogens are those that are not the actual cause of a disease but get established following the establishment of a disease by the primary causal agent. (a) control by reducing the number of organism through hygienic measure e.g. disinfection, (b) through the use of normal or low stocking rate allowing equal feeding and reduces the fighting chances, (c) segregation of age groups (by doing batch weaning), (d) gradual exposure to parasite which permits gradual build up of immunity, (v) reduce stress which may be due to trauma caused by sudden change in diet, intercurrent diseases and improper nutrition.
4. How can you increase immunity through Natural means (a) using breeds of high innate resistance, (b) utilizing age resistance i.e. at a particular age some animals are resistant to particular diseases; Artificially through vaccination or the use of antisera; Chemotherapy through (a) prophylactic (preventive treatment) or therapeutic (curative) ie. Use the actual dose; Application of

principles of public health (a) by inspection or seizing of the infected products, (b) treatment of product to sterilize it, (c) public health education in every home.

Concept of culturing disease organisms of farm animals

Culturing simply involves the technique of growing microorganism in special media in the laboratory. Although animal diseases caused by micro-organisms have been known since about 2,000BC. The study of this pathogenic cause of diseases was to await the development of lens and microscopes, methods of cultivating the organisms in artificial media and improved methods of identifying the organisms.

1. Lens and microscope: Lens were first made in the 18th century but it was not until the first microscope was made from an arrangement of lens by Hooke in the 17th century that a lot of micro-organisms including moulds, bacterial and also protozoa could be examined and drawned.
2. Improved methods of identifying the organisms: Staining micro-organisms became important to enable or make easy observation of these micro-organisms, therefore dyes such as aniline, fuschin, methyviolet and haematoxylin were experimented with. Staining was improved upon by first fixing the organism either by the use of alcohol or heat. Several workers experimented with these dyes to improve the staining techniques; Christian Gram showed that bacterial could be divided into two groups by staining with Gentian violet (blue colour), then applying Lugols iodine and finally treating with alcohol. He found that one group of bacterial retained the dye Gentian violet while the other lost the colour (it get decolourised). This very important observation formed the basis of the Gram's staining method which with minor modifications is still used universally.
3. Methods of cultivating the organisms in artificial media: While staining methods were being developed, experiments to grow micro-organisms on artificial media were going on in order to isolate them or in-growing them in pure cultures. Louis Pasteur was the first to start this experiment in 1861. Later in 1881 Loeffler made preparations containing meat infusion, Peptone, Sodium phosphate and Sodium chloride. Up till now these ingredients have continued to be the basis for preparing nutrient broth (liquid medium). Solid media preparation began in 1865 and agar is now used to solidify broth media. After this development the way was open to fully investigate pathogenic bacteria. There were several workers but the ones who stood clearly are Louis Pasteur and Robert Koch. They establish the foundation of microbiology. Within a short period of 10years many microbes were discovered as the causes of many prevalent diseases namely - Anthrax, caused by Bacillus anthracis, Fowl cholera, Tuberculosis; Glander, caused by Actinobacillus mallei, Typhoid, etc.

It was assumed that the growth of micro-organisms on artificial media was similar in all respect to the development of the organism in the host's tissues. Koch therefore postulated that for a bacterial organism to be identified as the cause of a particular disease-

1. The organism must be isolated in a pure culture on artificial media.
2. It must cause the development of the same disease when the culture is subsequently inoculated into a susceptible host.

Koch put forward 4 postulates known as Koch's postulates and they are-

(a) A specific organism can always be found in association with a given disease,
(b) The organism can be isolated and grown in pure culture in the laboratory,
(c) The pure culture will produce the disease when inoculated into a susceptible animal,
(d) It is possible to recover the organism in pure culture from the experimentally infected animal.

It as now become clear that Koch's postulates could not always be reliable criteria for identifying a bacterial organism as a specific cause of a particular diseases. This is because

(a) The cultivation of bacterial on artificial solid media can result in reduced pathogenecity, therefore when this pure culture is inoculated into a susceptible animal it may not cause a disease e.g. in the host some bacterial form capsule to resist phagocytes but on artificial culture, the capsule may be absent so exposing them to phagocytes.
(b) When organisms are inoculated into a susceptible animal most of the bacterial cells may be eliminated by the host from its tissue.
(c) When organisms are inoculated into the body, they may just be maintained inside the body and the animal will be in a carrier state and not cause any disease.
(d) If the organism is introduced into the host through an unnatural route (e.g. through the digestive tract instead of the respiratory tract), then a large dose of the organism may be required to cause the disease.
(E) There may be synergism between two or more organisms, for example a virus and a bacterium to cause a disease.

Particular toxins that are necessary to cause a disease may not be produced by the organism after laboratory culture. It is now known that the conditions in artificial cultivation are different from the environment of the host tissue.

Fungi	Virus	Bacteria
1. 2 . Lack chlorophyll 3. Most are saprophytic but many are pathogenic to man. 4. Some are useful to man e.g. Penicillium is lethal to certain bacterial, so penicillin is used in treating bacterial diseases. 5. The importance of fungi diseases in animals/man becomes higher with the increasing use of antibiotics and cortecosteroids, because antibiotics suppresses the bacterial population in favour of other microorganism, and corticosteroid suppress the natural ability of the body to overcome microbial infection. 6. Fungi cells are Eukaryotic i.e. with distinct nuclear membrane. 7. Some are multicellular e.g. Aspergillus while others are unicellular e.g. Yeast (Saccharomyces) and Cryptococcus.	1. It is the smallest of the microorganism known 2. Not capable of living independently. 3. They are intracellular parasites. 4. They require the cells of host plants or animals to replicate, that is, make copies of themselves using their own RNA or DNA genetic material. 5. They are made up of either RNA or DNA. 6. They cause disease in animals, plants, insects and even other micro-organisms like bacterial, where they are known as bacteriophage. However, some causes no harm. 7.They can only be cultivated in cells of living tissues e.g. developing chicken embryo. 8.Virus cells are Eukaryotic.	1. Cells are prokaryotic i.e. no nuclear membrane/ it is primitive. 2. They are unicellular. 3. Their shape differs depending on the genera, environment on which they find themselves and sometimes on age. 4. They grow in a characteristic manner they may be filament, chain or cluster and this is used in their classification. 5. Capsule, and/or flagella, and/or pili may be present. **Capsule** - are antigens, causing the production of antibodies in their host. They are gelatinous layer on the outer surface about 0.5µ or more, if less it is called microcapsule or envelope. **Flagella** - are hair-like structures originally from the basal granules in the cytoplasm, usually protein in nature and enables motility. **Pili** - shorter than flagella, helps in attachment to a surface either intestinal or any mucosa. 6. Reproduction is by binary fission.

On the basis of morphology (form/structure) bacteria may be classified in the following ways-

1. Bacilli (Bacillary): meaning they are rod-shaped, cylindrical and usually 2-10 microns long and 1-2µm thick. Genera include Bacillus (Bacillus enterakis is the only pathogenic one), Clostridium, Salmonella, Brucella, Mycobacterium.
2. Cocci: these are spherical and about 1µm in diameter. They can be arranged in bunches or clusters e.g. the Genus Staphylococcus; chain arrangement e.g. Genus Streptococcus; paired arrangement e.g. Diplococcus and Neisseria.
3. Vibrios: these are rod-shaped organisms usually curved or comma-shaped e.g. Genus Vibro and Genus Campylobacter.
4. Spirilla: they are spiral shaped and are filamentous i.e. long and thinned.
5. Spirochaetes: these are also spiral shaped but are flexuous.

COMPONENTS OF A BACTERIA CELL

1. CELL WALL - This surrounds a cytoplasmic membrane, gives shape and rigidity to the cell. It is composed mainly of muco-peptide complex. Other substances may be present in the cellwall e.g. teichoic acid and glycine. Gram positive bacterial contain muramic acid and this is the target for penicillin and lysozyme (enzymes produced by neutrophils to combat attacks). Gram negative bacterial do not have muramic acid and so are resistant to penicillin, however, they are susceptible to streptomycin which disrupt protein synthesis within the cell.
2. CYTOPLASMIC MEMBRANE: Encloses the cytoplasm, functions as a permeable membrane which allows water and nutrients to pass into the cell and waste product to pass out.
3. CYTOPLASM:
4. NUCLEAR MATERIAL: The nucleus has no nuclear membrane i.e. Prokaryotic. The nuclear material is made of threads of DNA. Reproduction is by binary fission with the nucleus dividing first.

   Other structures that may be present are capsule, flagella, or pili (or fimbriae), etc

Bacteria Spore: Are the dormant forms of bacterial cell which can survive for long period under adverse conditions. This is developed into by some bacteria in an unfavourable condition (environment).

Bacteria physiology

Bacteria use certain basic materials to provide energy for growth, multiplication and movement. These materials include carbon, nitrogen, phosphorus, sodium, calcium, magnesium, iron, hydrogen and oxygen. In addition certain other minerals and growth factors are required. **Autotrophic bacteria** are those that can synthesize all their needs from simple materials. They require for food a source of carbon and other inorganic substances; they can live and multiply from these substances only. Most of them would grow in the absence of light; however others require sunlight as source of energy. **Heterotrophic bacteria** on the other hand need at least one complex organic compound such as protein or fat. Parasitic bacterial are typically heterotrophic and this is why they can only be grown in culture media containing various organic compounds. However, there are some pathogenic bacteria that can grow in simple salt media. **Aerobes** are bacterial which can grow in atmospheric oxygen. There are some that can grow strictly when oxygen is present and this are called **obligate aerobes**. **Anaerobic bacterial** are those that cannot utilize atmospheric oxygen. Some pathogenic organisms are anaerobes and some are even sensitive to oxygen and may be killed by it. Bacteria can use the small amount of carbon (iv) oxide (CO_2) in the atmosphere but some requires more, sometimes more than 5% for growth e.g. *Brucella abortus*. Many species of bacteria requires a pH of 7.2 - 7.6 but some

species can tolerate acidic pH e.g. *Mycobacterium tuberculosis.*

Bacterial that are pathogenic to man and animal have adapted to the body temperature of their host. The optimum cultivation temperature in the laboratory is therefore 37°C. However, most would grow in the range of 25- 44°C. At temperature above 45°C vegetative bacteria are killed. In moist environment they are killed at 60°C when maintained from 15 - 20 minutes, but bacterial spores are more resistant and will only be killed when the temperature in moist environment is raised to 120°C. Death is due to cell protein denaturation. Desiccation is lethal to bacteria, however when micro-organisms are rapidly desiccated and stored in a vacuum, they would remain viable for many years. This process is referred to as lyophilisation (freeze-dry). Pathogenic bacteria are susceptible to light; they are killed rapidly by the ultra-violet rays of the light.

Culture technique of bacteria: To be able to identify a bacterial organism susceptible to be involved in any disease problem, it is essential -

(a) To obtain a pure culture of it on artificial medium
(b) If there are one or more than one species or types of organism, each must be carefully separated in pure culture.

To achieve the two objectives above, three operations are required

(1) The preparation of a suitable culture medium.
(2) The initial removal of other organisms from the region and its containers through sterilization.
(3) The cultivation of the organism and its isolation from others present in the material to be examined.

Liquid and Solid Media: Media can be classified into two broad groups liquid and solid. There are many types of liquid media containing different nutrients. Most bacteria would grow in at least one of them.

Disadvantages of liquid media

1. Bacterial growths do not show special characteristics unless they contain special chemicals for biochemical tests e.g. the ability to ferment lactose or fructose.
2. Organisms cannot be separated if they are in a mixed culture e.g. if staphylococcus and streptococcus are present.

This problem can be overcome by making the media solid, and this is done by adding gelatin (hoof, nail, skin) and more commonly agar-agar (extract from sea weed). On solid media, the appearance of the various growth colonies can be studied. To obtain a pure culture, solid media are indispensable. Usually bacteria isolations from pathological conditions are mixed; therefore solid media are widely used. Agar does not add to the nutritive property of the medium, also it can only be degraded by marine bacterial; therefore it is inhert when used for medical purposes. Agar melts at 95°C and solidifies at 42°C.

On the other hand gelatin melts at 24°C and is decomposed by many bacteria. Media can be classified into - Ordinary, Enrichment, Selective, and Indicator media.

1. Ordinary media: Consists of various fluid and solid media which can support the growth of a wide variety of organism e.g. Nutrient broth, Nutrient agar (nutrient broth + agar-agar).
2. Enrichment media: This meets the growth requirement of more exacting (difficult to please) or fastidious organisms. They contain substances like serum, blood or other ingredients e.g. blood agar.
3. Selective media: This contain substances which inhibit most types of organisms and therefore allows the growth of one type at the expense of the others e.g. Selenite broth (suppress all other organisms except Salmonella), Crystal violet agar (suppress all organisms except streptococci).
4. Indicator media: Allows the differentiation and the selection of organisms according to their characteristic properties of growth e.g. MacConkey agar used to differentiate between lactose fermenting organism e.g. *Escherichia coli* and non-lactose fermentors like Shigella or Salmonella.

Common Media usually stocked in the laboratory

1. Nutrient Broth (meat infusion + peptone)
2. Nutrient Agar (meat infusion + peptone + 1% agar)
3. MacConkey (contains Sodium taurocholate + lactose + neutral red indicator)
4. Deoxycholate Citrate Agar (DCA)
5. Sensitivity Test Agar
6. Robertson's Cooked Meat Medium

1. Nutrient Broth: It's a basic medium which allows bacterial growth. It is prepared by infusing lean meat in water overnight, then adding peptone to the infusion. Additional ingredients can be added to nutrient broth for specific purposes e.g. gelatin (15%) can be added to observe the ability of certain bacterial to liquefy gelatin. 5 - 10% whole blood (blood agar) can be added to encourage fastidious or haemophilic organisms and to observe the ability for haemolysis of certain bacteria. Examples of nutrient broth are Glucose broth, Serum broth, cooked meat medium, etc.
2. Nutrient agar: This is nutrient broth solidified by adding 1% agar. It is extensively used as a basal medium for supporting the growth of bacteria for antigen production and other purposes. Additional substances may be added to facilitate the isolation of particular bacterial specie and to encourage the growth of fastidious species. Substances that may be added include 1% glucose (glucose agar), 1% serum (serum agar), 1% blood (blood agar), we can also add crystal violet at a concentration of 1ml of 0.1% of crystal violet per 100ml of the agar, etc.

3. MacConkey agar: This medium contains the bile salts called Sodium taurocholate. This salt inhibit non-enteric (non-intestinal resident) bacteria, so it is used in isolating enteric bacteria such as *Escherichia coli*, *Salmonella species*, *Shigella*, *Klebsiella*, *Proteus*, etc.This medium also contains lactose; therefore the organisms that can grow on it can be identified either as lactose fermenting or non-lactose fermenting. This medium also contains the indicator neutral red. The lactose fermentors such as E. coli will produce lactic acid in the medium after growth which causes a change in colour of neutral red. Therefore the lactose fermentor appears brick red or pink on the medium while non-lactose fermentors appear pale because they do not cause any change.

Principles of Sterilization and Disinfection

Sterilizationis the act of freeing an item from all living organisms' i.e. total destruction or removal of all types of microorganisms. In practical bacteriology it is important to be able to study an organism in its pure culture without contamination with other organisms, therefore all equipment and media used for culturing and isolating organisms must be free from other living organisms.

Methods of Sterilization

1. **Application of Dry Heat**
   (a) Flamming (using Red heat) - Metallic objects like wireloop, spatula are commonly sterilized in a flame of bursen burner. The mouths of test-tube and other glass-containers are also sterilized in this way.
   (b) Hot-air oven - The hot-air oven may be used to sterilize if the temperature is adjusted to 160°C. The item is left in the oven from 1 to 1½ hours. Before sterilization the glassware or flask should be dry and plugged with cotton wool or caps. Using the hot air oven is the best method of sterilization of glassware and some surgical instrument. It is also used to sterilize powders and some grease like petroleum jelly.
   (c) Infra-red radiation: Although this may be used to sterilize metal instrument it has no laboratory application.
2. **Application of moist heat:** Moist heat can be used at temperatures below 100, at 100 or above 100°C. Only the last one ensures full sterilization (>100°C).
   (a) Moist heat below 100°C: This method is used if the material to be sterilized could be destroyed at a higher temperature, but it does not achieve a reliable sterilization. **Pasteurization** is the exposure to heat at a temperature below that of boiling water for a period sufficient to ensure the destruction of heat sensitive microorganism. It is a sterilization technique of heating a liquid material at 56°C for 1hour, can be left to cool and repeated for about 8 times.

.This method can be used to sterilize serum sample, milk, vaccines and other protein materials i.e. to disallow denaturation. The heating may be done in a water bath or an oven adjusted to 56°C.

(b) Moist heat at 100°C: Boiling at 100°C for at least 10 minutes will kill all the non-sporing and many sporing organisms; however some spores are not killed. This method is used generally for sterilizing hospital instruments like syringes and forceps. It can also be used for sterilizing pipettes.

Steaming at 100°C - The temperature of pure steam at atmospheric temperature is 100°C. If the object to be sterilized is exposed to this steam for 1 1/2 hours, then reliable sterilization can be achieved. **Tyndalization** is the intermittent exposure of material to steam for 20 - 45 minutes on 3 consecutive days; this will give a very reliable sterilization. At tyndallization, vegetative forms of the bacterial dies during the first exposure and in-between the exposure, the spores which germinates into vegetative forms are killed during subsequent heating. This method is particularly useful in sterilizing media containing sugars which will otherwise decompose when maintained at 100°C for long periods.

(c) Moist heat above 100°C:**Autoclaving** is the method by which water is heated under increased pressure to boil at a temperature above 100°C. The equipment used for this is called Autoclaves. This is the most useful and widely used method because at that temperature both spores and vegetative bacterial are killed. It is the usual method for sterilizing culture media. The temperature usually used is 121°C for 15minutes or 120°C for 20 minutes.

Disinfection is the destruction or removal of specific types of microorganisms i.e. sterilization using chemicals. Although the terms disinfectant (used when applied to in animate object) and antiseptics (for living object) are used to describe the type of chemicals used for the purpose of sterilization, the difference between the two is not clear-cut. Both are antibacterial chemicals which have a narrow spectrum of activity. They are effective against most bacteria except Mycobacterium but not very effective against spores. The term disinfectant should be preferred for all this chemicals. On the basis of chemical composition, disinfectant can be classified as follows:

1. Volatile disinfectant - e.g. Chloroform. Can be used to sterilize serum. It is mixed with the serum at a concentration of 0.25%. The chloroform is later removed by gentle heating at 56°C. Plate culture of vegetative bacterial can be killed by exposure to chloroform vapour for a few minutes. It is formally used for anaesthetic purposes but has been replaced recently by Ketamine
2. Phenolic group of chemicals - e.g. Lysol,Cresol, Izal, etc, they are very powerful. Lysol is used at 3% solution in water while Cresol is used at 0.5% solution. These compounds are extensively used in disinfecting animal houses.

3. Hypochlorites - e.g. Milton, widely used in laboratories to disinfect bacterial contaminated articles. Hypochlorite gives off chlorine gas, therefore fresh solutions should be prepared each days to obtain optimum result. Also widely used in hospitals and veterinary clinics.
4. Metallic salts or Organic compounds of heavy metals - e.g. Mercuric chloride, $HgCl_2$. It is widely used as 1:1,000 solution. Merthiolate or Sodium ethyl mercurial thiosaliculate is used as a solution in 1:10,000.
5. Formaldehyde - It is a water soluble and highly lethal cheap compound. Kills all kinds of microbes and spores. It is non-injurious to most materials and it is applied as a 40% weight for volume solution in disinfecting surfaces such as table tops and floors. It can also be used to kill bacterial cultures like chloroform, and can be used to disinfect farm articles such as rubber boots, farm vehicles, shoes, feeders, watering troughs, etc. Formaldehyde gas is used to disinfect poultry houses and hatcheries. In such a case the relative humidity of the atmosphere must be 80 - 90% and the temperature 18°C. The gas is released by heating formalin in $KMnO_4$.

PATHOLOGY

Pathology is the study of the structure and function of a diseased body. Disease is a change or deviation from normality; disease causing organisms (pathogen) are tiny organisms which cannot be seen with the unaided eye (microorganisms) except with the aid of microscopes. There are non-pathogenic and pathogenic microorganisms. The disease causing organisms include bacteria, virus, protozoa, fungi, helminthes (cestodes, nematodes, trematodes), as well as trauma.

Pathogenesis is the process of development or establishment of a disease. The relationship between microbial organism and the host can vary from commensalism, through symbiosis, to parasitism. **Commensalism** is the situation in which the organism adapts itself to live in the body without causing a disease e.g. Clostridia in the intestine. **Symbiosis** is that situation when the organism may metabolize some of the foodstuffs and break them down into substances which are more readily digestible to the host e.g. bacterial in ruminant's rumen. **Parasitism** is the situation in which the organism interferes with the normal metabolic process of the body. Organisms which are parasites in the body cause pathological changes in their host. The host in turn responds in an attempt to get rid of them. After the host has overcome the harmful effect of these organisms it would also have got rid of the pathogenic organisms as well as built up a specific immunity against them. This immunity allows the animal to withstand re-infection more effectively in future. Under the subject of pathogenesis, the followings are considered -

1. The routes by which animals become infected (whether by ingestion, skin wound, coitus, inhalation).

2. The pathogenic properties of the organism i.e. how they are resistant to phagocytosis by capsule formation.
3. The general and special ways through which the body defend itself.

The General Defence Mechanism of the Body: This includes the protection offered on the skin, by the conjunctiva, respiratory tracts, digestive tract and the urogenital tract. Because of the secretions of the skin the pH is usually 3 or 4 which is quite acidic, therefore the organisms that can live on the skin are usually nonpathogenic. Lachrymal fluid from the eye contains lysozyme which is antibacterial. Some protection is offered on the respiratory tract by the presence of lysozyme, mucus and cilia of the epithelium. However a variety of microorganisms lives in the respiratory tract as normal resident some of which are potentially pathogenic when conditions are favourable e.g. bacterial causing the common cold during rainy season. The digestive tract also offers some protection, for example, the pH in the stomach is highly acidic, so keeps down pathogenic bacteria invasion. The peristaltic movement of the GIT also helps in getting rid of pathogenic bacteria by helping in expelling them during peristalsis. The resident bacterial floral discourages the establishment of pathogenic bacteria in the GIT. In the urinogenital tract the passing of urine is a very important means of flushing out pathogenic elements.

Special Defence Mechanism of the Body: When pathogenic organisms have succeeded in penetrating the natural (general) defence systems, the host has to immediately produce a reaction to get rid of them. This function is taken up by the lymphoreticular system. The lymphoreticular system consists of phagocytic cells, and lymphocytes which may be fixed in the tissue or organ or wandering in the body. The mobile cells consist of microphages and the less mobile ones are the macrophages. Both micro and macrophages have the function of phagocytosing foreign bodies. The macrophages in addition can fuse together to form giant cells which are capable of dealing with larger particles e.g. fungal cells or bacterial which are difficult to get rid of such as *Mycobacterium tuberculosis*. The liver, spleen and the omentum (the transparent layer covering the stomach) have large numbers of fixed phagocytes.

The Development of Microbial Infection

For a microbial organism to cause disease it must be pathogenic. The term **pathogenecity** is used to apply to a genus or group of organisms that is capable of producing disease. The term **virulence** describes the ability of a particular strain of microorganism to produce disease e.g. not all strains of *Bacillus anthracis* are virulent while all in the genus Salmonella are pathogenic. The term **invasiveness** describes the way a pathogen attacks and spread through the host e.g. *Bacillus anthracis* is invasive while *Clostridium tetani* is not invasive i.e. it settles at one spot from where it causes all the diseases associated with it.

Inflammation is a collective name for all vascular and cellular responses from living tissues when injured (either by mechanical means or by pathogens). The causes of inflammation can be living or non-living things, however, microbial pathogens are the most important of these causes. The purpose of inflammation is to minimize the effect of the irritant of the tissue involved, thus serum and cells are poured into the site. The overall plan of inflammation is to dilute, localize, destroy, remove and replace the specific irritant. The serum dilutes the irritant and also brings to the scene antibodies and fibrin, the fibrin localizes the irritant andthe antibodies help in the phagocytosis by the White blood cell (WBC). The cells act to destroy/ remove the irritant and replace them. Of the white blood cells, the neutrophils are the first to arrive at the site of inflammation, their action is limited and they are later replaced by macrophages. There are four cardinal signs that are seen as a result of the response of the body to injury, they are-

(a) Swelling- It's due to dilation of blood vessel in that site and the flowing out of fluid from the vessel into the tissue.

(b) Redness - It's also due to vasodilation immediately at the site of injury. This is referred to as hyperaemia. Hyperaemia also leads to increased permeability of the vascular wall which allows more fluid, plasma proteins and sometimes some Red blood cell (RBC) to pass into the surrounding tissues.

(c) Pain - It's due to pressures on nerve endings which are produced by the exudates (fluid that pours or flows into the site).

(d) Heat- It's due to increased blood circulation to the area.

Types of inflammation

Inflammation may be classified according to-

1. Duration and severity: Therefore we have
   (a) Acute inflammation in which the onset of the process is rapid.
   (b) Chronic inflammation in which the process is prolonged.
   (c) Sub-acute inflammation which is milder than acute.
2. The predominant nature or type of exudates (inflammatory exudate).
   (a) Serous inflammation - It's the exudation of blood serum which is a clear fluid with little or no cellular component e.g. cold in which nasal passage runs water.
   (b) Fibrinous inflammation - It's the exudation of large amount of fibrin which has clotted. After fibrinous inflammation the fibrin is organized into connective tissue.
   (c) Catarrhal inflammation - It's characterized by mucus, surface epithelia cells and also leucocytes in the exudates.
   (d) Haemorrhagic inflammation - In this case the exudates is mainly RBC. It might be that the capillary has broken or ruptured or the RBC migrated through the capillary walls.

(c) Purulent inflammation- It's the type in which the exudates contain pus (a creamy coloured liquid) which may be thin, thick or semi-solid. Pus contains dead cells of tissue, leucocytes (mainly neutrophils killed during attack) and digested dead materials. It may also contain the microorganism. The term **suppuration** is sometimes used for purulent inflammation. It implies that a lot of pus is being produced, sometimes running to the body surface or filling a cavity. When the process of pus formation is localized, the lesion is called **abscess** but when it is spread in the tissue it is called **cellulitis**.

3. Agent causing the process e.g. a viral inflammation, bacterial inflammation, traumatic inflammation (due to physical injury).

BACTERIA: They are microorganism that can only be seen with the light microscope. They occur in clusters or colonies. A bacterium has a slimy capsule, cell-wall, a cell membrane, a dense cytoplasmic granule with no clear nucleus but has a nuclear material made up of Deoxyribose Nucleic Acid (DNA) which spread through the cell.

Classification of bacteria: Bacteria are often grouped either on the basis of its use of oxygen (aerobic, anaerobic, facultative) or on the basis of their shape (cocci, bacilli, vibrio, spirillae). The most convenient classification method is to divide all bacterial into two according to their reaction to Gram's staining i.e. whether they are Gram +ve or Gram -ve.

Then within any group the various genera can be arranged in an order whereby the adjacent (nearby) genera shows some similarities but the more distant ones have fewer characteristics in common. The arrangement therefore forms a sort of spectrum. This method is strictly speaking not a classification because they do not shows the identifying characteristics in a logical manner. However, the similarities and differences shown in such an arrangement lead the way to a more orderly arrangement of the different genera. The bacterial of animal health importance can therefore be divided into two groups -

Gram-positive	Gram-negative
Staphylococcus	Haemophilus
Streptococcus (and Pneumococcus)	Bordetella
Lactobacillus	Alcaligenes
Erysepelothrix	Brucella #
Listeria	Moraxella
Corynebacterium	Pseudomonas
Mycobacterium	Aeromonas
Nocardia	Vibrio
Bacillus***	Campylobacter (Vibriosis) #
Clostridium**	Proteus +

Gram-positive	Gram-negative
Actinomyces	Klebsiella +
	Yersinia
	Salmonella +
	Shigella +
	Escherichia +
	Pasteurella +
	Veillonella

Aerobic, **Anaerobic, ***Aerobic/Anaerobic, #Veneral or reproductive disease, +Enterobacterial

CHARACTERISTICS OF SOME BACTERIA OF ANIMAL HEALTH IMPORTANCE AND THE DISEASES THEY CAUSE

1. **Staphylococcus:** Staphs are Gram positive organisms which develop characteristically as bundles of spherical organisms. They occur in a variety of environment related to man and animals. Some are non-pathogenic and commonly live on the skin and are referred to as *Staphylococcus epidermis*. Another specie *Staphylococcus hircus* which live on the skin of pig, however, causes what is called exudative dermatitis. The pathogenic species of Staphylococcus are collectively known as *Staphylococcus pyogenes* (pyogene - pus generating). They produce the enzyme coagulase which coagulates blood plasma of humans or rabbits. Therefore, we use the coagulase test to distinguish between pathogenic and non-pathogenic Staphylococcus.

Staphylococcus may produce pigments on solid media which could be yellow-orange, lemon or white colour.

Staphylococcus aureus produce the yellow-orange pigments; *Staphlococcus citreus* produce the lemon pigment colour; *Staphylococcus albus* produce the white pigment colour.

However, pigment production in Staphlococcus is variable even within the same species.

Cultural Characteristics of Staphylococcus

1. Staphylococcus pyogenes are aerobes or facultative (can still grow without oxygen) anaerobes.
2. They grow well on nutrient agar but better on milk agar.
3. Have optimum temperature of 37°C although can still grow from 10- 42°C temperature.
4. They sometimes produce pigments.
5. On blood agar most strains are haemolytic i.e. breakdown RBC.
6. The selective medium for *Staphylococcus pyogenes* contains 5 - 10% NaCl.

Pathogenic factors of Staphylococcus Staphylococcus pyogenes produce many toxins which include:

1. Coagulase
2. Hyaluronidase - which facilitates the spread of organism into tissues.
3. Haemolysins - There are different type of haemolysins, one type kills mice when inoculated intravenously (directly into the blood).
4. Leucocidin- which produces gastroenteritis in man, it is called Staphylococcal food poisoning.

Staphylococcus pyogenes produces pus and causes abscesses and mastitis (inflammation of the udder). Also causes acute toxaemia (toxin in blood) and pneumonia in animals.

Coagulase Test: Emulsify a drop of Staphylococcus colony in normal saline on a glass slide, then add a drop of human or rabbit plasma and mix gently. If the organism is coagulase positive, the bacterial cell would clump together after a few seconds because the bacterial cell precipitate fibrinogen and this precipitate makes the surface of the cells sticky and so come together.

2. **Streptococcus:** Gram +ve coccal organism which develops characteristically in chains. They are either saprophytic or pathogenic and widely distributed in man or animals environment. Their natural habitats are skin, mouth, nose, throat, intestinal tract and genital tract. Pathogenic streptococcus cause acute or chronic mastitis, they also cause respiratory problems in horses called Strangles. They also cause a variety of pyogenic infections in many animal species. In man they cause tonsillitis, otitis media, arthritis and also cause problems with infected wounds. The group streptococcus consists of a large number of organisms which shows considerable variations in their properties. The majority are aerobes or facultative anaerobes. Others are strictly anaerobic, some streptococcus produce clear zones of haemolysis on blood agar, these are referred to as ß-haemolytic streptococcus and they include most of the pathogenic streptococcus. The pathogenic streptococci are differentiated into groups serologically. These serological groups are referred to as Lancefields group A to T on the basis of the carbohydrate constituents of their cellwall. Other streptococci produce partial haemolysis, and in this case the zone of haemolysis is greenish (□-haemolysis).

Cultural characteristics: They are generally like as in Staphylococcus but some organisms in group D can grow at temperatures above $45^{O}C$ and are referred to as thermophilic organism. The type of haemolysis on blood agar is important in characterizing streptococcus of animal origin. However, some pathogenic streptococci do not produce haemolysis. The majority of streptococci do not grow on MacConkey.The Lancefields serological test or method is used to identify streptococcus. Biochemical reactions are not so important.

Pathogenic factors: Pathogenic streptococci produce many toxins two of which are- O-streptolysin which is toxic to both red and white blood cells. S-steptolysin causes ß-haemolysis and it is anti-inflammatory. Pathogenic streptococci resemble pathogenic staphylococci in the varieties of toxins they produce which help in their establishment in the host.

3. **Diplococci (Pneumococci):** This organism is closely related to streptococcus and is more commonly isolated from human pneumonia cases (diplococcus pneumonial), however it also sometimes causes animal pneumonia and mastitis.

   Cultural characteristics: Like streptococcus it can be cultured. Growth is promoted in the presence of blood, serum or glucose and an atmosphere of 5-10% CO_2 improves the growth. It causes□-haemolysis.

   Pathogenic factors: Antigen/tosins - Pneumococci have a capsule which is important in preventing or allowing the organism to survive in host's tissue and to multiply. The capsule also enables the organisms to resist phagocytosis. No toxins have been identified yet from pneumococci.

4. **Lactobacillus:** Lactobacillus species are Gram positive rods (bacillary). They are (a) non-motile, (b) aerobic or facultatively anaerobic, (c) optimal growth is about pH of 6, (d) ferment lactose to lactic acid.
   Lactobacillus acidophilus is used to make yogurt. Lactobacillus bacilli are predominant in the stomach and small intestine of suckling animals and they help in the digestion of milk. However, these organisms have been implicated as the cause of gastric ulcers in weaner pigs.

5. **Erysepelothrix:** This group of closely related organisms causes disease in animals and man. They are collectively called *Erysepelothrix insidiosa*. They are Gram positive rods, sometimes slightly curved. In chronic lesions they appear as long filaments, but on solid culture media they appear as a mixture of filaments and bacilli, an organism like this is called pleomorphic. These organisms are micro-aerophilic but will grow aerobically. It also causes partial haemolysis on blood agar.

   Cultural characteristics: *Erysepelothrix insidiosa* causes a disease called Erysipelas in swine. The clinical symptoms of this disease varies. In the acute form there is septicaemia. Characteristics of septicaemia are fever, haemorrhages. At post mortem this haemorrhages are seen in various organs of the body and the lungs are oedematous (fluid-filled). In chronic form it is characterized by heart problems and arthritis. The organism can persist in putrifying meat for a long time and can survive for a long time in the soil. Erysipelas is a zoonotic disease (can be transmitted from animals to man).

6. **Listeria:** The only species in this genus is *Listeria monocytogenes* (monocytogenes -pour monocytes to the site of infection). These organisms affect a wide spectrum of hosts including mammals, poultry, fish, crustacean and even ticks and of course man. After overnight culture on solid media the colonies that are observed are made up of rods (bacilli) and may be slightly curved but after further culture for about 3-6 days the organism appears in chains.

Occasionally Listeria may appear as cocci and may be confused with streptococcus. Listeria is Gram +ve and actively motile when grown in glucose broth.

Cultural characteristics: a. grows moderately in the presence of atmospheric oxygen but some strains grow better in the presence of CO_2. Growths of all strains are enhanced by the presence of glucose, serum, blood or liver extract. It causes partial haemolysis.

Pathogenic factors: Antigens and Tosins - The organism has both 'O' and 'H' antigens. The O antigens are usually referred to as somatic antigen and the H as flagellar antigen. On the basis of this antigen the species can be subdivided into several serotypes e.g. $O_1 H_{10}$ or $O_1 H_9$. No toxins have been identified in this organism but the substance which causes monocytosis which is linked with a lipid on the cell wall. Listeria causes the disease Listeriosis which is characterized by nervous signs because it causes inflammation of the meninges (the surrounding membranes of the brain/spinal cord) and the brain tissue (cerebral cortex), the disease is called cerebromeningitis. The clinical signs of this disease include -

(a) Stiffness of the neck.
(b) Uncoordinated movement.
(c) Twisting of the neck (torticollis or wryneck - a painless contraction of one sternocleidomastoid muscle) and sometimes it causes abortion.

Listeriosis is a zoonotic disease.

7. **Corynebacterium:** There are several species of this genus but they are all Gram +ve rods, non-motile, non-sporing and do not form a capsule. Sometimes they appear coccobacillary. Some species produce potent toxins e.g. *Corynebacterium diphtheriae* which causes human diphtheria. Other species also produce toxins which cause disease in animals. There are two features common to corynebacterial infection in animals-

a. They are suppurative (lesion contains pus which oozes out)
b. Clinical symptoms after infection do not develop unless there is a pre-disposing factor.

Some species of corynebacterium that causes disease in animals are;

Corynebacterium pyogenes which cause mastitis in cattle and sheep, and suppurative lesions in many animal species. It produces haemolytic toxin on blood agar and liquefies solidified serum (inspissated serum).

Corynebacteriumovis causes inflammation of lymph node (lymphadinitis) in sheep and goats. It also produces a toxin which may or may not be haemolytic.

Others include *Corynebacteriumequi*, *Corynebacterium renale* in swine (which causes inflammation of the kidney). If it affects the whole kidney it is called pyonephritis. We also have *Corynebacterium bovis*,*Corynebacteriumsuis*.

Corynebacterium pyogenes: Exist worldwide on mucus membrane or surfaces of healthy animals including cattle, pigs, sheep and goats.

It is in this species that they cause suppurative conditions. *Corynebacterium pyogenes* appear short and coccobacilli or bacilli in infected tissues or young cultures and the cells are arranged in bundles which are called palisades. Young cultures are Gram +ve but old cultures decolourize easily and appear Gram -ve.
Cultural characteristics: *Corynebacterium pyogenes* (a) grows aerobically and anaerobically at 37°C, (b) growth is improved by blood or serum, (c) on blood agar the colonies are grayish with a clear zone of haemolysis around the colonies.
Pathogenesis: The organism causes mastitis in cattle, but before the disease they exist in the udder tissue and are latent there and do not cause any harm, however, under certain predisposing factors the organism multiplies rapidly and causes mastitis. The development of suppuration is accompanied or preceeded by the production of toxins in localized areas leading to the formation of pus. Some of the predisposing factors to pyometra (accumulation of pus in the metrium of the uterus which occurs after endometritis) and endometritis are abortion, calving and placental retention. In cattle nephritis (inflammation of the kidney) caused by *Corynebacterium pyogenes* may follow the obstruction of the urinary tract causing the trapping of urine.

8. **Bacillus:** There are many members in this group and all of them except *Bacillus anthracis* are non-pathogenic i.e. saprophytes e.g. *Bacillus megaterium*, *Bacillus cereus* and *Bacillus mycoides*. Some differences between the non-pathogenic and pathogenic Bacilli are-

Bacillus anthracis	**Non-pathogenic Bacillus**
Shows little or no haemolysis on blood agar.	Markedly or strongly haemolytic
Non-motile	Usually motile
Spores are central and do not bulge cell.	Spores can be central, sub-terminal or even terminal but usually bulge the cell.

Bacillus anthracis -

(a) It is a large straight non-motile rod. When isolated in the laboratory on solid media the cells are rectangular in shape, but when a smear is made from a lesion and stained the shape of the cell are more rounded.

(b) The organisms sporulate readily outside the body because of the presence of atmospheric oxygen but spores are not formed in the tissue. In the spore form the organism can remain viable in an environment of reduced nutrients which cannot support vegetative forms. When favourable conditions come each spores develop into a bacillus and during grazing a host may become infected orally. Inside the intestinal tract the organism localizes on the intestinal wall and multiplies and invades the blood circulatory system.

(c) In blood it develops a capsule which protects it against white blood cell attack. It is important to demonstrate a capsule in a smear in order to say that *Bacillus anthracis* was the cause of death. *Bacillus anthracis* is strongly Gram +ve but may appear Gram- ve in older cultures. The spores do not absorb the colour or become stained in Gram- stains. To demonstrate the presence of a capsule the smear is fixed by heat and then stained with Wright's or Giemsa stains which stains the cell blue and the capsule stains pale. Methylene blue can also be used but the capsule does not show well.

Cultural characteristics: *Bacillus anthracis* grows on laboratory media aerobically but it also grows in a partial anaerobic environment. Optimum temperature of 35 37°C is preferred. It form spores under aerobic conditions. On blood agar it is slightly haemolytic. The capsule is also formed more readily in liquid media (broth) containing blood or serum.

Pathogenesis: Resistance to Physical and Chemical Agents -Vegetative forms are killed at 60°C for 30minutes but the spores will survive steaming and boiling at 100°C for 5minutes. Spores would resist dry heat even at temperatures of 140°C for 2 - 3hours. Therefore the common method of fixing smears on the slide by passing it through a flame still leaves the spore viable. Note that the spores are also relatively resistant to disinfectant. Disinfect by burning it and using chemical, burry it and if possible use autoclaves.

Toxins: Bacillus anthracis produce an extracellular toxin which is composed of three protein component

Factor I	(EF edema factor)
Factor II	(PA protective antigen)
Factor III	(LF lethal factor)

These protein works in pair. Individually they are harmless (PA get its name from its use to make vaccines against anthrax). PA can team up with either EF or LF to produce edema (pathological swellings of tissue) or death respectively. It is the PA that does the groundwork by sticking to a special receptor on the membrane of the cell to be invaded and awaits the arrival of EF or LF molecule. Part of the PA molecule has to be lopped off before EF or LF can stick to it. Then EF or LF enters the cell through holes that has been bored by the PA molecules under a suitable condition.

Pathogenesis: Anthrax occurs worldwide and it affects mainly cattle, sheep, horses, goat and pigs in this order of susceptibility. Occurs less commonly in other domestic animal. Death in animal is caused by oedematous swelling, toxaemia which results in shock.

Post-mortem lesions: Carcass of herbivores which dies of acute anthrax rapidly decompose and become bloated. Blood oozes from the natural openings. The blood is dark in colour and clots poorly. The disease is diagnosed in such animals by making a smear and stain with Giemsa and check for the capsule.

9. **Clostridium:** (a) These are Gram +ve rods, (b) They form spores, (c) They grow anaerobically or in an atmosphere of little oxygen concentration (microaerophilic), (d) Their natural habitat is in the soil and are consumed along with food and excreted in faeces by animals. Spore formation is very important to complete their lifecycle and also to survive. A spore germinates into one bacillus which multiplies very rapidly. So out of one spore many millions of vegetative bacilli develop, all of them can form spore leading to a heavy population of clostridia organism which can be maintained in one area. There are many species which can be divided into three (3) groups -

Group 1 - Saprophytes: These lives in the soil and are closely associated with putrifying plants and animal matter.

Group 2 - Commensals: lives in the intestinal tract of man and animals and under special conditions do not cause any trouble.

Group 3 - Pathogenic: few are pathogenic, producing harmful toxins to host tissue. The damage that pathogenic clostridia cause depends on the quality and quantity of toxins produced.

Clostridium tetani which causes tetanus multiplies in a localized area of the body. Produce its toxins there which paralyze the nerves. On the other hand *Clostridium botulinum* which causes botulism cannot grow and live in the tissues of living animals but in foodstuffs, carcasses and other materials outside the living animal's body. Therefore the toxins are preformed in these materials, if an animal consumes this contaminated foodstuffs it becomes poisoned. Other species of Clostridium exist in various organs of the body e.g. the liver or injured muscle. Clostridia organisms actively decompose carbohydrates and proteins and in most species one or the other of these activities is predominant i.e. it is either predominantly saccharolytic or predominantly proteolytic. The saccharolytic clostridia include *Clostridia welchii*, *Clostridia septicum*, and *Clostridia chauvoei*. The proteolytic ones are *Clostridia tetani* and *Clostridia botulinum*.

The saccharolytic Clostridia grows in cooked meat media producing rapidly acid and gas, the meat becomes pink but not digested, in contrast the proteolytic Clostridia are able to digest protein causing its decomposition and it turns black.

CLOSTRIDIUM TETANI: Widely distributed in soils richly fertilized with faeces. It is usually present in spore form. The vegetative form is long and slender, actively motile and has flagellar. Spores are terminal, Gram positive in young culture but negative in older cultures.

Cultural characteristics: Strictly anaerobic, grows in cooked meat broth turning it black. It would grow in blood agar with a narrow zone of haemolysis. Spores are highly resistant and can only be killed by autoclaving.

Toxins: Some strains of *Clostidium tetani* produce toxins i.e. they are toxigenic,

but others are not. The toxigenic ones produce tetanolysin and tetanospasmin. Tetanospasmin is toxic to the nerves (neurotoxic). It is an endotoxin (retain toxin). Causes tetanic contraction of muscle, it is sometimes called lockjaw.

Pathogenesis: It starts with a deep wound which may be contaminated with spores, as the wound is in the process of healing anaerobic conditions are created at the site and this condition are needed for germination of spores and multiplication of the bacilli. The multiplying organism produce their toxins tetanolysin and tetanospasmin, the toxins paralyze the local nerves and travels along their length and get to the central nervous system.

Symptoms: This is mainly characterized by stiffness and twitching of muscles. In the terminal stages of the disease muscles are rigid and the limbs and the neck are extended, the jaws are locked, hence the other name lockjaws, the ears are erect and the nostrils are dilated. Tetanus affects most species, the horse been most susceptible. Ruminants and pigs are also highly susceptible but dogs and cats are less susceptible. Man is highly susceptible.

CLOSTRIDIUM BOTULINUM: Widely distributed in nature. It is also a Gram positive rod but the spore is oval and subterminal. The organism is very motile and strictly anaerobic. Most strains are haemolytic on blood agar but the zone of haemolysis is narrow. The strains that produce toxins are proteolytic but the non-toxigenic ones are not proteolytic.

Toxins: The organism produces a neurotoxin which is more toxic than any known substance, it is said that only one milligram of the purified toxin can kill 40 million mice. Botulism toxins are also endotoxin and there are six different types.

Pathogenesis: For botulism to occur the following conditions must be met

(a) Toxigenic strains must contaminate food which is acceptable to an animal.
(b) A suitable micro-environment must be present in the foodstuff to permit multiplication and production of the toxins.
(c) An animal must ingest the preformed toxin. Note that the organism does not usually invade tissue or produce toxins in the tissue.
(d) For botulism to occur the toxin must not be destroyed in the body. The type of paralysis that is caused by botulism is referred to as flaccid as opposed to rigid in tetanus. In flaccid paralysis there is complete relaxation of the muscles i.e. they are unable to contract.

Other Clostridial organism include

(i) Clostridium oedematiens (novyi) - causes bacillary haemoglobinuria in sheep and cattles.
(ii) Clostridium septicum-causes the disease called black quarter and gas gangrene in ruminants.
(iii) Clostridium welchii (*perfringens*) - subdivided into 5- types A to E on the basis of toxins and the disease produced. Type C causes enteritis in lambs and piglets.

Management Factors that Predispose animals to Clostridial infection-

(a) The use of permanent pastures, pens or yard where infections can build up.

(b) Sudden improvement in diet or the use of improved pasture.
(c) Puncture or bruising of gut, liver, skin, etc.
(d) Poor hygiene.

Most of these factors are associated with the intensification of production.

Diagnosis: (a) demonstration of organism in impression smear of damaged tissues, (b) demonstration of toxins in tissues, body fluid and gut, (c) culture of organism and demonstration of its ability to produce toxins.

Treatment: Clostridial organisms are very sensitive to Pennicilin and other antibiotics. Antisera may also be given.

Control: (a) Avoidance of the above management factors, (b) Vaccination good vaccines consisting of inactivated toxins (toxoid) are available to control most Clostridial species. However, cross protection between species is not good and it is important that species are carefully identified.

Immunity: Immunity lasts approximately 12 months. Inoculations are usually done so that animals are fully protected in advance of the period of risk. Very young animals are protected by their dam during pregnancy. Antibodies are passed to them via colostrum.

10. Mastitis: This is the inflammation of the mammary gland (udder) due to infection by bacteria mainly and other microorganisms occasionally.

Clinical mastitis - the effects are clearly obvious, heat, swollen and pain in the gland, visibly altered milk yield.

Sub-clinical mastitis - the effects are not visible. Special means are needed to detect it unlike the obvious ones. For example the demonstration of increased White blood cell (WBC) in the milk.

Causes of Mastitis - this can be classified into (a) Specific, (b) Non-specific and (c) Environmental types.

Specific types - the causal organisms are true pathogens which get to the gland via blood circulation or lymphatic tissue and this is typified by Tuberculosis and Brucellosis.

Non-specific types - these are of low pathogenecity, the predisposing (secondary) factors are of greater importance in initiating and perpetuating the condition e.g. bacterial of lower pathogenecity (opportunist pathogen ie. Secondary invaders) e.g. Staphylococcus, Streptococcus, Corynebacterium, etc which are commensal of the udder. Predisposing factors are (a) poor hygiene, (b) sore on teat, (c) trauma/ wound e.g. laceration or thorn or horn wound, (d) tick/ fly bite or milk machine wounds, (e) poor disinfection, (f) poor milking technique, (g) poor equipment design.

Environmental mastitis- these are associated with microorganisms which lives in the animal environment which are not regarded as udder or teat commensals e.g. Coliforms and Pseudomonas.

Effects of Mastitis-

(a) Decreased milk yield
(b) Decreased milk quality

(c) Public health aspect - Mastitis may serve as source of pathogen to human especially children.

(d) Indirect effect such as - interference with milking routen in terms of labour/ time, veterinary and drug bills (high cost of treatment), culling.

Control: This is aimed at (i) reducing the effect of predisposing factors to the minimum through the following means

(a) Good general hygiene in the cow shed such that the udder/ teats are clean and dry.

(b) Treat sore immediately after detection

(c) Correct faulty milking machine

(d) Correct faulty milking technique

(e) Wash udder if dirty and clean it very well, preferably with paper towel or ensure sufficient contact time with cloth in disinfectant, or on the other hand milkers can use gloves.

(ii)Identify animals with mastitis and milk them separately one after the other.

(iii)Identify the bacterial causing mastitis and treat correctly e.g. clinical mastitis could be treated immediately with correct drug and later a sensitivity test is done for confirmation.

In problem herd, teat dipping (application of disinfectant after milking) may also be used to control bacterial infection and consequently the transmission of the organism. Most importantly give the milker the time and incestive to milk properly believing that reliance on teat dip and antibiotic may be useless if the routine measures listed above are not carried out effectively. Cull chronic mastitis cases or the ones that suffers repeatedly.

11. **Contagious Bovine Pleuro Pneumonia (CBPP):** This is a slow developing disease of cattle which is usually perpetuated by their influence of - closeness of contact, virulence of organism, susceptibility of individual to infection and trekking of cattle.

Aetiology: *Mycoplasma mycoides*

Natural host: Cattle, Water buffaloes

Route if infection: Aerosol or inhalation

Signs: Incubation period is about 2 weeks. Signs are not obvious until there is mortality. Mortality may range from 10 - 50%.

Diagnosis: Blood or nasal swab culture; in postmortem, serological test of lung culture.

Treatment: It is not recommended because it leads to carrier state. It is best to vaccinate, but the efficacy of vaccine is difficult to access.

Control: Strict movement control, test and slaughter. In low incidence zones, combine vaccination with test and slaughter. In endemic areas vaccinate and control movement as much as possible.

12. **Contagious Caprine Pleuro Pneumonia:**

Aetiology: *Mycoplasma Capri*

Natural host: Sheep

Incubation period: about 4 weeks

Recovery - carrier are less common than in bovine pleuro pneumonia

Immunity: is good following clinical disease but not long-lasting. Vaccination is most useful where the causal organism is properly identified.

Treatment: Tylosin and Streptomycin.

13. **Brucellosis:** Otherwise known as Contagious abortion or Bangs disease. It is a bacterial infection characterized by the infection of the uterus and foetal membrane causing abortion in late pregnancy and infertility.

Aetiology: *Brucella abortus* (Cattle), *Brucella melitensis* (Sheep and Goat), *Brucella suis* (Pig).

Distribution - worldwide

Incidence: Variable, higher where cattle are close herded.

Source of infection: (a) vagina discharge (during abortion or during normal calving), (b) milk, (c) semen.

Survival of the Brucella organism is few days in the tropics and in months in the temperate.

Route of Entry: Usually by ingestion. It may be through mucus membrane of the nose or the eye.

Incubation period: Minimum of 40 days, maximum of several months depending on the stage of pregnancy.

Clinical signs: abortion, premature calf, retained placental, chronic metritis, mastitis, and orchitis.

Diagnosis: Culture of foetus or placental, also the discharges, milk, semen, etc. Detection of antibody in milk or serum (serology).

Control: (a) By eradication (culling) in cases of low incidence; (b) Reduction of prevalence through - (i) increase herd resistance by vaccination, (ii) decrease challenge from infected animal; (c) Vaccination - S19 (strain 19 of Brucella) is a live A-virulent strain and use it to vaccinate 3 - 8 months old animal. 45/20 strain this is lead adjuvant vaccine for any age of cattle.

Effect of Brucellosis in livestock

(i) General economic losses in calves - through abortion of calves and birth of premature/ weak calves.

(ii) Infertility, which manifested by - poor conception rate, returns to service and slow uterine involution.

(iii) Mastitis

(iv) Control of cost.

14. **Tuberculosis:** This is a slow progressing of all livestock diseases (poultry inclusive).

Aetiology: Usually *Mycobacterium tuberculosis*

Comparative Table of the Pathogenecity

	M. tuberculosis	M. bovis	M. avium
Man	+++	+++	+
Cattle/Buffaloes	+	+++	+
Horse/Camel	-	++	++
Sheep/Goat	-	+	-
Pig	+	+++	+++
Dog	+++	+++	-
Cat	-	+++	-
Fowl	-	-	+++
Parrot/Cage birds	++	-	+++

+ affected, - Not affected

Incubation period - last for months or years.

Factors that influence the cause of tuberculosis (TB)

1. Virulence of organisms.
2. Stress of pregnancy, lactation, starvation.
3. Housing the infection - spread from one organ to the other via blood lymph or contiguity (closeness).

Excretion - depends on the site of lesion. It may be through faeces. Organism survives well but don't multiply in the environment but does so on special medium.

Diagnosis: (a) Post-mortem examination, (b) Tubercullin test if it test positive to the test it means you've diagnosed it. The culture takes 6- 8 weeks, selective medium is required to culture it and special stain is required for staining (Ziehl Neelsen stain, ZN - a microbiological staining technique used in the Identification of acid-fast bacilli such as *Mycobacterium tuberculosis*).

Control:

a. Test and slaughter
b. Meat/milk inspection
c. Public health practices such as pasteurization of milk, proper cooking of meat/offals and separation of animal houses from that of man.
d. Vaccination the type of vaccine is BCG (Bacillus Calmet Guerin) although it is not too effective but it is recommended.

Treatment: very uneconomical because it is done for too long and drugs are very expensive.

Clinical Signs: Emanciation and dry cough.

15. **Escherichia:** The group Escherichia is made up of many type of *Escherichia coli*. *Escherichia coli* are normal inhabitant of the intestinal tract of man and animals. It is found in the soil, water and on vegetation through faecal contamination. There are commensal and pathogenic *Escherichia coli*. The commensal ones are found normally in the small intestine but the pathogenic organisms may also be found in small numbers inside the intestinal tract. Under certain conditions this small number of pathogenic organism multiplies rapidly and produces toxins which cause disease sometimes ending in death.

Morphology and Staining: *Escherichia coli* are a motile Gram negative rod. The capsular antigens are actually pili or fimbrae.

Cultural characteristics: (a) *E. coli* is aerobic and facultatively anaerobic, (b) Optimum culture temperature is 37°C but can grow within the range 18 to 44°C, (c) Some serotype or strains especially those pathogenic to pig are haemolytic in sheep blood agar, (d) *E. coli* ferment lactose with the production of acid and gas.

Laboratory Isolation of *E. coli*: In attempting to isolate it from faeces it should be remembered that it is a normal inhabitant of the intestinal tract of healthy animals; therefore its isolation from faeces is meaningless unless other factors are considered. These factors include -

(a) Detailed history of the case, the symptoms and the lesions.
(b) The amount of culture and its purity (primary culture).
(c) The site from which the *E. coli* is obtained; it is normal when obtained from intestine but abnormal when obtained from heart, lung, etc.

The media used for isolation are MacConkey and blood agar. On MacConkey it appears brick-red because it is lactose fermentor. On blood agar it appears large and grayish. They can be differentiated from non-lactose fermentors like Salmonella and Shigella which appears pale on MacConkey. The 'K' antigens develop well on blood agar.

Antigens and Toxins: possess 'O', 'K' and 'H' antigens and they are put in different serogroups according to the type of antigen they have e.g. O_{149}; $K_{91,88}$; H_1 meaning it has only one antigen 'O' with type 149; two 'K' antigen with types 91 and 88 and one 'H' antigen with type 1. *Escherichia coli* that causes diarrhoea produce enterotoxins (toxins that are active in the intestine). There are three (3) main types of enterotoxins

(a) Endotoxins (LT) which is heat labile i.e. it is destroyed by heat.
(b) Exotoxins (ST) which is heat stable
(c) Verotoxins

Disease causing *E. coli* belongs to specific serotype and they require predisposing factors in order to cause disease. Diseases caused by *E. coli* include - (a) diarrhea, (b) septicaemia, (c) Oedema disease, (d) poly-arthritis (Joint ill), (e) omphalitis (inflammation of umbilical cord), (f) or yolk sac disease in chickens.

16. **Salmonella:** This is a group of over one thousand serotypes and is found worldwide. Some of them are found in specific host while others have a wide range of host. Host specific ones are-

(a) *Salmonella gallinarum*
(b) *Salmonella pullorum*
(c) *Salmonella cholera suis*
(d) *Salmonella abortus equi*

However others affect a wide spectrum of host including man e.g. *Salmonella typhimurium* which causes disease in a variety of animals and man. The disease caused by Salmonella is called **Salmonellosis**. It is a zoonotic disease i.e. can be contacted by human from animals. Salmonellae are intestinal pathogens. Infected individuals excrete the organism intermittently in the faeces which now contaminate the environment, thus infected animals may remain carriers for a long time.

Morphology and Staining: Salmonellae are Gram negative short rods. They all, with the exception of *Salmonella gallinarum* and *Salmonella pullorum* has peritrichous flagellae (flagella which surrounds the body).

Cultural characteristics: (a) Salmonellae are aerobic and facultatively anaerobic, (b) They grow well on laboratory media at 37°C but some grow less abundantly e.g. *Salmonella pullorum*, *Salmonella cholerae suis* and *Salmonella abortus equi*. They are more difficult to culture because of the other bacteria floral in the intestine which grow more readily. Therefore to be able to isolate it from intestinal content or faeces reliable methods have to be used.

(a) First inoculate the infective material into an enrichment medium such as Selenite broth or tetrathionate broth which allows the growth of Salmonellae but inhibit other enteric organisms such as *Escherichia coli*. This is incubated overnight.

(b) Then sub-inoculated into a selective medium such as the solid media Deoxycholate citrate agar (DCA), Mac Conkey Agar, Brilliant Green Agar. After this, detailed biochemical and serological test are performed to distinguish between the different groups.

Antigens and Toxins: Salmonella have 'O' and 'H' antigens except the two sero-groups (*S. gallinarum* and *S. pullorum*) which do not have flagellae. The majority have more than one 'O' antigen e.g. the 'O' antigen of *S. typhimurium* are $'O'_{1, 4, 5, 12}$ and that of *S. cholera suis* are $'O'_{6, 7}$. Some Salmonella have the same 'O' antigen but they are differentiated by their 'H' antigen. The serotypes are identified by what is called the Rapid Slide Agglutination test.

SALMONELLOSIS IN LIVESTOCK:

Salmonella typhimurium causes disease in all livestock. Salmonella in adult mammals often does not lead to disease instead this animals become carriers for

months or even years, therefore they are sources of infection to other animals. Salmonella organisms may survive in faeces for 2 - 4 months. However, in pregnant mammals, Salmonella infection leads to late abortion. When such a case occurs then Salmonella can be isolated in pure culture from the aborted fetuses and the placenta and also the uterus of the animal. In young mammal the manifestation of Salmonellosis is septicaemia and the clinical signs are the following -

(a) Increased body temperature.
(b) Weakness.
(c) Haemorrhagic enteritis which manifest first as diarrhea and later end in dysentery.
(d) Difficult breathing.
(e) Death usually occurs in a few days.
(f) Navel ill and joint ill may be observed as a result of localization in the umbilical cord and joints. The joints become hot, swollen and painful.

Adult cattle may suffer from acute haemorrhagic gastroenteritis as a result of *Salmonella dublin* infection. The signs being diarrhoea and dysentery.*Salmonella cholera suis* causes pig parathyphoid, 4 - 8 weeks old are more susceptible, the adults are usually symptomless carriers. The young pig shows various forms of the disease which may manifest as a result of septicaemia and gastroenteritis.

Salmonellosis in poultry: Poultry constitute an important animal reservoir for Salmonellae. Many serotypes have been isolated from various species of poultry. In chicken the disease is caused by *Salmonella pullorum* and the disease is called **pullorum disease** or **bacillary white diarrhea**. Salmonella gallinarum causes Fowl typhoid. Other serotype cause Avian paratyphoid.

1. Pullorum disease (Bacillary white diarrhoea): This disease is important wherever intensive poultry production is practiced. Adult birds are symptomless carriers and the organism is present in their ovaries. This means that eggs laid by such birds may contain the organism *Salmonella pullorum* in the yolk. Therefore transmission is transovarian or vertical transmission (mother to offspring). Such eggs usually will not hatch, but the few which hatch will constitute a very serious source of infection to other chicks in the Hatcher(incubator) through horizontal transmission from faeces, dry feathers, chick boxes and litter. Chicks are highly susceptible to pullorum disease during the first 2 weeks of life. High mortality rate may be recorded as sudden death but when symptoms are observed the following can be seen-

(a) Increased thirst
(b) Inappetence (anorexia)
(c) Respiratory distress
(d) Whitish diarrhea, hence the other name bacillary white diarrhea
(e) Nervous symptoms like in-coordination or staggering
(f) Lethargy (dullness)

(g) Vent are covered with dry faeces
(h) Growth is stunted

2. Fowl typhoid disease: This is a disease of older birds (8weeks upward), even though chicks can also be infected transovarianly. The common route of infection however is by ingestion with food or water. The manifestation of fowl typhoid are the following -
(a) Chronic infection resulting in mortality
(b) Restlessness
(c) Greenish diarrhea
(d) Severe anaemia
(e) Dis-colouration of the wattle and comb.

17. **Proteus:** These organisms are found in the intestine as saprophytes. They are also present in the environment generally. However, under certain conditions it can cause abortion and diseases of the new born animals. It can cause otitis, peritonitis, dysentery and also diarrhoea. It causes disease commonly in zoo animals and reptile; this is mainly because of the stress of captivity. They are Gram negative rods but may appear as cocci or filament (pleomorphic). All the strains are motile because they have peritrichous flagella.
On solid media like nutrient agar, the growth is spread over all the surface of the plate as a thin film. Pathogenic proteus is believed to produce toxin.

18. **Klebsiella:** The organisms are found commonly as saprophyte in water and soil; however it may be present in the respiratory and intestinal tract of healthy animals. Most important members of the group which cause disease in animals are *Klebsiella aerogenes* (*Aeromonas aerogenes*) which causes septicaemia in fish and *Klebsiella pneumonia* which causes pneumonia in mammals including man.
The organism is a Gram negative thick rod and it produces a capsule. The cells are not motile but they produce fimbrae. The organism grows on solid media. On Mac Conkey they appear pink. They are non-haemolytic. They have 'O' and 'K' antigen but with repetitive sub-culture the 'K' antigen is loss. In mammals pathogenic Klebsiella are responsible for secondary suppurative pneumonia and metritis.

19. **Shigella:** These are Gram negative organisms that are important as the primary cause of human bacillary dysentery. Similar infections sometimes occur among ape and monkeys in the zoo.

20. **Pasteurella:** The genus pasteurella was named after Louis Pasteur for his work carried out on Fowl cholera, which is caused by *Pasteurella multocida* or *Pasteurella septic* in poultry. The other important members of this genus are*Pasteurella haemolytica*, *Pasteurella anatipestifer* (causes disease in ducklings), *Pasteurella pneumotropica* (causes pneumonia in laboratory rodents).

The following species were originally included in this genus but are now designated *Yersinia pseudotuberculosis*, *Yersinia pestis*, *Fransicela tularensis*.

PASTEURELLA MULTOCIDA: *Pasteurella multocida* can cause acute or chronic disease in all domestic and many wild animals. It is however present as commensal organisms in the respiratory tract of animals which are clinically normal. In cattle it can cause haemorrhagic septicaemia. In sheep and goat it causes haemorrhagic septicaemia and pneumonia. In pigs and rabbits it causes mainly pneumonia. The disease in rabbit is known as "snuffles" and it starts as a watery discharge from the nose.

In poultry *Pasteurella multocida* cause Fowl cholera which is a septicaemic condition causing sudden death in adult chicken. This organism occurs normally as a commensal organism in the respiratory tract but during sudden changes in temperature as occurs during the rainy season, it becomes pathogenic, multiplying rapidly and causing the congestion of the lung, liver, and haemorrhages, etc. Most of the time animals are found dead before any treatment. So prevent by giving antibiotics such as Streptomycin, Neomycin (usually for Gram negative organisms), Tetracyclin (a broadspectrum antibiotics), Ampicillin, and Penicillin (for Gram positive organisms).

Morphology and Staining:*Pasteurella multocida*shows variable morphology. When newly isolated from animals dead from infection, they are short ovoid rods i.e. coccobacillary, but when isolated from the respiratory tract of healthy animals or if they have undergone repeated sub-culture they appear bacillary (rod). The organism is non-motile and does not produce pus. It is Gram negative and has tendency for bi-polar staining (deep stains at edges and then in the middle). This is more clearly observed with newly isolated strains from tissues or if the organism is stained with methylene blue. Strains isolated from acute disease may have capsules.

Cultural characteristics: (a) it grows aerobically and anaerobically, (b) it will grow on ordinary media but better on blood or serum, (c) *Pasteurella multocida* is not haemolytic.

Antigens and Toxins: There are different antigenic serotypes and they are denoted by a number and a letter e.g.

1: A The number is the somatic antigen
3: A The alphabet is the capsular antigen
2: D
6: E

The number refers to the somatic antigen and the letters refer to the capsular antigen. For example 6: E causes haemorrhagic septicaemia and 5: A causes Fowl cholera. Predisposing factors such as a sudden drop in ambient temperature are important for the disease to occur.

PASTEURELLA HAEMOLYTICA: This causes pneumonia in ruminants (cattle, sheep, goat, etc). It has morphological and cultural characteristics similar to *Pasteurella multocida* but the main differences are -

Pasteurella haemolytica	***Pasteurella multocida***
(a) It is weakly haemolytic on blood agar and also breaks down maltose.	Not haemolytic
(b) When grown on bovine blood agar it produces an extracellular substance which increases the haemolytic effect of streptococcal ß-toxin (ß-haemolysin).	Does not
(c) It grows on Mac Conkey bile salt medium	Do not grow on Mac Conkey bile salt medium.

VIRUSES: These are microorganisms that are too tiny to be seen with an ordinary microscope except with the use of electron microscope. They are the smallest/ simplest microorganism without a cell structure. Each cell consists of a strand of nuclear protein and could be grouped as either a DNA (parvovirus, herpesvirus, poxvirus, papillomavirus, adenovirus) or RNA (picornavirus - enterovirus/aphthovirus; influenzavirus, paramyxovirus, morbillivirus, coronavirus, lyssavirus, togavirus, vesiculovirus) viruses. Some are rod like in shape while others are spherical which may be enveloped or without an envelope i.e. they are naked and can only reproduce inside a living cell. Viruses can be extracted from microscopy through filteration of suspension of suspected viral specimens. They filter through membranes and by varying the size of the pore of the membrane the size of the virus can be estimated. They can also be centrifuge out of suspension by ultracentrifugation. A viral infection is confirmed when round or oval bodies referred to as inclusion bodies are detected in the cell cytoplasm or the nucleus. They are detectable using specific stains e.g negribody (ies) found in certain nerve cells of animals suffering from rabies. The presence of this negribody confirms that the animal is infected. Viral infection may also occur through ingestion as in Swine fever; through inoculation or bite as in Rabies and midge (small flies - cullicoides) bite in case of African Horse sickness.

Some viruses resist adverse conditions such as dessication e.g. Foot and Mouth Disease (FMD) virus which can survive for three (3) years under some adverse conditions. In general, viruses survive freezing but they are thermolabile i.e. heat sensitive at 60°C for 30minutes.

Viraldiseases

1. **Kata (*Pestes des Petits Ruminantes*, PPR):** Rinderpest- like disease of small

ruminants (sheep/goat) characterized by necrotic stomatitis (necrosis- localized death of tissue; stomatitis- inflammation of the mouth) and intestinal/ lymphoid tissue changes which resemble that of Rinderpest in cattle.

Aetiology: A virus of the class Paramyxovirus which is antigenically related to the bovine Rinderpest, Canine distemper and Measle virus. Some but not all the strains are neutralized by Rinderpest antibody (antigenically related). Cattle may show serological response without clinical signs, in the field the disease does not spread on contact to Rinderpest susceptible cattle.

Transmission: (a) Aerosol, (b) Close contact between infected and uninfected animal.

Signs: Incubation period lasts 2 - 6 days.

(a) Fever
(b) Mucosal erosion (nasal discharge or rhinorrhea) follows the fever
(c) Diarrhoea for 2 - 3 days later
(d) Rhinorrhea becomes profuse and mucopurulent
(e) Death from 1 week of occurrence or onset
(f) Pneumonia in terminal stages
(g) Exudative labial dermatitis (labial -lips; dermatitis skin inflammation) on survivors.
(h) Scalp formation within 10 days.

Diagnosis: (a) Clinical signs and epidemiology, (b) Isolation of virus from antigen in the epithelium of lymphoid tissue.

Control: (a) Segregation of newly purchased stock is the most effective (Quarantine).

2. **Lumpy Skin Disease (LSD):** An acute viral infection of cattle characterized by fever, cutaneous nodules and generalized lymphadenitis (superficial lymphadenitis being prominent).

Aetiology: Neethling virus, which is related to arthropod borne virus of sheep and goat. Morbidity rate is between 5 - 45% and mortality is 1 - 10% but may reach 75% of it is precipitated by secondary infection. Exotic cattle are more susceptible.

Transmission: Method of spread under natural condition has not been determined, but the following is seen as transmitter -

(a) Insects, probably mosquito are main vector,
(b) Fomites (feeders/ drinkers) are implicated since saliva is infective. The disease has been reported in areas where mosquitoes could not be reported as vectors.

Signs: Incubation period is between 4 - 14 days

(a) Rise in body temperature
(b) Anorexia

(c) Increased salivation
(d) Lachrymation
(e) Clear nasal discharge, later mucopurulent
(f) Nodules or lump appears, uniform but vary in number on the neck, brisket, back, thighs, legs, perineum, and udder/scrotum. Hairs over lump stand erect. Nodules on mucosal surfaces are yellowish grey and soft, macerate easily leaving erosions and ulcers. When in the mouth there is salivation and nasal lesion.

Diagnosis: (a) Skin lesion

Differential diagnosis: Streptothricosis and demodicosis.

Treatment: None, but secondary infection may be treated with antibiotics.

Control: (a) Quarantine is not very effective because of inability to control suspected vector, (b) Vaccination using Sheep pox virus vaccine and vaccines from attenuated Neethling virus on Lamb kidney tissue culture.

3. **Foot and Mouth Disease (FMD):** An acute febrile disease of cloven footed animals like cattle, characterized by vesicle formation in the mouth, feet, teeth and in the rumen. It is not highly fatal but the lack of production following the infection and the prohibition on the movement of the livestock with their product makes it one of the serious animal diseases in the world. The incidence tends to increase in the cooler season.

Aetiology: FMD is caused by one of the smallest known RNA virus (picornavirus). It appears in 7 serotypes of which there are many subtypes. They are designated as serotypes O, A and C, and the South-African types SAT I, SAT II, and SAT III which accounts mostly for the African FMD outbreak, and the Asian type Asia 1 which is associated with the outbreak in the East i.e. Indian, Burma, Thailand, Pakistan, Hong Kong and Israel. There is no cross immunity among types and certain subtypes are immunologically distinct from others in the same group. Young animals are more susceptible.

Transmission: (a) Contact with infected product such as carcass from animal, since it can survive freezing, clothing, hair, equipment, straw or hay, (b) Ingestion, (c) Air e.g. exhaled air from infected animal under suitable relative humidity (60 - 70%), (d) Milk, saliva, faeces or urine of infected animal.

Symptoms: Incubation lasting between 3 - 8 days (may be as short as 1 day and as long as 21 days).

(a) High fever, less pronounced in old animals.
(b) Inactiveness
(c) Anorexia
(d) Stomatitis* which leads to slow mastication/ swallowing, smacking sound, rumination is protracted
(e) Staring eyes
(f) Massively drooling saliva

(g) Hot and reddened inner surfaces of mouth
(h) Vesicle formation* on inner lips, opposing gums, dental pads, back/ side of tongue, inner cheek (3 days) and udder
(i) Moist red painful erosion, when vesicle ruptures*
(j) Lameness*, when feet are affected
(k) Mastitis in milking cow
(l) Abortion in Sheep with lamb dying
(M) Gastro-enteric disturbance

Diagnosis: (a) Specific symptoms*

Differential diagnosis: Vesicular stomatitis, swine vesicular disease, vesicular exanthema (exanthema skin eruption).

Treatment: No specific treatment. Treatment depends on government regulation. Slaughtering in developed countries. Disinfect using 10% Formalin, 4% Sodium carbonate, 0.2% Citric acid, protective dressing is sometimes effective in shortening the course.

Control:

(a) By slaughter when there is an outbreak
(b) Massive vaccination - in most tropical areas where the disease is enzootic the slaughter policy is not rigid because of the immense expenses involved. Where it is newly introduced or not enzootic, the slaughter policy can be most effective as the eradication measure provided action is early to avoid extensive spread. Carcass must be burnt or buried so that the virus does not escape destruction.
(c) Disinfection of all inanimate and animate objects that have come in contact with virus, and burn those that can't be effectively disinfected. Leave the disinfected area unstocked for a period of time to rest.
(d) Complete quarantine of areas surrounding the infected environment. The slaughter policy for eradication is often implemented in countries where the disease has been enzootic and in which energetic vaccination program has reduced the incidence to a stage when total elimination by slaughter can be economically carried out.

Vaccination: Vaccines are better produced from locally isolated virus because there is little or no cross immunity among subtypes. Polyvalent vaccines prepared from standard types have been made but has not been too effective. Immunity following a single vaccination lasts up to 8months which is even up to 12 months after a second vaccination at 3-4 months after the first vaccination, however once a year vaccination in enzootic areas has produced adequate protection.

It is essential with any vaccination program that the virus type involved is first identified and also that the vaccine used contains specific antivirus against that specific virus. Following reduction in incidence through vaccination the slaughter policy is then economically feasible. Its then necessary to prevent re-introduction through the following ways-

(a) Complete prohibition of animals/animal product as well as hay, straw, vegetables and similar objects.
(b) Movement restriction

(c) Disinfection of farm workers by use of footbath, tyre-bath, etc.

4. **Rabies (Hydrophobia)**: A highly fatal viraldisease of great zoonotic importance. It is a disease of the nervous system. All mammals are susceptible but predominantly it is a disease of carnivores. It is transmitted to man through bite by rabid dog. It manifested as a motor irritation with clinical signs of mania (madness), paralysis and death.

   Epidemiology: Caused by a virus Rhabdovirus that is susceptible to destruction by standard disinfectants. There are various strains with the major ones being the street virus (occur naturally) and the fixed virus (which is adapted from the street virus through vaccine preparation). There is no antigenic variation among strains. It is neurotropic, travelling along nerve tract to the brain. Locus is almost worldwide. Hosts are all mammals, but the dominant host varies in all continent e.g. the Vampire bat in South/ Central America, Foxes in Europe/ America, Wolves in the middle East, Jackal in Africa/ Asia.

   Transmission: (a) Bite by rabid animal, (b) Aerosol, (c) Ingestion of dead rabid animal through human error as is seen in cornea transplant or bone marrow transplant.

   Signs: Incubation is about 3 weeks (20 - 60 days, average of 21 days). The virus may be found in the saliva 2 - 4 days before clinical signs appear in the infected animals. Clinical signs include-

   (a) Change in the normal behavior which ranges from dumb to furious behavior.
   (b) Voice change
   (c) Progressive paralysis
   (d) Death within 7 days

   Mortality rate is nearly but not always 100. A dog showing the dumb form without mania shows characteristics staring expression due to paralysis of facial muscle. Dogs showing the furious form attempts to bite moving and stationary objects such as doors, wire cages, feeding troughs, etc.

   Diagnosis: Facial skin biopsy (biopsy - sample from live animal; autopsy sample from dead animal). Head, brain and salivary glands are samples to be taken.

   Differential diagnosis: Diseases of the brain.

   Control: (a) Use attenuated inactivated vaccine in endemic areas, (b) control stray dogs, (c) vaccinate imported animals and quarantine for 6months in low risk area.

5. **Hog Cholera:** An acute contagion of pigs characterized by fever, widespread haemorrhages and death.

   Epidemiology: Locus is more in North Africa, America and Europe. Host is the domestic and wild pig.

Transmission: (a) Horizontal transmission and vertical transmission.
Signs: Incubation is 3 - 10 days.
(a) Fever
(b) Depression
(c) Staggering gait
(d) Skin decolouration
(e) Paralysis
(f) Death

Survivors exhibit chronic signs particularly the skin lesion and emaciation. Most infected animal dies within 3months.

Postmortem lesion: (a) Haemorrhages in acute cases, (b) Necrosis in chronic death.

Diagnosis: Specimen to collect includes blood in anticoagulant, serum, pancreas, spleen, lymph node, tonsils and brain in 10% Formol saline.

Control: (a) Vaccination in endemic areas, (b) Prohibition of import of pigs and pig product from infected areas.

6. **African swine fever:** A contagious viral infection of pig transmitted by soft tick (*Ornithodorus moubata*), characterized by fever, widespread haemorrhages and death. Surviving pigs become carriers.

   Epidemiology: Locus is Africa, Portugal and Spain. Host is the soft tick *Ornithodorus moubata*, the warthog, bush pig, domestic pig.

   Transmission: (a) Vector *Ornithodorus moubata*, (b) Ingestion of uncooked pig meat, (c) Secondary cases through contact.

   Signs: Incubation period is 3- 15 days.
   (a) Fever
   (b) Depression
   (c) Skin colouration
   (d) Posterior paralysis
   (e) Early death

   Survivors become emaciated and have undulant fever, painless oedema.

   Diagnosis: Specimen for collection includes blood in anticoagulant, serum, spleen, liver and kidney.

   Differential diagnosis: Hog cholera

   Control:
   (a) Fencing in endemic areas
   (b) Slaughtering of all pigs in case of outbreak and the destruction of the cadaver (dead body)
   (c) Disinfection/ cleaning of premises to destroy ticks
   (d) Prohibition of import of pigs and pig products from endemic areas.

7. **Rinderpest:** This is referred to as cattle plague. It is a highly contagious disease of cattle which in the past has cause devastating losses in numerous parts of the world including Europe.

Aetiology: A Morbillivirus under the broad classification of Paramyxoviridae. This is a virus of many strains but are immunogenically the same. They are readily destroyed by heat, drying and disinfectants. It occurs naturally in ruminants and pigs. It is of greatest importance in cattle, buffaloes, wild ruminants (which serve as reservoir). Sheep and goat are relatively resistant. Because of the ease by which this virus can be destroyed, animals readily become carriers. Elimination however may depend much on the organization of vaccination programmes and quarantine. The virus may survive for months under refrigeration and this explains the prohibition of importation of carcass from enzootic area.

Transmission: (a) Close contact between healthy and infected animal by inhalation.

Signs: Incubation period ranges between 6 - 15 days.

(a) High fever
(b) Loss of appetite
(c) Nasal and lachrymal discharge and staring coat.
(d) Inflammation of buccal and nasal mucosa
(e) Bloody and bubbly salivation which is clear but later becomes purulent
(f) Necrotic points on lower lip which is first discrete, white and raised but later becomes eroded, coalesce and ulcerate. Secondary invasion may follow, such lesion may be seen on nasal/ nasal mucosae
(g) Severe diarrhea follows lesion occurring in abomasums/intestine
(h) Difficult breathing with persistent coughing
(i) Dehydration/death within 6 - 12 days

Clinical symptom is similar in sheep/goat except that there is less salivation, no lachrymation, lungs commonly affected, mouth lesion is limited to soft palate and tonsil. It is generally milder in this specie of animal.

There are four (4) diseases that are similar in appearance and can be mistaken for Rinderpest, they are

(a) Haemorrhagic Septicaem
(b) Bovine Malignant Cattarrh
(c) Mucosal diseases
(d) Vesicular Stomatitis

Treatment: No satisfactory treatment. Early treatment using antisera intravenously at a rate of 1ml per kg body weight. Administration of sterile normal saline to counteract dehydration.

Control:

(a) Vaccination using tissue culture vaccine
(b) Quarantine newly purchased stock
(c) Slaughter if disease is newly introduced
(d) Prevent wild animals from farm to avoid transmission

Control is easy because all the strain of the virus have common antigenecity, however there is problem in selecting vaccine that will produce the required immunity without too severe reaction in the animal. The method employed in the past include-

(a) The use of varieties of vaccine of different attenuation gauged to suit

The resistance of the type of animal

(b) A goat spleen vaccine using a virus attenuated by consecutive passage through more than 250 goats have been widely used in the control of African and Asian rinderpest

(c) Lapinised vaccine has been found useful in less resistant European cattle.

(d) The sheep embryo vaccines have been used because the degree of attenuation can be adjusted to suit the susceptibility of the cattle on which it is to be used.

(e) Kidney cell culture vaccine is now been used widely and has been found to be the most effective.

Where the disease is very enzootic total herd vaccination is recommended. Subsequently, vaccination of the growing stock is usually sufficient. Because of the maternally transmitted immunity via colostrums calves under 9months do not take well. Consequently there is need for annual vaccination of young stock until the disease is known to have been eliminated. Despite vaccination there is need to watch out that it is not re-introduced from neighbours. It is also good to observe that slaughter of all ill contact animals is done where the disease is newly introduced. Stock quarantine of surrounding areas to prevent wild animal's entry and consequent transmission from which there is usually difficulty of control. Reserve stock of vaccine is advisable in countries with recently eliminated outbreak. The tissue culture vaccine immunity is assumed to be live-long.

PSEUDO RINDERPEST: Pseudorinderpest are viral infections of cattle resembling rinderpest clinically and pathologically. These diseases include the following-

Bovine Viral Diarrhoea (BVD), Infectious Bovine Rhinotrachitis (IBR), and Malignant Cattarrhal Fever (MCF).

	BVD	IBR	MCF
Epidemiology	Worldwide in domestic/ wild ruminants.	Worldwide.	Worldwide.
Transmission	Direct, indirect and Direct vertical.		Contact with carrier antelope/sheep., can also be vertical
Signs	Incubation is 9 - 6days	Incubation is 4 -	Incubation is 10days. 3weeks (21 days).
	1. Sudden onset, fever	1. Sudden onset, fever	1. Sudden onset, fever
	2.Diarrhoea	2. Nasal	2.Gastrointestinal erosion
	3.Death	3.Respiratory difficulty	3. Purulent catarrh
	4.Gastrointestinal erosion.	4.Recovery.	4. Death
Diagnosis	Specimen: scraping of intestinal mucosa, paired sera.	Nasal swabs, paired sera.	Lymph node, spleen/ brain in 10% Formol Saline.
Control	In almost all cases control is by quarantine/vaccination.		

8. **Contagious Pustular Dermatitis (Orf):** It is a benign pox condition in sheep and goat characterized by development of centrifugally distributed exuding proliferative lesions seen commonly on the lips/muzzle of lambs and kids and teat of ewes. A parapox virus group structurally and antigenically related to Bovine papular stomatitis (pox around the mouth). It is worldwide in distribution and primarily occurs most frequently in lambs/kids that are 3- 6 months old. It may also occur in suckling animal. There is seasonal prevalence i.e. around lambing/ kidding season.

Transmission: (a) contact between infected and healthy animal through a break in integumental continuity i.e. an essential precursor for infection, (b) ingestion - through milk.

The virus survives from one season to another as a latent infection not as earlier conceived that it exists in scabs lying dormant on pastures.

Signs: Experimentally the lesion goes through a classical pox stage in the susceptible sheep/goat. The stages are-

(a) Macule - swelling
(b) Papule
(c) Vesicle - transparent when water is seen
(d) Pustules
(e) Scabs

Naturally this disease is more proliferative in character

a. Starts with a first few days of incubation following contact with infected animal.
b. Papules emerge, enlarge and exude with crust formation.

C. Protruding scabs appears (first noticeable sign by stockman). When scab is removed it reveals a white mass which is rapidly flooded with blood. Scabs detach within 3- 5 weeks leaving a white scar of new epithelium. The disease is non-febrile. Lesions are centrifugally distributed, clustering around the lips, muzzle and lower part of leg. Tooth eruption favours the development of the oval lesion which spread to the lips/muzzle. The lesion may also develop at docking and castration sites and interdigital clefs. This disease rarely kills but may cause considerable loss in condition when lesions interfere with feeding. Serious consequences may follow superimposed bacterial infection or myasis. Mastitis is also a common sequel to infection of the teeth.

Diagnosis: History of the outbreak, clinical signs and laboratory techniques using electron microscopy.

Differential Diagnosis: PPR and Labial Streptothricosis.

Immunology: Recovered animals have circulating antibodies which can be passed to neonates through colostrums. However the level of neutralizing antibody is low, so no passive protection. The majority of previously infected animal exhibit accelerated immune reaction when they are re-exposed to the infection and this reaction progress very rapidly through the classical pox stages

and resolve within two weeks

Control: This is by live vaccine which are available commercially. The condition is endemic because it spreads through contact and this makes prevention relatively difficult to achieve.

9. Infectious Bovine Rhinotrachitis (IBR) and Infectious Pustulo-vulvovaginitis (IPV): They are both disease of the herpes virus but shows different clinical manifestations, survivors usually remain carrier.

	IBR	IPV
Aetiology	Herpes virus characterized by fever/rhinitis; worldwide	Herpes virus characterized by fever/vulvo-vaginitis; worldwide in ewe
Host species	Cattle, Buffaloes/wild ruminants	Goat majorly, though also in sheep
Transmission	Airborne, close contact between infected and healthy animals	Venerally, airborne since it is known to develop in vagina of heifers through air borne infections.
Signs	Incubation is under 1week. a. Sudden high fever b. Loss of appetite c. Ocular discharge d. Rhinorrhea e. Decrease milk production f. Increased respiratory rate g. Ocular/nasal discharge, Mucopurulent h. Abortion/death of newborn i. Infertility Affected animal recover within 2weeks.	Incubation is under 1week. a. There is no great fever. b. Congestion of mucosa of urogenital tract. c. Oedema of vulva. d. Petechiation (pin-point haemorrhages i.e. with dotted in lactating animal reddening) e. Pustule formation in an inflamed vagina with some thick yellowish discharge. f. Vagina irritation is quite intense g. If numerous the pustules coalesce and necrosis supervane, and resultant exudates forms pseudomembranes. h. Irritant posthitis (inflammation of prepuce) in bulls, adhesion due to balanoposthitis when it involves the penis may lead to permanent inability to serve. Acute form lasts few days with complete healing in 2days.
Diagnosis	(a) Clinical findings, (b) Laboratory confirmation; Paired serum.	(a) Clinical finding, (b) Laboratory technique confirmation

Treatment: There is no treatment, recovery leads to carrier state. Resistance to infection may last up to 3 years. Relapse may occur despite presence of circulating antibody.

Control:

(a) Isolate infected animal

(b) Vaccination - vaccines are produced using attenuated virus. Vaccine may not be use on pregnant animals because it may react. The vaccine does not prevent the infection but limits its severity. For infectious Pustulo Vulvovaginitis (IPV) local antibiotic application may be carried out.

(c) Stop breeding with infected animals temporarily until recovery.

(d) Recovered bull remains carrier, so prevent spread through artificial insemination (AI).

10. **NewC astle Disease:** An acute contagious viral disease of chickens, turkeys and occasionally other poultry. It is an important disease of broiler industry. Though not always fatal in layer, economic loss resulting from lower egg production is probably as great as the loss by death or delayed maturity in broilers.

Aetiology: A paramyxovirus which is known to remain viable for 5½ months in faecal material at 5°C. It can remain viable for 6months in the bone marrow and muscle of chilled chicken carcasses, for more than 6months in eggs, and for shorter periods in the surroundings of infected chicken houses.

An important property of the virus is its ability to **cause haemagglutination of avian erythrocytes**, as it is by this means that the virus can be identified in laboratory tests.

Transmission:

(a) Airborne droplets from coughing/ sneezing of infected bird.

(b) Contaminated food.

(c) Fomites such as clothing of farm workers.

(d) Through contaminated eggs. It can be distributed widely in infected flocks through contaminated eggs which may be accidentally broken in yards and houses. The virus normally kills the embryo in eggs laid by infected hens, and therefore infected eggs will not hatch.

Signs: All ages of birds are susceptible, but adults are less susceptible than young birds. Incubation period is 5 days.

(a) Dullness

(b) Coughing, sneezing and gasping

(c) Depression

(d) Prostration

(e) Profuse greenish diarrhea

(f) Drop in egg productions in layer, and eggs have soft shells. The condition spreads to all in contact, and there is a tendency for birds in a flock to huddle together.

(g) Nervous symptoms develop within a few days, especially in young birds paralysis of legs/wings as well as torticollis which may develop into complete twisting of neck and bird is seen to do a complete backward somersault.

Morbidity is up to 100%, mortality 1-100%, usually 50%. Symptoms may be subclinical due to environmental differences and degree of resistance of bird.

Diagnosis: (a) Clinical sign, (b) Serology

Control: (a) Sanitation, (b) Vaccination - should be done at least twice a year. Its effect starts to wane in 2 - 6 months after vaccination. Young chicks should be vaccinated within 10 - 14 days.

Route of vaccination

(a) Oral (Lasota)
(b) Intramuscular (Kamorov, 8weeks)
(c) Intraoccular or intraconjuctival
(d) Intranasal
(e) Aerosol spray.

11. Infectious Bursal Disease: It was first reported in Gumboro, Delaware hence the common name Gumboro disease or Avian nephrosis. Gumboro is an acute highly contagious viral disease affecting the bursa of Fabricius of young chickens. Chickens are the susceptible host (chicks 3- 6 weeks old).

Aetiology: (a) Infectious bursal disease virus, (b) an RNA virus in the family Reoviridae.

Transmission: (a) ingestion of food/water contaminated with infected faeces, (b) probably transferred by fomites because of the remarkable hardiness of the virus. It persists for longer periods in infected environment.

Signs: Incubation period is 3- 4 days.

(A) Onset is sudden with severe prostration, dehydration and in-coordination of movement.
(b) Infected birds have tendency to pick at their own vent.
(c) Whitish or watery diarrhea with soiled vent.
(d) Death may occur 3 days after onset of clinical symptoms.
(e) Generally affected chicks recover within 5 - 7 days time.

Postmortem lesions (Pathonomic lesion):

(a) Dehydration with darkened discolouration of pectoral muscles.
(b) Haemorrhages in the thigh/pectoral muscles.
(c) Increased mucous in intestines.
(d) Degenerative changes in kidney with enlargement.
(e) Enlargement of the bursa of Fabricius with gelatinous yellowish transudate (fluid covering its surface).
(f) There may be petechial haemorrhages and necrotic foci in the mucous surface of bursa.

(g) Normal white colour of the bursa will be changed to cream colour. Bursa in the later stages get atrophied and becomes gray in appearance.

Gumboro has the characteristics of immunosuppression so that infected birds cannot produce sufficient antibodies and become susceptible to other infectious diseases like Marek's disease, Mycoplasma infections, etc. Vaccination against NewCastle disease/ Marek's may not be fully effective in Gumboro affected birds. Moreover, the affected birds will have increased susceptibility to coccidiosis.

Diagnosis: (a) Clinical signs, (b) Postmortem lesion, (c) Serological test.

Treatment: No treatment is effective to change the course of infection. Birds get spontaneous recovery even in the absence of any treatment.

Prevention (Prophylaxis):

(A) Vaccination - Vaccinate healthy chicks from 1-7 days of age with FIBROGUMBO VAC - 10" of NVRI, Vom.

(B) Vaccinate the bird again after 30 days i.e. vaccinate the first 1week and 2weeks later (oral administration). It is preferable to give NDV i/o at day old and then the Fibrogumbo vac on 7th day.

Control: (a) Proper hygiene, (b) Disinfection- using Iodine containing disinfectant and 5% Formalin, (c) Protection of breeding stock to ensure protection of their offsprings.

12. **Avian Leucosis Complex:** The two diseases represented in the leucosis complex are Lymphoid leucosis and Marek's disease. They are characterized by the presence in the bird of neoplastic growths of a malignant nature. They are grouped together because of their similar appearances despite their different aetiological factors i.e. they are caused by the same virus. The differential diagnosis is listed below -

	Lymphoid leucosis	Marek's diesase
Age of occurrence	16 wks or later	4- 16 wks or later
Enlargement of nerves	Never	Often
Tumours in :		
Bursa of fabricus	Always	Never
Liver/other soft tissue	Always	Always
Skin	Never	Often
Muscle	Never	Often
Eye	Never	Often
Vaccination with MD vaccine	Non-effective	Effective

LYMPHOID LEUCOSIS: It is also referred to as big liver disease. It is mainly a disease of young chicken that is up to 4 1/2 months old although now seen in turkeys today. Aetiology: A light virus of low resistance easily destroyed/clear of the chicken's body.

(g) Normal white colour of the bursa will be changed to cream colour. Bursa in the later stages get atrophied and becomes gray in appearance.

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Eye	Never	Often
Vaccination with MD vaccine	Non-effective	Effective

LYMPHOID LEUCOSIS: It is also referred to as big liver disease. It is mainly a disease of young chicken that is up to 4$^{1}/_{2}$ months old although now seen in turkeys today. Aetiology: A light virus of low resistance easily destroyed/clear of the chicken's body.

Neoplastic in nature and the growth may affect soft tissues as well as bones.
Transmission: (a) by contact, (b) the virus lives well in eggs and the main means of transmission is embryonic, but slow and incomplete transmission between pen mates is common, especially with birds up to 4 weeks of age.
The usual manifestation is the appearance of symptoms and lesions in a number of birds which have come from a hatchery which is known to harbor the virus and the evidence seems to indicate that the virus is disseminated through the egg.

Signs: Signs are not very definite except the post-mortem lesions which give distinct characteristic. There is a very long incubation period, the virus being present but not causing disease from hatching to sexual maturity.

(a) Shrinking of comb/wattles which become pale/scaly.
(b) Characteristic big liver, observed through palpation of abdomen.
(c) Jerky gait or stands flat footed with rigid appearance if bones are affected.
(d) Rapid death or remain unproductive.

Postmortem- the liver and kidney are the major organs involved, although all other organs show some degree of involvement. In birds below the age of sexual maturity the bursa of fabricius is very enlarged and this is believed to be the starting point of the growth of this tumor. Once it is established here the growth spread to the tissue. Bone involvement (osteopetrosis) shows as enlargement or irregular thickness of leg or wing bones and they become extremely hard; a cross section of an enlarged bone will show the marrow cavity to be filled with bone.

Diagnosis: observed symptoms - no great problem is presented in diagnosis except to differentiate Lymphoid leucosis from Marek's disease.

Treatment: No treatment for Lymphoid leucosis

Control: (a) Selection of birds to get great resistant strain, (b) Replacement stock should be obtained from hatcheries known to be free of Lymphoid leucosis.

MAREK'S DISEASE: Marek's disease (MD) occurs in chickens and is characterized by abnormal growth in most soft tissues of the body. When nerve tissue is involved the birds show paralysis.

Aetiology: A herpes virus which exist only as one serotype. It is widely distributed in the tropics although it does not cause the disease all over the place. The virus has no protective outer skin and so it is easily destroyed outside the host cell. When the virus infects epithelia tissue at the site of feather follicles it acquires an outer skin from the host cell which allows it to survive for many month. It has an adverse effect on the bursa of Fabricius, and therefore on antibody production and the immune response of the bird; other diseases are able to penetrate and become established e.g. where coccidiosis is kept under control by coccidiostats in the usually way i.e. by allowing the coccidiosis to exist at a low (non-pathogenic) level, clinical coccidiosis will break out after the Marek's disease, MD virus has invaded.

Transmission:

(a) The disease is spread by dander (feather dust) from feather follicles. Dander is airborne and readily inhaled.
(b) Through excretion in saliva.
(c) By egg transmission (a rare means of transmission).
(d) Agent transmission e.g. other birds like sparrow; humans, flies, etc is common but impossible to prevent.

Symptoms: Chicks are infected after hatching but the production of the disease depends on the following factors -

(a) The virulence of the virus.
(b) The number of virus taken in.
(c) Ability of the body to produce antibody.
(d) Age of bird at the time of infection.

Some birds may die without any sign manifesting; some show variation in growth rate; some may become blind due to the optic nerve involvement; paralysis of the legs/wing may be a remarkable sign. Death occurs mostly between 10th and 18th week. Mortality rate is 50% and above.

Treatment: none

Control: Vaccination using tissue culture vaccines. Vaccination should be given at day old stage in the hatchery i.e. before infections set in because once the disease set in vaccination has no effect any more. Handling of vaccines should be done carefully.

13. **Fowl Pox:** Fowl pox is a viral disease of poultry characterized by pox lesion on the head (more on comb/ wattle).

Aetiology: The virus is found in at least 4- serotypes, each generally infecting its own host, which are the chicken, the turkey, the pigeon and the canary. The four serotypes are however immunogenically related. The virus is able to withstand dessication and sunlight for several weeks. It is inactivated by heating to 60°C for about 8 minutes. It remains viable in dried scabs from lesions for exceptionally long periods i.e. for about 10years.

Transmission: (a) Direct contact, (b) Contact with contaminated fomites. Injury to the skin is necessary for penetration by the virus as the virus cannot penetrate intact skin or epithelium. Such injury may be slight like small abrasions brought about by fighting or pecking especially in the region of the mouth, comb or wattles. (c) Insects such as mosquitoes, biting flies, ticks and lice are also transmitter.

All ages of birds are susceptible particularly those in their 6 - 12 months of age are more susceptible than older birds. Insanitary conditions and overcrowding are conducive to perpetuation of the disease in a flock, particularly where cleaning of feed/water trough is not thorough.

Symptoms: Incubation period is 4 -14 days. The disease spreads slowly and its course in a flock may be 2 - 3 months. The mortality may be up to 50% but is generally lower than this. Symptomatically there are two forms of fowl pox - (a) Contagious epithelioma and (b) diphtheric form.

(a) Contagious- epithelioma Lesions are found on the comb, wattle, eyelids and the corners of the beak. Severe cases may extend its lesion to the leg and body skin. The lesions are small white transparent vesicles which increase in size and coalesce to become larger, grey or brown wart-like growth which later detarch leaving raw bleeding surfaces.

(b) Diphtheric form Lesions are small white patches at the corner of the beak, sides of tongue, root of mouth and on epiglottis. This becomes caseous, then coalesce and later become necrotic. As the areas enlarge occlusion of the larynx may occur and death results from suffocation. This is usually more fatal although less common than the contagious form.

Diagnosis: Signs and lesions - Characteristic head lesions seen on the skin (contagious form). The signs of the diphtheric form may be confused with those of some respiratory diseases and to avitminosis A. This is usually confirmed using serology.

Control: (a) Recovered birds has a conferred level of immunity. (b) Vaccination - vaccines are produced from chick embryo. The young chick responds to vaccines from 6 weeks old. Where there is an outbreak, affected birds should be culled while the unaffected ones are vaccinated, kept under observation for 14 days. (c) Maintain standard sanitation.

RICKETTSIAL DISEASE

Rickettsia is mid-way between bacteria and virus. These are organisms which are over 0.2μmm in diameter. The rickettsial organisms are resolvable by a light microscope, but not filterable through bacterial stopping filters except for a few species that have filterable phases. They are Gram negative and only a few of their species grows on cell-free nutrient media. Examples are

(a) Rickettsia prowezeki
(b) Coxeller
(c) Cowdria ruminantum
(d) Chlamydia
(e) Anaplasma

1. **Heartwater:** This is a disease of ruminants (cattle, sheep and goats) named after its characteristic lesion **hydropericardium**, common in Africa. Its causative agent is a rickettsia *Cowdria ruminantium*, an intracellular parasite transmitted by the tick *Amblyomma hebraeum* (bont tick) or other ticks of this genus.

The rickettsia is found in groups in the cytoplasm of endothelial cells and in circulating blood of infected animal. Wild and domestic animals are susceptible. Temperate climate breeds of cattle, sheep and goats are much more susceptible than indigenous breeds which have been constantly in contact with the microorganism. There is also an important age difference in susceptibility, since animals that are less than 3 weeks of age are highly resistant. Animals that have recovered from the disease appear to be immune and apparently do not act as a reservoir of infection.

Transmission: Transmission is transtagia through a 3-host tick. The main vector Amblyoma can transmit the infection through metamorphosis from larva to nymph, and nymph to adult, but not through the egg. The microorganism itself is very small, rod-shaped or diplococcoid, and can be demonstrated with suitable staining in endothelial cells, particularly of the jugular vein, vena cava/ blood vessels of the brain. Infection may be transmitted by subcutaneous inoculation of whole blood from sick animal either by mechanical transmission or horizontal e.g. biting fly, syringe.

Clinical signs: Incubation varies from 1 - 5 weeks, average of 2 weeks. It is longer in cattle than any other ruminants. The disease may run a peracute, acute phases as well as subacute and chronic.

The peracute course may be observed in the exotic breeds with -

(a) Sudden collapse of animal/ death due to convulsion with very high temperature just before death.

In the acute form there is -

(a) High temperature (pyrexia), rising to over 41°C in 1 or 2 days.
(b) Anorexia.
(c) Ruminant stasis (non-movement of rumen).
(d) Sinosis of mucus membrane (blue mucus, showing shortage of blood i.e. Anaemia).
(e) Difficult breathing (dyspnoea).

In most cases central nerve symptom appears within a few days and it include

(f) Rapid blinking.
(g) Protrusion of tongue.
(h) Muscle twitching.
(i) Hypaesthesia (extra sensitiveness or cutaneous hypersensitivity).
(j) Unsteadiness - circling and high stepping.
(k) Aggression and convulsions.

Central nerve symptom is more pronounced in cattle, sheep and goat, recovery is rare. Other symptoms are haemorrhage, diarrhea and moist cough. In sub-acute and chronic form the course is prolonged and results in either slow recovery or death. A severe diarrhea often accompanies recovery. Indigenous cattle with high natural resistance or immunity show only a transient fever.

Postmortem findings:

(a) Accumulation of fluid in the pericardial sac, the thoracic and peritoneal cavity, hence the name heart water disease. Hydropericardium is common in sheep than cattle and goats.
(b) Pulmonary oedema (lung enlargement).
(c) Froat in trachea.
(d) Greatly enlarged spleen.
(e) Haemorrhages on endocardium, mucosa of stomach/intestine, trachea/bronchi and lymph nodes of the viscera.
(f) There is also oedema/enlargement of the thoracic lymph nodes and the lymph nodes of the head/neck.

Treatment: Early intravenous administration of tetracycline or sulpha drugs such as Sulphadimidine and Sulphametazine.

Control: (a) Control of Ticks - thorough elimination of the vector achieved through standard dipping/ spraying procedures, preferably at weekly intervals and with an acaricide to which the tick has not become resistant. (b) Immunization - by giving intravenous inoculation of whole blood of infected animal with the mild strain of the organism *Cowdria ruminantum* i.e. Ball-3-strain. After administering, watch the animal closely and when there is the sign of temperature increase, treat with tetracycline. The short coming or disadvantage is the means of cold storage. In South-Africa, the use of filtrate of homogenized engulfed infected nymph (collecting young infected tick, ground and dilute before inoculation into animal) has been practiced.

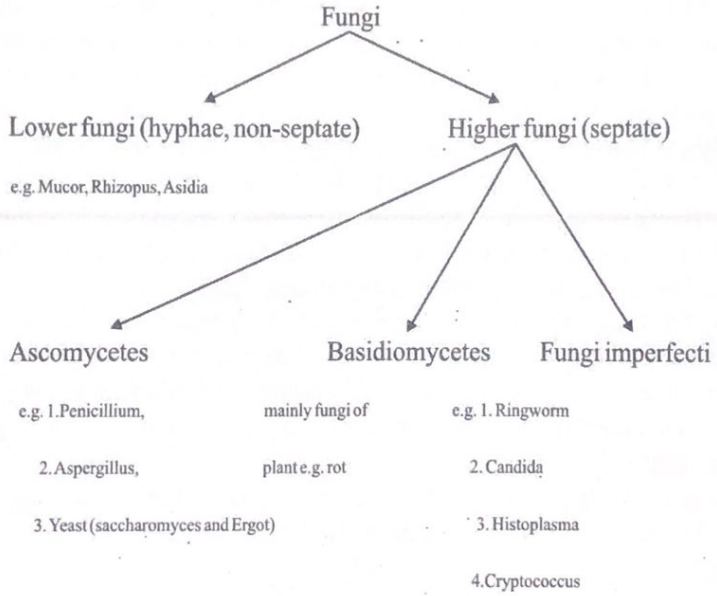
TEST QUESTIONS

1. A litter of 3 day old piglets were passing greenish diarrhea and *Escherichia coli* was suspected. How would you proceed to confirm that your suspicion was right?
2. A goat was injured on its foot on barbed wire, and not treated, but was noted to be having locked jaw and *Clostridium tetani* was suspected. Describe the sequence of events which led to the clinical signs.
3. Describe the probable sequence of events after Rinderpest virus gained entry into the body of a Cow through the oral route.
4. Compare and contrast the causes and pathogenesis of Botulism and Tetanus.
5. A flock of Turkeys were observed to be dull with some showing nervous signs. Aflatoxicosis was diagnosed as the problem. Discuss the cause(s) and pathogenesis of the disease.
6. Why do we describe some organisms as "acid fast"? Give one example.
7. What do you understand by the formula O141: K85: H9.
8. What is septicaemia and state clinical signs of septicaemia?

9. Outline a simple method you will adapt to test if a flock of parent stock of birds is harboring Salmonella organisms.
10. What are the components of pus and list the bacteria species that causes pus.
11. Differentiate between the following words (i) Endotoxin and Exotoxin; (ii) Virion and Rickettsia; (iii) Fimbrae and Flagella; (iv) Enrichment and Selective medium; (v) Saprophyte and Commensal organism.
12. A sheep has pneumonia and you isolated *Pasteurella multocida*, how will you confirm it is not *Pasteurella haemolytica*.
13. As a worker in a rural area without any laboratory, you just found sudden death occurring on your growing chicken, and you suspected the cause to be *Pasteurella multocida*. (i) What postmortem lesion do you observe? (ii) What are the colour/ shape seen on staining? (iii) How will you confirm your lesion? (iv)What factors do you think could have led to the infection?

FUNGI

Fungi are saprophytic or parasitic non-green plants. The saprophytic fungi are beneficial while the parasitic fungi cause different types of diseases.



Fungi imperfecti - This is defined as fungi in which no sexual phase of its reproduction is known. Apart from the ringworm fungi, others are Candida which causes thrush in animals and its very common in pregnant animals due to stress. Others are Histoplasma, Cryptococcus, etc.

1. **Aspergillosis:** This disease is caused by the fungus *Aspergillus fumigatus*.

It can cause a respiratory tract infection of birds and animals. In birds the disease is called brooder pneumonia and it occurs in young chick and other poultry species. Apart from lung infection *Aspergillus fumigatus* may cause infection of the skin, external ear, and the nasal sinuses. Occasionally it can cause meningitis. It also can cause mycotic abortion in cattle. Brooder pneumonia is caused by the inhalation of *Aspergillus fumigatus* spore which grows on damp and dusty food or bedding e.g. straw bedding or litter material.

Clinical signs:

(a) Sudden death of chicks
(b) Anorexia
(c) Restlessness
(d) Fever
(e) Increased respiration, and
(f) Sometimes convulsion

Similar disease conditions may be caused by other species of Penicillin, Mucor, Rhizopus and Asidia.

2. **Aflatoxicosis:** This is intoxication (effect of toxin on blood) due to the consumption of aflatoxins. Aflatoxins are produced by certain varieties of *Apergillus flavus* (gives black colour to stored feedstuffs). They are produced in some stored food or feedstuffs such as maize, groundnut or groundnut cake, palm kernel cake and soyabean. The following aflatoxins have been identified - aflatoxins B_1, B_2, G_1 and G_2. Not all strains of *Aspergillus flavus* produce toxins. The optimum condition for the production of aflatoxins is (a) temperature of 30°C and (b) relative humidity of 80 85%. Therefore to prevent aflatoxicosis, feedstuffs should be harvested and dried well before storage, and should be stored under conditions of low relative humidity. The aflatoxins affect the liver and the major lesion is found as liver cirrhosis, haemorrhages and tumours.
3. **Ringworm:** These are microsporon, trichophyton and epidermophyton causing ringworm infection in man and animals. They belong to fungi imperfecti group.

   Epidermiology: Animals get infected from contaminated buildings and objects within its environment. There are inapparent infection in dogs, cat and mice and this may lead to human infection.

   Pathogenesis: Fungi utilize the keratin and thus parasitise keratinous structures such as hairs, epidermis, horny structures. From the initial point of infection the inflamed area spread.

   Diagnosis: Prepare wet smears from deep scrapping from the edge of the lesion macerated in water or 4% KOH and look for the hyphae under the microscope.

   Secondly, the material can be cultured on Sabouraud's Dextrose Medium incubated at room temperature, usually around 25°C. The growth can be stained with Lactophenol cotton blue. Observe the hyphae which are stained blue under the microscope.

LIVESTOCK PARASITES

Parasitism - living together of two or more organism in which the host suffers.

Symbiosis - a relationship between two or more organisms in which the participants are of mutual aid and benefit to one another i.e living together of two organisms in which both gain mutual benefit.

Commensalism - living together of two organisms in which one benefits while the other is unharmed.

An efficient parasite lives in harmony with its host i.e. it approaches commensalism. The four (4) critical stages in the lifecycle of a parasite include -

- Entry into a suitable host
- Multiplication within the host
- Exit from the host
- Transmission to a new host

Parasites undergo either sexual or asexual reproduction in order to perpetuate itself in the host species.

Asexual reproduction involves the division of a single gamete into two or more individuals' e.g.

(a) Binary fission

(b) Multiple fission (Schizogamy) in this condition the nucleus divides several times before the cytoplasmic division with the production of several daughter cells.

(c) Budding.

Sexual reproduction involves the coming together to two different gametes to form two or more individuals' e.g.

(a) Conjugation - this is the pairing of two organisms with the exchange of nuclear material and then separate into different organism.

(b) Syngamy -this is a relationship between two organisms in which a microgamete and a macrogamete comes together to form a zygote (sporozoite). The act of formation of the zygote is called sporogony.

Asexual reproductive phase is the phase that usually produces disease in the host. The degree of pathogenecity depends on -

(a) Resistance of the host

(b) Rapidity of multiplication of parasite

(c) Number of parasites introduced at the time of infection

(d) Their virulence (degree of invasiveness) for the host

(e) Rapidity with which the host can develop resistance to them

(f) Whether the parasite is normally intracellular or extracellular

Types of disease transmitters

(a) Mechanical or non-cyclical transmitter - This is an organism that is not a host to a phase in the life cycle of the parasite but help in transmission e.g.

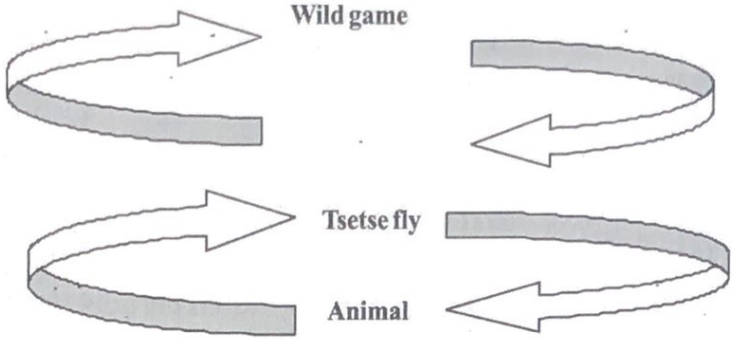
Tabanids and Stomoxys are vectors of Plasmodium parasite, or through the use of needle/syringe.

(b)Biological or cyclical transmitter - This is an organism that is a host to a phase in the lifecycle of the parasite in the process of transmission. There are different types of biological transmitters such as -

(1) Obligate host - This is a biological transmitter that is essential for the survival of the parasite.

(2) Principal host - this is a biological transmitter that is most important as a host i.e. the parasite just as to pass through it.

(3) Accidental host - this is a host in which the parasite finds itself unusually i.e. it is not the normal host.



Epidemiology - This is the study of the natural history of a disease.

Prevalence - This is the total number of cases within a population at a given period of time.

Enzootic - This is the continuing prevalence of a disease in a defined group of animal.

Enzootically stable situation - Mortality rate is low enough to be acceptable. Cattle are infected as calf with minimal clinical symptoms and then become lifelong immune carriers. In unstable situation, cattle may encounter infection for the first time until they are older in which case they will suffer a clinical disease.

Incidence - This is the number of new cases in a given period of time.

Epizootic - This is the sudden increase in the prevalence of a disease may be for a short or a long time duration.

Short or point epizootic - This is an explosive increase in the incidence of a disease.

Long or progressive epizootic - This is a peak in oscillating enzootic disease.

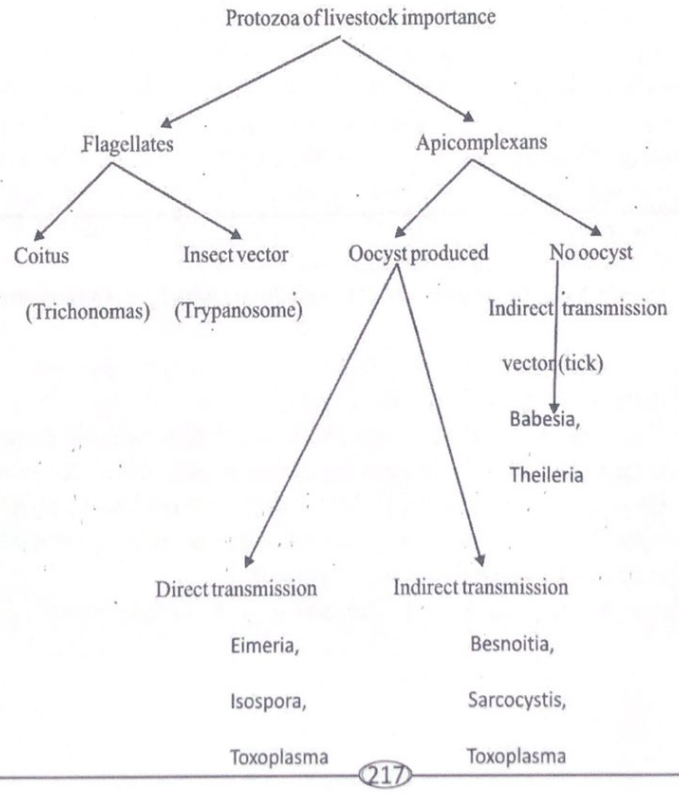
Virgin epizootic - This is a new occurrence of a disease in a defined group of animals in which the disease was previously absent.

$$\text{Morbidity rate} = \frac{\text{no of animals affected by disease}}{\text{Population}} \times 100\%$$

$$\text{Mortality rate} = \frac{\text{no of death recorded}}{\text{Population}} \times 100\%$$

PROTOZOA: Protozoa are single-celled organisms which reproduce by splitting, budding, disintegration into spores, or sexually through merging and subsequent division. They are microscopic, free-living, unicellular animals e.g. amoeba /paramecium. Some are parasites e.g. trypanosomes (cause trypanosomiasis)/ plasmodium (cause malaria-fever). There two types of protozoa - flagellates and apicomplexans

Flagellates	Apicomplexans
1. Motile 2. Possess one or more flagella 3. Reproduction is asexual (binary fission) 4. Do not produce cyst, undergo indirect transmission. e.g. Trypanosomes	1. No obvious means of locomotion 2. No flagella 3. Reproduction is complicated, based on three sexual/asexual stages (Schizogony, Gametogony, and Sporogony). e.g. Babesia and Theileria



Trypanosome -This is a protozoa found naturally in the blood of wild animals were they are not known to cause any clinically significant disease unless the animal undergoes a stressful condition. Trypanosome is bigger than Anaplasma and it is found in the blood outside the red blood cell (extracellular) and not inside the cell like Anaplasma (intracellular). It is called a flagellated parasite because of the flagellum. It is capable of dividing along the longitudinal line (binary fission). Due to its presence in the blood it causes the production of antibody which destroys the parasite and in the process releases endotoxin. It causes the disease trypanosomiasis in livestock where it is transferred by the bite/ passage through the saliva of blood sucking insect (Tsetse flies). The blood form of trypanosome is the trypomastigote while the infective form is the metacyclic form (amastigote - has no flagella), with other forms being promastigote and epimastigote (it's the flagellate form which appears in the gut of invertebrates). There two main type of trypanosome- Stercolarian and Salivarian.

(a) Stercolarian (Posterior station) - this type develops in the mid and hind gut of bug and is transmitted through bug faeces e.g. *Trypanosome cruzi* which cause Chagas disease.

(b) Salivarian (Anterior station) - this type undergoes a cycle of development in the digestive system of the vector before it changes to the infective form in the mouth part of the fly. Transmission to the host is through tsetse-fly bite e.g. *Trypanosome brucei*, *Trypanosome congolense*, *Trypanosome vivax*, *Trypanosome simiae* which causes Nagana disease; *Trypanosome evansi*, *Trypanosome equiperdum* which causes Dourine disease in Equidae family and is transmitted through coitus; and *Trypanosome suis* which affect pigs.

Clinical symptoms: (a) Increased body temperature (fever) due to the destruction of red blood cells by endotoxin, (b) Loss of condition.

Treatment: Using Suramin, Berenil, and Metamidium which are all injectable drugs.

Control: Destruction of the vector (Tsetse fly).

TICK-BORNE PROTOZOA (Babesia and Theileria)

(a) Babesia - They are intracellular parasites like Anaplasma and are only observed as dots inside the red blood cells. Itcauses the disease babesiosis (or red water in cattle) in cattle, pig, sheep, dog and horse. It is present in the red blood cell (RBC) where it multiplies by simple fission. It is transmitted transovarianly (transmission through eggs to young by infected adult ticks)by hard ticks.

Adult ticks → infected eggs → infected larva → infected nymph

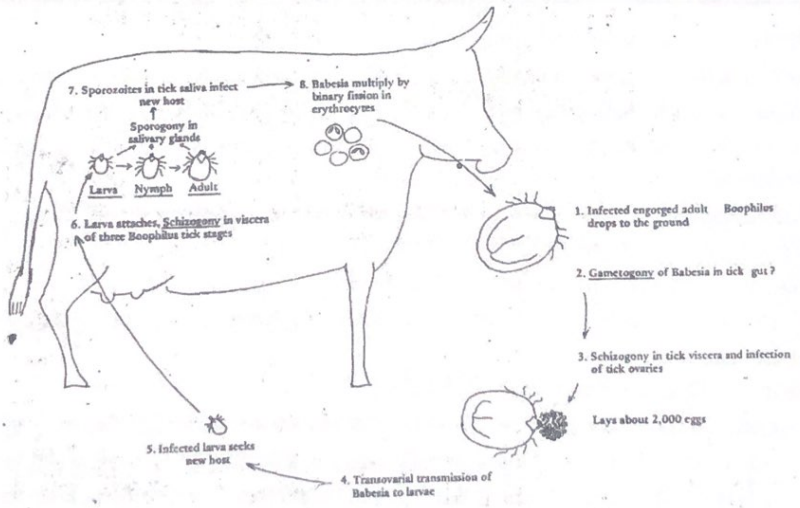
Animal	Babesia	Tick
Cattle	*Babesia bigemia* (large >3μ)	*Boophilus microplus* *Boophilus decoloratus*
Sheep/Goat	*B. motasi* (large), *B. Bovis* (small <3μ)	*Haemaphysalis species*
Pig	*B. trautmain*, *B. Perroncitoi*	?
Equidae	*B. caballi*, *B. Equi*	*Hyalomma species*, *Dermacentor species*, *Rhipicephalus species*
Dogs	*B. canis*, *B. gibsoni*	*Haemaphysalis species*

Babesia bovis and *Babesia bigemia* are both transmitted by *Boophilus microplus/ Boophilus anlatus*. *Boophilus decolouratus* can only transmit *Babesia bigemia* and it is the commonest in Africa due to the presence of *Boophilus decolouratus*, hence *Babesia bigemia* is of more importance than *Babesia bovis* in Africa.

1-host tick - egg to larva (attaches to a host animal and develops through the nymph/adult stages, then drops as engorged adult to lay eggs)

2-host tick - egg to larva (attached to host and proceed to nymph stage, drops off) nymph to adult attaches to another host as adult, then drops as engorged adult to lay eggs.

3-host tick - egg to larva (engorged and drop off to form nymph), nymph attaches to a second host and engorge/drop off to form adult on the ground, than adult attach to a third host, then drops as engorged adult to lay egg.

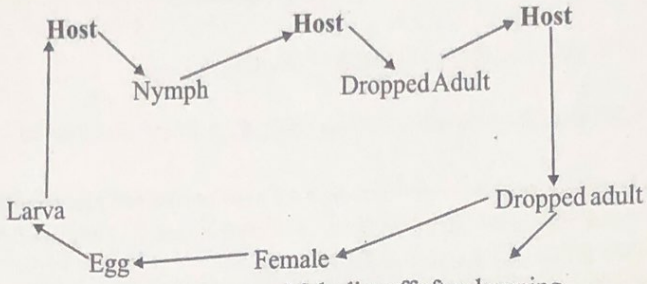


Symptoms: (a) Fever, (b) Pale mucus. Babesia is more commonly found in adult animals, (c) When RBC is destroyed, it gives yellow colouration to urine, a situation referred to as haemoglobinuria, (d) Jaundice i.e. yellow colouration of other parts of the body, (e) Anorexia, (f) Urine is red in Babesiosis other than the yellow colouration which leads to its name redwater disease.

Diagnosis: Confirmation is by examination of blood sample. Organism can usually be seen in blood films stained with Lieshmans or Giemsa stain; tentative diagnosis is done using the clinical symptoms such as mucus membrane jaundice and haemoglobin in urine.

Treatment: Use Berenil.

(b) Theileria - This cause the disease theileriosis of Cattle, Sheep and Goat. It is transmitted transtedially (transmission through stages) by 2 or 3 host ticks. Transtedial transmission means that the infection goes from one stage to another as the larva acquires this infection from the host, drops, and get onto another host and then transmit the infection.



Theileriosis are caused by the following species of Theileria -

(1) Theileria parva e.g *T. parva parva* causes Eastcoast fever and it's the most pathogenic, it is transmitted by the vector *Rhipicephalus appendiculatus*; *T. parva laurenci* causes Corridor disease or Buffalo disease; *T. parva bovis* causes malignant theileriosis.

(2) T. mutan

(3) T. ovis (not very pathogenic)

Diagnosis - This is done through the demonstration of sporozoite in blood stream or by the Koch's Blue Body (kbb) in smears taken from lymph glands through various serological tests.

Treatment - Use of Parvaquone and Halofugmone

(C)Anaplasma - They are small parasites mostly located in the circulatory system and cause the disease anaplasmosis in Cattle. It occurs where there is Babesia. It is smaller than babesia, it is a rickettsia organism. The two popular species are *Anaplasma marginale* and *Anaplasma centrale*.They are intracellular

organism (occur inside the red blood cells). They are transmitted by ticks, parasitise only red blood cell. The disease is important in the tropics and subtropics. The more virulent of the two is the disease produced by *Anaplasma centrale*. Transmission is through the ticks -Boophilus species (leading to the occurrence of anaplasmosis and babesiosis together). The major species of ticks that serve as vector are *Boophilus microplus*, *B. decoloratus* and *B. anulatus*.*Anaplasma marginale* can also be transmitted by - bitting flies notably Tabanids, surgical procedures like dehorning/ castration, syringe needles, etc.

Whether a disease is enzootically stable or unstable depends on the followings -

(1) Introduction of infection and/or infected ticks into a farm or region by livestock movement such as goat and sheep.

(2) Host susceptibility - adult are more susceptible than calf, Bos Taurus than Bos indicus, probably due to tick resistance.

(3) Ticks number and the level of challenge do influence infection rate and disease incidence. It is affected by seasonal variation in rainfall, dipping or spraying, alteration in pasture and rangeland management.

Severity of infection depends on (a) susceptibility of the host (Age and Breed), the strain of the organism.

Diagnosis -(a) may be based on history, (b) clinical symptom, (c) pathological changes especially blood picture.

Symptoms: (a) High body temperature, (b) Difficult breathing (dyspnoea), (c) Anorexia, (d) Anaemia due to the destruction of red blood cells, (e) In some cases faeces contains blood or mucus. When they are many in the body it leads to acute state with rapid death, it can also be chronic.

Treatment -There is no ready treatment but can be treated at the early stage with antibiotics such as oxytetracycline.

Control: (a) Separate animals that have high temperature, (b) Regularly spray or dip reduce ticks.

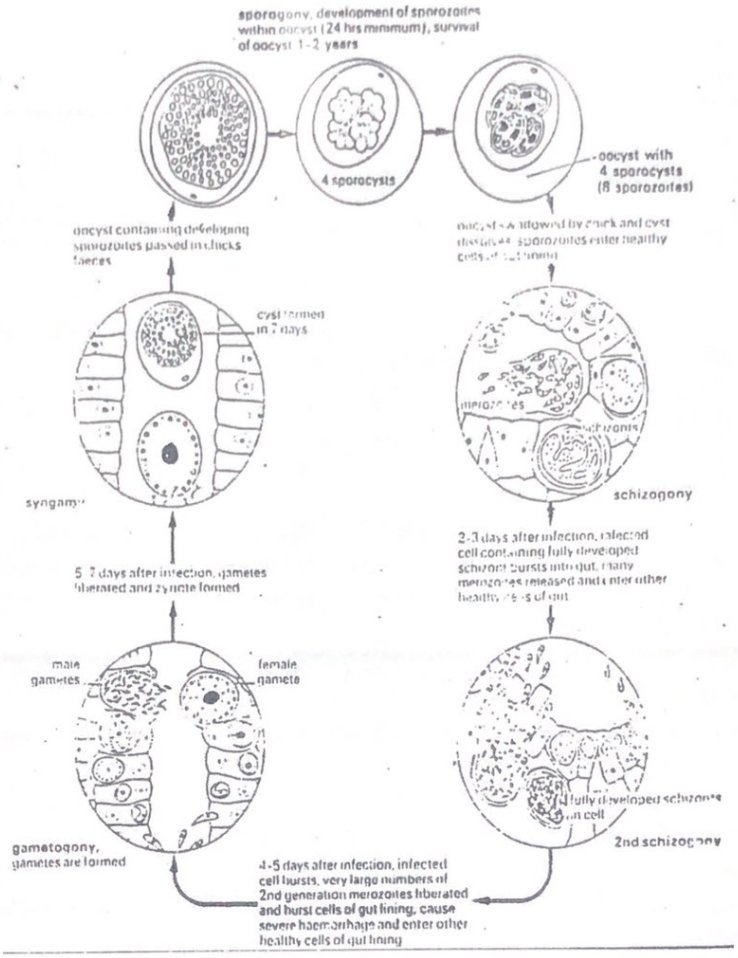
(d) Coccidia - This causes the disease Coccidiosis in poultry, rabbit, cattle, sheep, pigs and goat. The two species are Eimeria and Izospora.

Lifecycle:

1. Ingestion of faecal oocyst containing sporozoite which infects intestinal epithelia cells.
2. Sporozoites grow to produce the first generation schizont which divides to produce the first generation merozoites.
3. Merozoite is liberated to infect new epithelia cells, thus becoming the second generation schizont.
4. Up to the third generation of schizont may be produced.
5. The second and third generation merozoite infects fresh host epithelia cells and form microgamete/macrogamete, which fuses to form the zygote, this

develops walls round itself to become oocyst.

6. The oocyst breaks out of the intestinal cells and are passed out in the faeces ready to infect new hosts, and so complete the lifecycle. The total lifecycle takes about 9days.



Harmful effect - Young animals are mostly infected. Clinical signs vary according to where the parasite is located, in those with the intestine as the predilection site there is blood stained diarrhea. Affected animals usually drink water but refuse to eat.

- Coccidia in cattle Emeria zurnii and B. bovis, found in the large intestine/caecum, causes extensive damage and haemorrhage. Animal becomes debilitated, with loss of condition, abdominal pain and diarrhea with blood and mucus.

- Coccidia in sheep /goat - Occur mostly in debilitated old animals and young ones. Lesions are seen in the small intestine with the animal showing signs of anaemia and diarrhea.
- Rabbit - *Emeria stiedia* and *E. perforans* occurs in liver and intestine respectively, the animal becomes pot-belly, with weakness in hindlimb, diarrhea and emaciation.
- Poultry - *Emeria tenella* (located in caeca) causing caeca coccidiosis; *E. necatrix*, early stages in small intestine while sexual stage in caecum; *E. brunette*, lower part of small intestine, caecum and large intestine; *E. acerrulina* and *E. mivati*, found in small intestine and caecum; *E. maxima*, found in small intestine.

Clincal signs depends on (a) level of infection (the number of oocyst ingested), (b) the species of coccidian parasite, (c) immunity of the bird (depends on previous exposure).

Diagnosis is based on (a) history of the flock i.e. location of building, dampness of sawdust, etc. (b) demonstration of oocyst in faeces, (c) postmortem finding.

Symptom - include loss of appetite apart from blood stained diarrhea/emaciation.

Treatment: Nitrofuran, Sulphonamides and Amprolium.

Control: (a) Avoid overcrowding, (b) do not mix new stock of animal with old ones, (c) avoid condition that favour sporulation

(e) Histomonas - This causes the disease histomoniasis, enterohepatitis and blackhead in turkeys. *Histomonas meleagridis* is an extracellular amoeboid protozoon. It is paleomorphic i.e. changes with the space it occupies. Its predilection site is the liver and caeca of turkey.

Symptoms: watery discharge that is not tinged with blood, weakness, loss of appetite.

Diagnosis: sulphur coloured faeces and a characteristic liver and caeca lesions.

Control: (a) control of caeca worm *Heterakis gallinae* with antihelminths, (b) rearing of chicken and turkey separately, (c) disinfection of footwears and prevention of visitors' entry into farm.

(f) Trichomonas - This causes the disease trichomoniasis. There are various species of trichomonas found in domestic birds such as *Trichomonas gallinae*, *T. gallinarum*, *T. anseri*, and *T. anatus*; *T. ovis* (in sheep), *T. vaginalis* (rats/mouse), *T. tenax* (non-pathogenic, man) and *T. foetus* (pear shaped).

Harmful effect: (a) watery discharge from vaginal, 2weeks post infection with flakes of pus cells visible in discharge, (b) early or late pregnancies are aborted, sometimes with expelled foetus, (c) irregular oestrus which may eventually stop, leading to sterility.

TICKS: These belong to the arthropod phylum and to the class Arachnidae, subclass Ixodidae, families - Argasidae and Ixodidae (differ in morphology and parasitism, though they are similar in development from egg to six-legged larva, to the eight-

legged nymph and then after renewed moulting, to the imago). Argasidae are wandering ticks which only remain on their host while feeding, they attack several hosts and so are temporary parasites that prefer stables, cracks in walls/ similar hiding places for female to lay its eggs e.g. the genus Ornithodorus (*Coxiella burnetii*) and the species *Argas persicus* (*Anaplasma marginale*) are vectors of vector-borne cattle disease. Ixodidae (ixos gr.=fly glue, ixodes = glued) (hard ticks) they are "sticking" ticks/stationary parasites, they cling to their host with their oral apparatus and only engorge themselves once during each stage of development. Ixodidae are one-, two- and three-host ticks. They are the disease vectors which are most important for animal production in the tropics, they mostly field parasitesTicks are the most dangerous and most widespread of ectoparasites and disease vectors as they occur in temperate as well as in the tropical and subtropical regions of the world. They are vectors of a wide spectrum of pathogenic microorganisms, such as protozoa, rickettsia, spirochaetes and viruses. Ticks are obliged to be parasites because they are unable to feec on anything but on a living being. They have a tough, leather-like skin and live on the blood of the host. Unlike insects, ticks do not bite but dig a small pool with their proboscis which gradually fills with blood which they then suck up (pool feeder). Because of its elastic cuticula the parasite may increase its volume considerably. The host will lose important nutrients under a heavy attack and because of the loss of blood, anaemia/general weakening may result which cause a reduction in milk production, body weight and resistance to other diseases. Many lesions caused through feeding by the ticks reduce the quality of leather as well as carcass damage apart from been a location for skin infection (dermatophilosis). Enzymes secreted by ticks during feeding to inhibit coagulation of hosts blood may cause severe diseases because of an allergic reaction (tick toxicosis, sweating sickness). The most important problem is the transmission of pathogens of vector borne diseases.

There are three categories of ticks

1. One-host tick all stages of development from egg to adult takes place in only one host i.e. larva climbs on animal, develops into nymph and adult on same animal and afterward drops off and deposit eggs on the ground e.g. *Boophilus annulatus*, *Boophilus decoloratus*, and*Boophilus microplus*.
2. Two-host tick here larva develops into nymph which drop-off and is later attached to another or same animal e.g. *Rhipicephalus evertsi*, *Rhipicephalus bursa*, *Hyalomma detritum*, and*Hyalomma turanicum*.
3. Three-host tick here ticks look for a new host during each stage of development in order to feed. Egg hatches to larva which attaches to a host sucks blood and drops off, develops into nymph which get attached to another animal, grows and drops off, develop into adult which attaches again to the third animal. Adult female remains about one week on the host to suck

considerable amount of blood and copulates with the male while feeding. Afterwards, it drops off and deposits up to 20 000 eggs under the protective cover of grasses, stones or dry leaves, after which it dies off e.g. *Amblyomma gemma*, *Amblyomma hebraeum*, *Amblyomma pomposum*, *Amblyomma variegatum*, *Dermacentor* spp., *Haemaphysalis bispinosa*, *Haemaphysalis punctata*,*Hyalomma dromedarii*, *Hyalomma excavatum*,*Hyalomma marginatum*,*Hyalomma truncatum*, *Ixodes ricinus*, *Ixodes dammini*, *Rhipicephalus appendiculatus*, and *Rhipicephalus simus*.

HELMINTH PARASITES

A **parasite** is an organism living in or on another organism called the host. **Parasitism** is a condition in which an organism lives at the expenses of the other with one of them being harmed. The parasite derives benefits (nutrient) from the host while the host is harmed or injured by the association. A parasite which lives on or outside the host is called **ectoparasite** e.g. ticks, lice and mites while those that lives inside its host is called **endoparasite** e.g. Cestode (tapeworm), Nematode (roundworm -Ascaris) and Trematode (flatworm -liverfluke). Helminthology is the study of parasitic worms. Helminthiasis is the condition resulting from infestation with worms.

Economic importance: The economic impact of helminthes vary greatly from year to year, depending on the climate, stock management, level of infection, host immune status and age of animals. The overall economic losses are the result of several concomitant factors

(a) Morbidity or mortality of infected animals,
(b) Reduced growth rate, wool and milk production,
(c) Complete or partial condemnation of fluky livers and/or cachectic carcasses,
(d) Increased susceptibility to secondary infections,
(e) High risk of abortion, still birth and low birth weight of the neonate, and
(f) Expense of control measures

Economic loss through: (a) obvious losses as in the death of host, wasting away of animals even when alive, condemnation of human food.(b) The hidden losses when we have reduced live weight gain, poor food conversion, reduced lactation, and poor fleece. Probably much serious but often unnoticed. (c) Control cost like drug, labour, fences and inefficient use of land.

Control of Helminthiasis: Reasons for control of helminthes include

1. To eliminate or reduce the prevalence of the parasite involved in zoonosis.
2. To improve the profitability of the animal industry.
3. To increase the aesthetics/ acceptability of pet animals.

Approaches to control involves the following -

(a) By reducing the prevalence of the parasite and this is also by reducing the chances of survival or development using the following means:

(1) Introducing worm poisons (antihelminthes, larvicides),
(2) Selecting or developing resistant host,
(3) Making the larva micro-climate adverse,
(4) Introducing predator for the intermediate host or the parasite,
(5) Keeping the host and the parasite apart.

(b) Increasing the ability of the host to support the parasite by -
(1) Better nutrition,
(2) Better protection for the young animal and those under exceptional stress,
(3) Supportive therapy by giving haematinics (a substance required for the production of red blood cells).

Parasitic Gastroenteritis Complex: This is a disease complex that affects ruminants by reducing their production in different ways like resulting in death, loss of weight, reduction in milk production, wool, abortion can also result.

Aetiology: Haemonchus spp, Trichostrongylus spp, Ostertagia spp, Nematodirus spp, Cooperia spp. There are other secondary parasitic agents like Oesophagostomum spp, and Bunostomum spp.

All members of this group are located in the digestive tract.**Prediletion site is the area inside the animal where the adult parasite is found** e.g. Haemonchus and Ostertagia spp is found in the abomasums, while Bunostomum (hookworm) is found in the large intestine. Parasitic gastroenteritis complex (PGC) is most prevalent during the raining season because the lifecycle of the parasite needs a moist environment for larva to survive. The lifecycle starts from an egg which is produced by the females and comes out of the host's body with the faeces. The egg develops when there is sufficient moisture forming an embryonated egg. The eggs hatches into a larva that moves around and climbs on grass leaves. When larva stage 1 or 2 is consumed with the grass-leaves it is not infective unless larva stage 3 is consumed before it is infective. Larva stage 3 starts development inside the animal to become larva stage 4, 5 and adult.

The stages of development outside the animal is called **preparasitic phase** and the stage inside the animal is referred to as the **parasitic phase**.After development in the host to the adult stage, copulation occurs with the production of eggs and the cycle continues.

Haemonchus feeds only on blood; Trichostrongylus also feeds on blood; Ostertagia feeds on blood, burrows deep into the tissue; Nematodirus produces irritation in the lumen of the intestine; Cooperia also produces loss of blood, irritation of intestinal mucosa leading to inflammation. Inflammation of the mucosa of the intestine is referred to as **enteritis**. Blood loss is not only due to some of the parasites sucking blood but there is also blood-letting (little blood coming out from the cuttings made by the parasites after it leaves that area due to in sufficient blood sucking from the area).

Clinical signs of PGC- include Anaemia, Diarrhoea (may be profuse and darkish in colour with bad smell), Rough hair coat, Emaciation (loss of weight) and Anorexia. Lesions include - ulcers, red mucosa, haemorrhages, oedomatous swelling, and nodules in large intestinal wall.

Diagnosis: (a) Examination of faeces (frèsh faeces), do direct smear or floatation and examine it on the microscope, (b) Post-mortem examination.

Treatment: Using anthelmintics such as Thiabendazole, Oxfendazole, Nematax, Ivomectin, Banmith, Loxon, and Fenbendazole. Piperazine is use for round worms.

Control: (a) Do not graze animals early (before 9AM) in the morning or late in the evening, (b) Do pasture rotation i.e. rotational grazing, (c) Do periodic examination of faeces and treatment treat every month for small ruminants, (d) Prevent young animals from grazing with older animal.

Fascioliasis: This is a disease produced by Fasciola species. There are two types *Fasciola hepatica* and *Fasciola gigantic* (common in Nigeria). Predilection site is in the liver (bile-duct). It has oral and ventral suckers for attachment. It undergoes indirect lifecycle i.e. a lifecycle that involves an intermediate host (egg ---- miracidium, which penetrate a snail host ----sporocyst ----redia in the snail tissue ---- cercaria which burrows out the snail --- metacercaria, encysted on grass leaves, the infective stage). The major problem is in the liver because the predilection site is in the liver. After ingestion the cyst of the metacercaria is broken, the larva get to the surface of the liver and starts to move around on the liver surface. Eventually it burrows into the liver tissue to get into the bile duct. Its burrowing site leads to haemorrhage, enlargement of liver, thickened bile duct, after some time the liver becomes thickened and smaller. This is a situation referred to as cholangitis (inflammation of the bile ducts) due to irritation of the larva.

Economic importance:

(1) Leads to condemned liver, leading to fascioliasis being referred to as liver-rot.
(2) Usually a chronic disease in cattle but can be acute in small ruminant caused by heavy infestation and massive bombardment of the liver.
(3) Leads to losses of weight.
(4) Rough hair coat.
(5) Insufficient meat production.

Diagnosis: Through clinical symptoms but not specific. It has a specific symptom such as bottle jaw (accumulation of fluid on jaw) the same with haemonchosis.Observation of typical egg with operculum in faeces.

Treatment: Using Ranide or Trodax, found in different forms such as injectable.

Control: Use Molluscide to kill Snails e.g. CopperSulphate as well as qualitative/quantitative feed.

Paramphistomiasis (Stomach fluke): It is produced by *Paramphistomum cervi* or *Paramphistomum microbothrium* found in ruminants. Its predilection site is the rumen. Its egg is similar to that of liverfluke. It is seen as a whitish speckle on rumen,

red when young. They are hermaphrodites, with the land snail as the intermediate host. After ingestion of the metacercaria, the immature form goes to the intestine causing enteritis (inflammation of the intestine) and does not go to the circulatory system like liverfluke. It leads to severe bloody diarrhea and it later moves to the rumen where it stays.

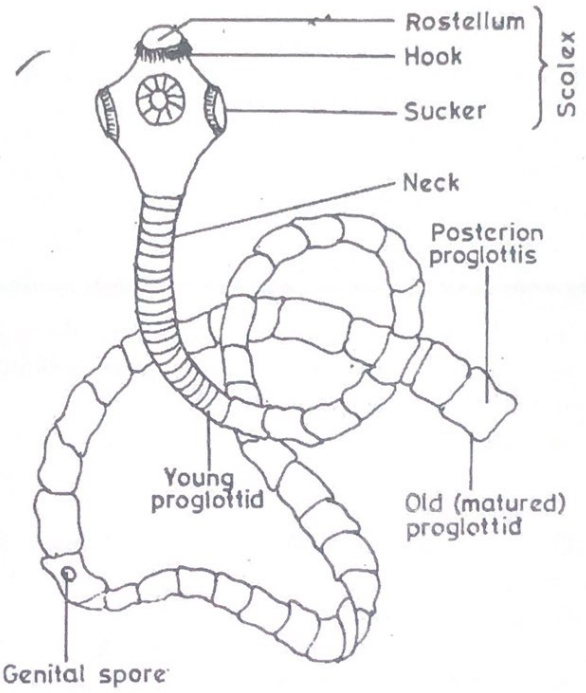
Symptoms: Smelly/bloody diarrhea and loss of weight.

Diagnosis: Blood-stained diarrhea.

Treatment: Use Menichlofolam

Control: The same as for fascioliasis.

Tapeworm: They are helminthes with segmented body differ from the flukes. Echinococcus granulosus has three segments while others have multiple segmented bodies. In the general structure of tapeworm, it has a head (with some having hooks and/or suckers), neck which give rise to the proglottides and proglottides which contains immature, mature and gravid (containing eggs - Onchosphere) segments. Prediletion site is the small intestine of their host, though some are found in other parts of the body e.g. *Stilesia hepatica* in the liver.



Lifecycle of tapeworm is indirect but instead of the snail serving as the intermediate host, it has mites as the intermediate host. Either onchosphere (larva) or gravid

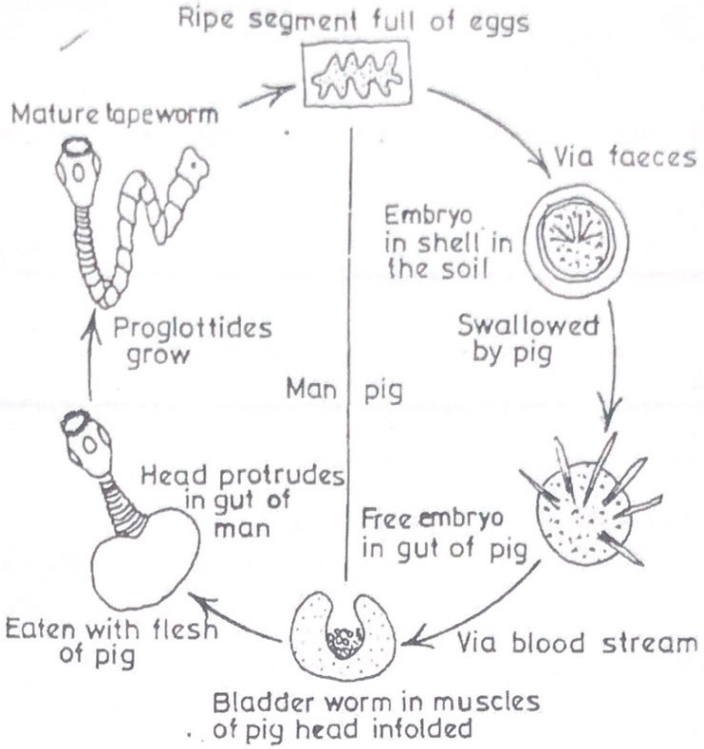
segments are found in the faeces. Onchosphere develops into **coracidium** which is ingested by the mite. Further development takes place inside the mite into **cysticercoids**.This mite climbs on vegetation and are taken into the body with forage.

1. The problem with tapeworm is that they block the intestine.
2. Absorb nutrients which could have been used by animal leading to loss of weight (emaciation).
3. Also it absorbs vitamin B_{12} from the body leading to pernicious anaemia different from the anaemia in the other parasites.
4. Rough hair-coat.
5. Desire for continuous drinking of water ie. The animal has appetite.

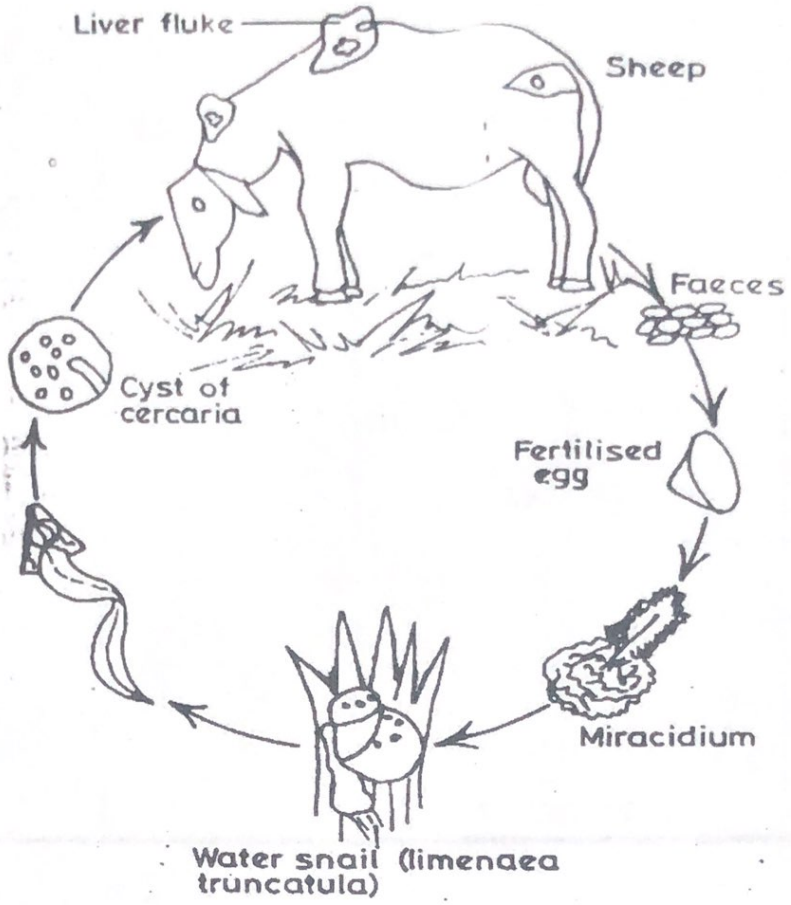
Diagnosis: Presence of egg in faeces i.e hexacanth embryo with three pairs of hooks
Treatment: Using Mansonil. Very easy in ruminants. The commonest ones are *Moniezia expansa* and *Moniezia benedeni.*

LIFECYCLE OF TAPEWORM, LIVERFLUKE AND ROUNDWORM

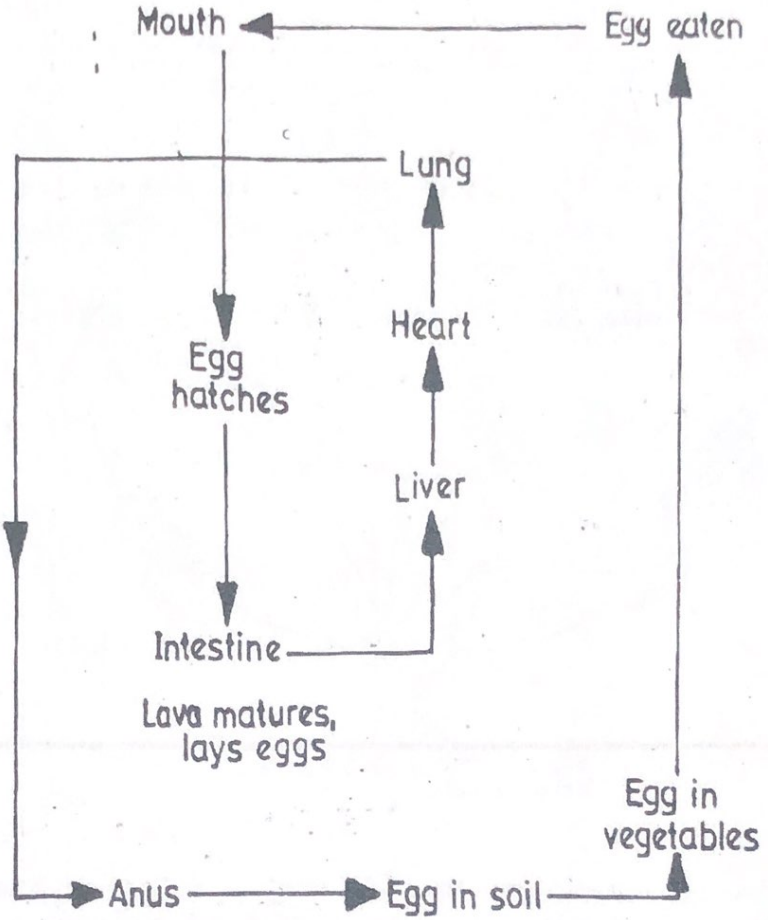
Tapeworm (Taenia solium) - It is a long endoparasite flatworm with a very small head (scolex), neck and long segmented body (proglottides). Taenia solium is found in pigs while Taenia saginata is found in cattle. The scolex has suckers and hooks with which it attaches itself to the intestinal mucosa of its primary host (man). Pig or cattle are the secondary host. The proglottides are arranged in a long row formed from the small/ young segments in the neck region to the largest/ oldest ones far from the neck. Tapeworm is an hermaphrodite with both male and female reproductive organ and at such can fertilize itself. When a mature and fertilized proglottide is detarched from the body of the adult tapeworm in the host intestine, it is passed out with the faeces to the ground from where it can be picked up by the animal during feeding. It eventually gets to the intestine of the pig or cattle where the enzymes acts on the egg and liberates the embryo; the embryo finds it way into the blood stream by passing through the intestinal wall and finally resides in the muscle or heart of the pig. Each embryo forms a cyst around itself to become bladderworm with the head turned inside out so that its sucker lies on the inside. When raw or undercooked pork or beef containing the bladderworm is eaten, the digestive enzyme of man dissolve the bladderworm and the young tapeworm with its head turned inside out emerges as illustrated below-



Liverfluke This is a brown coloured, flattened, leaf-like organism that is about 2cm long, an endoparasite of cattle, sheep and goat. Farm animals are the primary hosts while the snail (*Limnaea truncatula*) is the secondary host.Fertilized eggs of liver flukes are passed together with faeces. At favourable weather the eggs hatch into small ciliated larvae (**miracidia**) which swims in water and is attracted to the water snail (Limnaea) which is the secondary host. It enters the body of the snail during which it losses its cilia and changes to a **sporocyst** and reproduces asexually to give rise to a new larva called **rediae.** The redia comes out of the sporocyst and goes to the digestive gland where it develops into a minute worm called **cercariae**. The cercaria leaves the body of the snail and swim about in water until it finds a suitable host when the animal drinks the contaminated water. At times the larva (cercaria) leaves the host snail and encysts on vegetation. From there, they are ingested by grazing animals. The cercariae penetrate the skin and tissues to enter the blood stream, then to the liver tissue and finally getting to the bile duct where they finally settle down and develop into adult liver fluke.Liver fluke causes a disease called bilharzias or schistosomiasis.



Roundworm (Ascaris lumbricoides) - This is an enlongated, cylindrical white worm that is pointed at both ends. It has a smooth body covered by thick, tough cuticle of few centimeters long. The eggs of the round worms are fertilized in the female worm and the larva developed within the egg shell. The eggs are deposited in the intestine of pig from where they are passed out with the host's faeces into soil where it can remain for many years. When the eggs are picked up by pigs either through feeding or drinking, the egg shells are dissolved by digestive enzymes and the young larvae emerge. The larvae then pierce through the intestine wall to the blood, then to the liver, the heart and then to the lungs. From the lungs, they pierce into the mouth and throat of the pig. From the throat, the larvae are swallowed through the gullet into the intestine. Here the larvae develop into mature worms and the lifecycle is repeated all over again.


Mouth
Egg eaten
Lung
Heart
Egg
hatches
Liver
Intestine
Lava matures,
lays eggs
Egg in
vegetables
Anus
Egg in soil

CHAPTER TEN
PIG AND RABBIT PRODUCTION

PIG PRODUCTION:

Pigs are highly prolific monogastric animal although the meat is well relished for its tenderness and taste. Pork is not universally accepted, consumption of pork is forbidden by certain religion. The common exotic breeds kept in Nigeria are Large-white or Yorkshire, Landrace and Duroc. Pigs can also be kept by intensive, extensive and semi-intensive system.

Breeds of Pigs

- West African Dwarf (WAD)
- Large white or Yorkshire
- Landrace
- Hampshire
- Duroc Jersey
- Large black
- Wessex Saddle back
- Tamworth
- Poland china
- Chester white
- Belgium pietrain
- Berkshire

Housing in pig management

- Pigs should be given housing for protection from adverse weather conditions such as cold and excessive heat.
- The siting of the building should be planned to give protection from the sun and exposure to wind hence an east west orientation of the building is recommended.
- The floor should be sloppy for drainage of urine and spilled water for maintenance of good hygiene.
- The floor of the pig house should be made of concrete or cemented for easy cleaning.
- A concrete floor also prevents "rooting-out of the land" practiced by pigs.
- Roofs should be made of corrugated iron sheets or asbestos roofing sheets.
- Walls should be made of sandcrete blocks and should not be more than 1 - 1.55m high.
- The space between the wall and the roof should be left open for good ventilation.
- The pig house is usually divided into pens for ease of management.
- A pen measuring 2m x 3m could be used for one sow with her piglets or 3 - 4 dry

sows or 6 - 7 growers.

- Wallows should be provided in the pens.
- Feed and water troughs should be made of concrete in the pen.

Flushing of pig: Flushing is the process by which the nutritional intake of a female animal is increased so that it can produce more ova and therefore increase the possibilities of obtaining more fertilized ova. Flushing should be done 7 to 10 days before breeding and maintained until the animals are bred but not exceeding 28 days. The period of greatest fertility for the sow or gilt is during mid oestrus i.e. 35- 48 hours after onset. Ovulation continues for several hours and so pigs can be served two times. The first service should be attempted 12 hours after the onset and the second service should be 36hours after the onset. Gestation period is about 114 days. Pigs should be given a high level of nutrition of not less than 15% crude protein throughout the gestation period. The house must be adequately stocked with farrowing equipment such as farrowing crates, rail guards, feeding and watering troughs and heating devices where necessary. Iron dextran injection, an intramuscular injection, should be given to prevent anaemia. The second dose of the injection should be given 2 to 3 weeks later. Anaemia can be prevented in piglets by oral administration of iron drugs or intramuscular injection of iron drugs or supply of sterile laterite to piglets. Ear notching for identification purpose should also be done. Male piglets not intended for breeding are castrated to remove boar odour and increases meat quality.

Creep feeding of pigs: Creep feeding involves placing feed which is accessed only by the piglets. Creep feeding the young pigs is the best method during the suckling period. It is done to meet the nutritional requirement of piglets which differ from those of the sow,the ration should contain higher protein and antibiotics but with a lower fibre content. Rations should contain 24% protein. Produces uniform piglets with high weaning weights and less mortality. It is introduced to piglets from about second week after farrowing.

Lactation period of a sow is about 12 weeks but when piglets are about 8 weeks old they are weaned. This is done by removing the sow from the piglets thereby allowing the piglets to remain in the same pen.

RABBITS

Rabbit production is becoming important in Nigeria. It is easy to manage and compare favourably with other farm animals in their efficient conversion of feed into meat for human consumption. Rabbit meat is of high quality having a high protein content and low fat. The common breeds of rabbit in Nigeria are New-Zealand White, Flemish Giant, Californian white, Chinchilla, Champagne d'Argent, Crosses, Checkered giants, New Zealand Red, Beveren, Angora, Dutch, Lop, English splot, etc.

Housing of rabbits depends on whether the animals are to be raised indoors or outside. This on the other hand depends on available local materials, climatic condition, size of operation and how much one is willing to invest on it. For indoor housing the rabbit hutches should be located on a leveled well drained soil. Shade should be provided with either the use of trees or the side of a building. Protect hutches from dogs/ cats. Hutches could be made of wood, bamboo, or wire netting, the wire netting is preferable because rabbits chew wood and it could be soaked by urine. The hutches are constructed individually or in colonies. Roofing materials include asbestos corrugated iron sheets or thatches. Standard area of a hutch is 3 -4 sq. ft. (0.6 - 1.2m^2). Provide adequate floor space. Floor is made of concrete for easy cleaning. Hutch is raised about 2 ft (0.6m) above the floor. Nest box is placed inside the hutch for safe kindling. Doe and buck are kept in separate hutches. The hutch is placed under shade inside or outside a ventilated building. A breeding doe requires a maternity hutch of about 2 - 3 times the size of a normal hutch. This maternity box should be accommodated in the main hutch and should be accessible from above. Rabbits can be raised on solid floors. Poultry deep litter pen, car garages where protected shade can be used. Feeders and well positioned drinkers must be provided and should be tied down so that they will not be tipped over. Breeding: Does and Bucks should be about 5 - 6months old before breeding and a ratio of One buck to 10 does should be used. In mating, take the doe to the buck pen and not the other way round. Breeding life of a buck is 3 - 4 years. Gestation period is 28- 32 days, a doe comes back on eat by the 18th day after mating if not pregnant. Pregnant doe will make her own nest 3 - 4 days before kindling. Young kids are born harmless/ blind and are weaned at 6 - 8 weeks of age by removing the mother to another hutch. The sex of rabbits can be determined at day old but it's strongly advised to wait till the weaning time. In case of the death of a mother, the kids should be taking to a foster mother after rubbing them with urine from the foster mother. Castration has no advantage as the growth rate for males and females are the same till market weight. Most does has 8 teats so the litter size should be less than 8 or 6 - 7. Feeding: Rabbit is a non-ruminant herbivore; it has a monogastric digestive tract with large active caecum. Caecum supports a large population of micro-organism. Rabbits digest cellulose poorly but still needs the fibre to promote intestinal motility. They can be raised on limited green foods which can be supplemented with cereal grains. Concentrate rations can be formulated but should not be fed dry because of palatability. If dry, the concentrate can be mixed with water to form a wet mash. Fryer (baby rabbits) is fed on mother's (doe's) milk for 4 - 6 weeks before weaning. Rabbits are fed on concentrates in form of pellets or mash. Rabbits are also fed with fresh green feeds such as *Tridax procumbens*, *Aspilia africana*, *Talinum triangulare*, etc. They are fed on tubers such as cassava. Rabbits are fed continuously (*ad libitum*). Provide adequate water. Feeding trough and water are

provided, as well as vitamin and mineral supplements.

Finishing: rabbits are weaned at 4 - 8 weeks. Weight at weaning is 0.75 - 0.80kg. Finishing involves giving feed and water *ad-libitum*. Finishing feed with 5 - 10% fat/ oil assist rapid weight gain. Remove doe into a different hutch.

Diseases of rabbits This include the following-

1. Nasal catarrhal this is a complex disease presenting itself in various forms like conjunctivitis (inflammation/ discharge from the eyes), otitis media (ear infection), genital infection, pneumonia, abscess
2. Samonellosis -
3. Rabbit pox
4. Diarrhea
5. Coccidiosis

Hygiene: clean floor daily, disinfect building regularly, clean feeding and water trough daily, isolate sick rabbits promptly. Dead rabbits should be removed and buried promptly. Keep the surrounding of the building weed free. Provide disinfectant foot dip at the entrance of the house. Fryer should not be touched with bare hands (between 1 8 days) to prevent the doe from eating them. Sanitation in the rabbitry is the best disease control mechanism.

CHAPTER ELEVEN
BEEF CATTLE

The most important animal domesticated by man is cattle. It is also the most ancient after the dog. The world cattle population is 1.3 billion. Beef is the meat derived from cattle and it is the most important and popular of all the red meats. It provides energy and protein per kg than other meat and it is in greater demand than other meat like pork, mutton, goat meat and fish. In addition to provision of meat cattle also provide raw materials such as hide, bones and other by-products.

Origin and domestication of cattle

Cattle was first domesticated in Europe and Asia during the new stone age it is believed that cattle has blood of either or both of two ancestors ***Bos taurus*** and ***Bos indicus.*** Either species or sub-spieces are frequently encountered in any writings but these are seldomly referred to today.

Bos taurus: are domestic cattle common to the temperate region. They are generally humpless and are derived from a mixture of descendants of Aurochs (*Bos primigenius*) and Celtic short horn (*Bos longiferous*). Most cattle are believed to have descended from the Aurochs which have been referred to in earlier writing as Uri, Ur or Urics. They are described as mighty wild ox and they were hunted by ancient men. It was believed to be extinct in 1627AD. About 65BC Caesar mention this ox in his writing but it was probably domesticated earlier than that time. The writings of Caesar described this ox as approaching the elephant. The complete skeleton of this animal shows that it would be about 6-7ft high at withers. In addition to the Aurochs the Celtic short horn or the Celtic ox is another progenitor of the modern breeds of cattle. These animals have only been found in the state of domestication. They were the only oxen in the British height until 500AD when the Anglosanson came bringing with them cattle derived from Aurochs. The Celtic short horn was of a smaller size than Auroch and has a dished face.

Bos indicus: These are humped cattle more commonly found in the tropic referred to as Zebu cattle, the Americans called them Brahman. They are mainly domestic animal with no history of wild ancestor, it is believed that cattle of this type were first domesticated sometimes between 2100 4000 BC. The zebu is characterized by a hump of fleshy tissue over the withers. The hump sometimes weighs about 18-22kg. They have very large dewlap, large drooping ears and a voice that is more of a grunt than a moo (mu:). They appear to have more resistance to certain diseases and parasites and to heat than the descendant of the *Bos taurus*, they have therefore been used in breeding programmes in many parts of the world including southern USA, Australia, Jamaica, etc.

Beef production: Meat consumption per animal species is shown in the table Below:

Species	Kg Carcass Weight	% Total meat consumed
Beef	3.6kg/head	44.9% of total meat consumed
Goat	1.78	22.1%
Mutton	0.78	9.5%
Pork	0.93	11.4%
Poultry Meat	0.95	12.1%

Source: Food and Agricultural Organization

In Nigeria over half of total meat consumed is beef. It is estimated that 10% of total cattle in Nigeria (11 million) is from the northern states. This is because the bulk of cattle in Nigeria are from the north due to the fact that the area is predominantly grassland.

The consumption of beef in Nigeria is inadequate in comparison with other parts of the world where beef consumption ranges from 31.75 - 36.28kg per annum. In Nigeria, consumption is only 3.6kg. In recent times the situation has become worse as beef prices have gone up even below the average man's reach. The consumption pattern is concentrated in urban centres because the cattle traders concentrate supplies in the urban centres. In effect the distribution of beef is not even. It is high time this distribution pattern be changed. Also an improved production practice is imperative if the Nigerian populace will increase their beef consumption status.

The Dry Beef: This is salted; sun dried or smoked beef usually brought from the north. It has the advantage of keeping longer and forms the bulk of beef consumed in the villages.

GOVERNMENT'S EFFORT AT IMPROVING BEEF PRODUCTION

There have been government efforts in the past to improve beef cattle production in Nigeria. Some of these government farms are still around but poorly managed e.g. Fashola farm, Akunnu Cattle Ranch and host of the state Livestock Improvement and Breeding Centres (LIBC) which are mostly common in the northern states. These include the federal government research farm or government institute such as National Animal Production Research Institute (NAPRI), National Veterinary Research Institute (NVRI), etc. The NVRI farm has since been privatized. The Obudu Cattle Ranch in Cross River State is now being run and managed by the Cross River State government. The situation of supply of beef in Nigeria now calls for serious effort from both private and government establishments. There is need for improved management method to improve the reproduction, growth rate and meat quality of our beef cattle. Beef industry can thrive in Nigeria. There are vast areas of land in all States of Nigeria for the development of beef ranches. Even the so called forest area can support beef production.

The federal government must start the establishment of breeding and research farm on zonal basis and breeds adapted to various zones developed because all the cattle breed in Nigeria are potentially beef breed.

Breeds and characteristics of cattle

Beef is meat derived from cattle either of dairy or pure beef breeds. The pure beef breeds are those cattle which possess special conformation and which are accepted by breeders as the ideal for beef animal. The ideal beef conformation is that the animal should be short with thick muscle, broad back, and square rump and should carry a maximum quantity of flesh. Such animal is said to be blocky or to have a shape of a parallelogram. The long legged animals with narrow flat size are unsuitable for beef e.g. the Rahaji breed in Nigeria although they could be developed. Since the consumers are not interested in the conformation most cattle breeds in Nigeria are used for beef production as long as the quantity the consumers demands can be attained at the least cost. In Nigeria however there is very little emphasis on quality since we don't even have enough in quantity. One quality of beef which consumers normally look for in developed countries is **marbling** (ability to lay fat in muscles). The animal that can produce good quality meat with marble fat is good for meat. Such an animal capable of developing marble fat is an efficient converter of feed into good quality meat.

Breeds of beef cattle

Temperate breeds

1. Angus or Aberdeen Angus (Scotland): dominant black coats & polled with occasional small white patches on belly and flank.Excellent grazer.
2. Herefords: Dominant white face and deep red coat, with occasionally white markings over the crest, brisket, belly, leg.Larger than Angus, grows quickly especially when at grass, hardy and excellent grazer.
3. Charolais (France): Creamy white, horned and round hind quarter, rapid growth rate, size and lean meat.
4. Short horn cattle
5. Simmentals (Switzerland): Has white face rather similar to Herefords which is colour marking, coat colour is yellowish brown or red with characteristic white markings. There is frequently a white stripe on the shoulder and further white markings on the loin, belly, legs and tail.
6. Limousin (France): Rich golden red coloured coat which shades to a lighter tan under the belly and around the legs.
7. Brahman (humped)
8. Dexter
9. Galloway
10. Lincoln red
11. Beefmaster

12. Chianina (Italy): Pronounced Key-a-neena, claimed to be the largest cattle in the world. Coat colour is white, but exposed skin areas are black. The eyelids, switch and hooves are also black. Docile and easy to handle.
13. Belmont red (Australia)
14. Africanda (South Africa): humped

The Nigerian breeds include:-

1. Kuri
2. Muturu
3. Keteku
4. Ndama
5. Zebu - Sokoto Gudali, Adamawa Gudali, Red Fulani (Rahaji), White Fulani (Bunaji)

Most of the temperate breeds except the Brahman are humpless

1. ***Angus:*** Scotland, black colour, polled. There is the red strain red Angus: it has a noticeable amount of white in front of the navel or on one or more legs. It is characterised by early maturity. It has been used extensively for cross breeding in the USA.
2. ***Hereford:*** Hereford originates in England, red colour with white markings, white face and white on the underline, flank, crest and switch. It is predominantly horned but polled strains have been identified and developed. It has large size and can withstand climatic variation as a result of which it is now widely distributed all over the world, South America, Australia, New Zealand.
3. ***Charolais:*** origin is France, light tan at belt and changes to cream colour in a few weeks, horned and has pink skin and mucus membrane. Noted for its large size and can attain about 450kg in 1year.
4. ***Short-horn cattle:*** originated in England. It was the first breed to have a herd book. The name short-horn stems from the facts that through breeding, early improver, bred for short-horn. Colour is red, white or a combination of both. The breed has short refined in-curving horns. It is a hardy breed which has been used under poor condition for beef production. In southern USA it has been used for cross breeding to produce breeds adaptable to tropical condition. Under such program the Santa Gertrudis had been developed in Texas. This breed is 5/8 short horn and 3/8 Brahman.
5. ***Chianina:*** Origin is Italy where they have been used as draft animal for a long time. The largest of all cattle breed with males weighing about 1800kg and female 1000kg at maturity. It is late maturing suited for slaughter as yearling. Carcasses are muscular, lean and free from waste. The breed is white with black skin, it is said to be involved in the original development of the Charolais. It has showed great hope for cross breeding with the large framed cows of the dairy or beef breed.

Found in America/Australia. Arrived Australia via semen importation. The history of development begins only in 1973.

Nigerian breeds

1. ***Kuri:*** This is a humpless breed found in the Lake Chad area. It is a large frame breed with mature males weighing 498kg and females 363kg. In terms of conformation they have long shallow body, slopy rumps and poorly developed hind-quarter. They are long legged and narrow thighs, so this is not a good beef conformation. In spite of this, it forms a large proportion of beef slaughtered in Nigeria. It does not survive well outside the Lake region so can't be used for ranching. Trial ranching could however be tested in its ecological zone.
2. ***Muturu:*** Origin is within the forest zone. It is noted for its resistance to trypanosomiasis. It has a small body, with mature males weighing 227kg and females 181kg. The body is deep and wide at the chest, broad and levelled back, well developed rumps with good muscles, legs are short. The breed therefore has an excellent beef conformation. However, the prospect of using it for large scale beef production is not bright because they are not available in large number. The breed has really been transferred outside its ecological zone. It is an excellent breed to upgrade for beef production, can be use as purebred for ranching operation. This has been tried by the defunct Western State government, LIBC Ado-Ekiti. But the results are unknown. The breed is found in the Ondo province consisting basically Ondo State. A program where farmers were encouraged to buy Muturu females and Ndama bulls supplied by government was tried by the defunct Western State government.
3. ***Ndama:*** This breed is not entirely indigenous to Nigeria. It has its origin in Guinea. It is highly resistant to trypanosomiasis. Much bigger than Muturu with mature males weighing 340-363kg and females 227-272kg. It has compact body with short legs, straight and levelled back with good hind quarter reasonably well fleshed and fully developed. Has excellent conformation for beef. Superior for growth rate and beefy quality than Muturu and Keteku. So it has considerable advantage and potential for large scale beef production particularly in the Southern States. Has been used with Muturu and Keteku to increase mature size growth rate and beefy quality in this breeds.
4. ***Keteku:*** This breed is indeterminate but is believed to be cross between Muturu and Zebu. Possess trypanotolerant characteristics and thrive well in Savanna and Forest zones. Male weigh 272kg and female 227kg.

   Conformation: It has narrow/shallow body, lacks width and chests, flat over the ribs, has sloppy back and rumps, short hind quarter, thighs lack width and fullness. Therefore the breed does not has ideal beef conformation but it is a useful breed for large scale beef production because it is found in large number

and so can be a source of foundation stock for grading with the Ndama and Exotic breeds. For example the defunct Western State government made some attempts to cross them with the exotic breed like the Brahman and Angus in the present Fasola farm but the results were not spectacular. The offspring were susceptible to trypanosomiasis and streptothricosis.

5. ***Zebu:*** These are humped cattle breeds which are more common in the tropics. The Nigerian Zebu includes Sokoto Gudali, Adamawa Gudali (sometimes spelt as gudale), Rahaji and Bunaji.

a) *Sokoto Gudali:* This is one of the least tolerant of the Zebu; thrive best in the dry part of the country. It is a hardy breed. It is a big size animal with mature males weighing 500kg and female 340kg. Has a well balanced body conformation with deep and wide chest with back sloping from back to sacrum. The thighs are fairly wide, well developed and fully fleshed, legs are moderately long. They produce a fairly good amount of milk, at least more than enough to rear their young. They are available in large numbers especially in the North Western area of Nigeria. Although its conformation is not iz because of their low resistance to trypanosomiasis.

b) *Adamawa Gudali:* It is found on the Adamawa Island in an area relatively free of tsetse fly and therefore no trees, no trypanosomiasis but streptothricosis is common. But the area is good in pasture all year round with cool temperature especially in the night. Has essential conformation for beef with short and compact body. The back is level and broad especially over the loins. It has very well fleshed thigh, wide and full rump and less sloppy back compared to other zebu. They have shorter leg. Males weigh an average of 450kg and females 360kg. The breed has been used for beef production under ranching condition at the Obudu cattle ranch. Some authorities have claimed that this breed has the best quality and potential for beef cattle production of all the West African cattle.

c) *White Fulani:* This is the most common and numerous of all cattle breed in Nigeria. Most widely distributed over a wide range of ecological zone. The males and females average 450 and 380kg respectively. The body is well balanced with good depth and width with a sloppy back. The breed can show good muscular development under good management condition. Its legs are of medium length. It is a breed that has been used for beef production under the natural system because it is the most numerous and has been used under experimental condition for beef production. The steers fatten well, has good carcass and attains maturity at 3 years.

d) *Rahaji* (Red Fulani or Red Bororo): This is a large frame animal but generally narrow at the shoulders and ribs with flat and sloppy back and rump. The breed has hungry look (thin) with long leg. They are more adapted to the ecological

Zone in which they are found. They can trek long distance for food and water. It accounts for a great proportion of cattle for beef in Nigeria even though the conformation is not that for ideal beef cattle.

Conformation of Nigerian breeds

There are basically two (2) types of conformation. There are those whose conformations approach the European beef cattle which are capable of converting large forage quality into good quality meat and carcass. They include:

1. Ndama
2. White Fulani
3. Sokoto gudali
4. Adamawa gudali
5. Muturu

These breeds have the meat carrying part of their body very well developed. Those that are not ideal in terms of European conformation are those that survive on sparse forage and convert this into meat. Even though the meat may be of low grade by European standard, it is of considerable value in the diet of Nigerians. This breed includes:

1. Rahaji
2. Shuwa Arab
3. Keteku

Climate and beef production

Climate: It is a combination of element that includes temperature, humidity, rainfall, air movement, radiation conditions, biometric pressure and ionization. Of this, temperature and rainfall are the most important.

Classification of Climate

Various attempts have been made to classify the world climate. The best known classifications include that of Köéppen in 1931, Thornwait (1948), Holdridge (1967).Holdridge classification as based on life zone ecology classification and he combines latitude, altitude, rainfall and mean temperature. These are element particularly useful to agriculturist. A simpler classification proposed by the United States Department of Agriculture, USDA (1941) classify the tropical climate into equatorial or super humid, humid, semi arid and arid zone.

Equatorial or Super-humid climate has a vegetational cover of rain forest, humid forest, sub humid grass land, semi arid (steppe or thorn bush, arid). It is characterized by constant heat, high rainfall and high humidity. Mean annual temperature of 27^{0}C and Total rainfall ranges between 2,032 - 3,048mm. It is not usual for rainfall to be evenly distributed throughout the year. In some area there is maximum rainfall, others double maximum. Equatorial climate is found between latitude 5-7^{0} North & South of the equator of Congo basin, Guinea Coast of Africa, Southern part of Nigeria.

In India subcontinent, Malaysian Peninsula, Indonesia, New Guinea, Southern Phillipine, Amazon Basin, East coast of Malagasy. Vegetational cover is tropical rainforest.

Typical temperature of the super-humid is tropical rainforest. Climatic stress on domestic animal is considerable. Indigenous domestic animals are not numerous. Climate favour plant growth and forage all year round, internal & external parasites are favoured. Animal products deteriorate rapidly when stored. A great deal of basic and applied research is needed before it can support cattle production.

Humid climate: Characterised by high seasonal temperature, humidity & rainfall, area covered include Ogun, Oyo, Ondo, Anambra, part of Imo States, etc. Temperature extremes are shorter than in the Equatorial climate, usually 3 seasons, cold dry, hot dry & hot wet. Natural vegetation is rainforest; climatic stress on animal is not severe, forage supply more seasonal, potential for beef production is high.

Sub humid: Found in North and South of humid forest area. In Nigeria it is found in the North from Kwara up to Kaduna State characterised by seasonal climate, short raining season and longer dry season, temperature variation under with hotter summer due to high intensity of solar radiation combined with longer day length. Natural vegetation is savannah. Nomadic cattle productions flourish in this area. Climatic stress of cattle is less, forage production is seasonal. Nutritional stress is a major problem. It is a zone of epizootic animal diseases such as rinderpest. Internal and external parasites are easier to control.

Semi arid: Characterised by seasonal condition such as low rainfall and very long dry season. Diurnal and seasonal temperature fluctuations are very wide. Humidity is low most of the year. High intensity of solar radiation, total rainfall ranges between 254-508mm. Such areas are Bauchi, Borno, Kano and Southern part of Sokoto State, it is an area more suited for livestock production including beef cattle, although productivity is limited by lack of feed and water with consequent nutritional stress as well as climatic stress. Internal and external parasites can be controlled with relative ease. Control of epizootic diseases is more difficult. The area is more suitable for sheep, goat and Camel production.

Arid climate: It is found at the fringes of this country.

Montane climate: Are found in highland areas like Obudu, Jos plateau, Adamawa. Temperature here is low, rainfall is moderate (April - Oct). Good vegetation for half of the year.

Systems of beef production

Traditionally beef is produced on the range where pasture could be had for little or nothing and where the land is of little value for any other form of agriculture e.g. where the land is too distant from centres of production such lands can't be used for dairy or poultry production due to its distance, for example cattle can be slaughtered and its carcass sent to areas of consumption e.g.

Mokwa is a very small village with a ranch established there, when cattle are slaughtered the meat are conveyed in refrigerated vehicles to far off cities and urban centres such as Ilorin, Lagos, Kano and as far as Kaduna. Another example is the Obudu ranch where cattle are raised, slaughtered and the meat conveyed to Calabar. In advanced countries such meat is transported chilled or frozen to urban area e.g. beef is produced in South America and transported in refrigerated condition to other countries.

Dairy production cannot be produced from the range usually they are sited near urban centre. In other country it is possible to produce beef from range where there is surplus grains like maize especially where the disposal of such grains may involve a lot of transport. This is the same with the game bird of the United States. In such a situation it is cheaper to use the grains to feed the cattle thus using the cattle to convert the grains into meat which can be transported over a distance to consuming areas. In recent years beef production has been practiced by using intensive and semi-intensive system due to the increasing world population and demand for meat. However a great deal of the world meat is being produced under the traditional range system like in Australia, Argentina. In the USA beef is now produced under intensive system (feedlot operation).

Intensive system

The intensive system of production is usually found in agriculturally advanced countries such as USA, Britain. The intensive system aims at producing the type of beef that will satisfy the requirement for beef tenderness, flavour and juiciness. There are 3 broad methods under intensive production of beef:

1. The veal
2. The barley beef
3. Feedlot production system, basically America

The veal: Veal is the flesh of a calf. Ideally veal is calf slaughtered at a few days of age. This day's veal is meat from calf reared from 8-12 weeks and weighing about 120-180kg live-weight and dressing out on slaughter at 70-90kg carcass weight. Veal is consumed in large quantity in Europe particularly in Italy. It is not readily available in the market for sale because the calf has to attain a live body weight at such a short age; a high birth weight is an advantage. On account of this the heavier breed like the Charolais, Friesian, Hereford, etc are favoured. The calves required for beef are fed whole milk for 12 weeks, no grain or any other feed is used so as to produce white flesh. The whiter the flesh the higher the price. Milk feeding of veal calf is however very expensive and they require about 9.5 litres of milk per day. This day skimmed milk plus milk substitute are used. Skimmed milk is valuable since it is cheaper. Usually the calf is given colostrum and skimmed milk is fed *ad libitum*. By the time the calf are about 12 weeks old, quantity of skimmed milk per day could go up to 15-19 litres. No water and no hay or silage is given as feed.

It is often found that the skim milk may not provide adequate energy for growth so milk substitute are fed. These are made of energy source such as animal fat and protein supplied from powdered milk, mineral and vitamins; antibiotics are added to promote feed consumption and efficiency of feed conversion. The calves are kept in semi-darkness to minimize exercise so that energy is conserved. Additionally the floor of pen are slatted floors with no bedding to ensure that the animal do not eat bedding material. The farmers profit is estimated at 7-8 pounds per calf.

Barley beef: This is a system of raising beef cattle almost exclusively on barley based diets. It constitutes 80% of the diet. The idea is to provide energy for fast growth in concentrated form as possible such that the animal can express their growth potential. The idea has its origin in the USA where it was found that barley grain contains crude fibre, protein and itself is a balanced diet. It is enough on its own to eliminate conditions of growth and other digestive problems although the idea originated in the USA it was fully developed in Scotland.

The barley beef system provides for the rearing of calf on early weaning system and feeding of an early weaning diet up to about 8 weeks of age. At this time the calf is expected to gain about 0.9 - 1.0kg per day. After about 8 weeks the animal is transferred to a growing diet of about 85% barley with protein supplements. The feeding of this growing diet is continued until the animal is about 4 months old when it is again transferred to a fattening diet which may contain about 95% barley. The early stage involves the use of whole milk but this would prove expensive. Consequently, high energy liquid diets are formulated for the calf. The diet composition is as follows:

Dry skimmed milk	80-85%
High grade beef tallow	20-15%
Vitamin A	2 million international unit/ton
Vitamin D	3×10^6 international unit/ton
Vitamin E	20,000 international unit/ton

One part of this mixture plus 7 parts of water provides the liquid diet.

This diet is offered from the first week to the 6th week of age and sometimes up to 8 weeks of age. In addition an early weaning diet is introduced gradually from about the 3rd to the 5th week of age. At the time the early weaning diet is being introduced the liquid diet is gradually withdrawn to induce consumption.

At 6 weeks of age the birth weight of the calf should have doubled. The early weaning diet is composed as follows

Flaked maize	40%
Rolled oats	30%
Molasin meal	10%
Supplement	20%

The supplement is composed of 80% white fish meal, 7% molasses, 12% barley plus vitamin A and D.

This early weaning diet is fed until about 8 weeks of age. During this period no roughage or hay is offered. From the 8th week to the 4th or 6th month of age a grower diet is fed. This is made up of 85% barley and 15% supplement. Soybean meal may be use to replace fish meal in the supplement. The barley is rolled to preserve the husk of the barley grain which is the only form of roughage that the animals get in its diet. A transition diet is fed for about a week before the animal is transferred to the grower diet. This transition diet is fed for about 1-2 weeks beginning from the 6th week of age until the animal is transferred to the grower diet. The transition diet is usually a dry diet. The transition diet is made up of roughages and grain. This diet could be made up of 50% maize cobs and 50% maize grain, but a diet made up of the following composition may be compounded;

25% Oat husk
20% Rolled oat
28% Rolled barley
25% Undecorticated cotton seed
2% minerals and vitamins

Male calves on barley beef production system should be castrated at 4 months of age to remove the source of androgenic hormone which promote growth but at the same time affect carcass quality. Under normal condition, the entire (intact) male has been shown to grow faster than castrates. Castrates in-turn grows faster than female. The androgenic hormones secreted by the testis and adrenal gland are known to increase protein synthesis in animal hence they promote faster growth rate. To maintain the fast growth rate in castrate such animal are later implanted with synthetic growth promoting hormone usually diethyl-stilboestrol may be fed at 10mg/day which may later increase to 20mg/day with feeding continuing for about 6-7 months of age. Hormone feeding is stopped 2-3 weeks before slaughter to prevent any residual effect of the hormone. This precaution is to ensure that the consumers do not eat some of the hormone residues which have been shown to promote the development of secondary sexual character in man. Animals are slaughtered anytime from 10months of age when they weigh 400-450kg. The estimated live weight gain per day is 0.9-1.18kg with feed efficiency of 4.8:1.

Problems of barley beef production: Problems arising from feeding the barley beef diet include:

1. Bloat
2. Acidosis
3. Clostridia infection
4. Liver abscess

Bloat: High incidence of bloat is common in the barley beef production. This may be prevented by providing sufficient fibre or roughage in the diet e.g. preserving the husk of grain use in the diet as part of the diet. Addition of 5-10% high fibre product or provide feed all the time and let the animal loose in the stall. If an incidence of bloat occurs call the veterinarian.

Acidosis: This may arise as a result of imbalanced diet resulting in the excessive production of the lower fatty acid from fermentation process in the rumen. It may occur with animals previously on roughage and suddenly transferred to barley beef system. Deficiency of certain vitamin would also cause this condition particularly the deficiency of thiamine which is an important vitamin in fatty acid metabolism. Administration of this vitamin results in rapid recovery from acidosis. The condition can also be prevented by putting the animal on a transition diet.

Clostridial infection: may occur especially where housing condition is unhygienic. Control is by ensuring clean housing, vaccination using attenuated strains of *Clostridia chanvei.*

Liver abscess: About 30% of the livers of animal reared under barley beef system are condemned because of liver abscess. It develops gradually from bacterial infection which usually finds their way into the liver through the blood system and through damages to the rumen wall as a result of low pH. The condition could be prevented by the addition of a low level of antibiotic to the feed e.g. Auriomycin may be included in the ration at 20mg/kg of feed.

Urinary blockage: Another condition that can be found under barley beef system is urinary blockage which may occur in males due to the inability of the kidney to absorb materials from the blood. The urine of such animals usually contains a lot of nutrient.

The barley beef system of production is not applicable under the Nigeria condition because it is only useful when the prices of the meat pay for the production cost. Another problem is when there is no enough grain for human consumption there is no expectation for grains to be fed to animal.

In summary: - the Nigeria populace cannot pay for barley beef cost; - there are insufficient grains in Nigeria for barley beef production.

Feedlot operation:Feedlot finishing of cattle refers to the feeding of such cattle in a restricted area, feed are usually conveyed to the animals. The types of feedlot include open feedlot and confinement or sheltered feedlot (which is more applicable under Nigeria climatic condition). Feedlot operation requires a good planning and design.

Preliminary feedlot planning suggestions:

1. Decide on the type of facility i.e. is it going to be an open facility or confinement facility. In the tropics open feedlot with shades is preferred (shades could be artificial or natural).
2. Decide on the numbers of cattle, feed and storage requirement.

3. Determine the justifiable investment in the feeding facilities.
4. Select the facilities, equipment and arrangement that best fits your chosen management program.
5. Design a system that is labour saving and practical and environmentally suitable for economical gain of cattle.

Open feedlot: This type is without shelter except for tree shade plus a roof over the feed bunk. The feed bunk is usually constructed with concrete. An open lot is the cheapest. The investment cost in Nigeria is not quite known but it may be in the region of N100-150000/animal capacity whereas in the USA around 1970s the cost is around 30-50 dollars.

Class Project: Determine the investment cost per animal capacity of an open feedlot in Nigeria using 100 head of cattle.

When selecting a site plan for about 1.4 acres for about 100 head of cattle or 12 acres /1000 head. This allowance of land includes space allowance for facility and expansion of the feedlot to about double the initial capacity. The minimum requirement for space is about 0.8 acres per 100 head of cattle or 7 acre/700 head of cattle i.e. minimum space that is needed. 1acre = 2 ½ plots.

Feedlot Design requirement: Floor space 15-30 square feet per animal exclusive of feed bunk and alley (passage). Animals per pen should be 25-100 heads per pen. Feed bunk with 6-18 inches (averagely 12 inches per head) of linear bunk space/ animal with the amount of feeding space determined by the frequency of feeding and size of animal.

Waterer: locate waterer per 25 head at the back opposite the feed bunk, both can be made of concrete.

Manure production: this varies with size of animal and kind of feed. A 450kg animal will produce about 1-1cubic feet of solid waste and liquid per day with water being 80-90%. Sometimes when cattle are managed on slatted floor and storage pit occupies the entire area beneath the cattle, the pit fills at the rate of 8-10 inches per month.

Management of feedlot

Backgrounding: This is a term evolved in the United States of America with evolution of commercial cattle feeding. It simply means the preparation of cattle from weaning until is placed on finishing ration. It involves feeding maximum roughages to calf and achieving moderate gain before putting it into a proper feedlot.

Feed bunk management: This involves the management factors affecting feed intake to maximize performance, minimize digestive disorder and keep animals on feed. Such management practices should ensure maximum and economic performance from cattle.

Full versus limited feeding: Feedlot animal should be fed just the amount of feed required for maximum weight gain. Overfeeding is undesirable and restricted

feeding lowers rate of gain and feed conversion efficiency. Under most conditions cattle should be full fed through the finishing stage.

Mud problem: Mud can reduce cattle gain by 25-35% as by study from the University of California which shows that mud can reduce weight gain in cattle by 25-35%. This problem is important in high rainfall area especially the humid zone because they are not able to move so expend more energy in movement and there could be foot rot. Good drainage is important in a feedlot.

Health of feedlot cattle

It has been shown that the cost of one finished animal in a feedlot could be increased by a considerable percentage if good health program is not maintained e.g. the cost per head of feedlot cattle when health management program is inadequate could go up by about $20-25.

Health management program could be improved by -

1. Preconditioning the animal
2. Move cattle directly from producers ranch to feedlot
3. Reduce transit time from ranch to feedlot
4. Reduce stress exposure on animal
5. The feedlot operator should have adequate health and nutritional history of the cattle.
6. Handle the animals coming into the feedlot properly
7. Diseased animals must be promptly diagnosed and treated.
8. An operator that desires profit must ensure adequate vaccination against epizootic diseases.

Handling of incoming cattle

The critical period for the feedlot cattle is the first 21-28 days. The following recommendation could minimize death losses and maximize performance of feedlot:

1. Provision of clean, dry, comfortable quarters.
2. Processing of cattle upon arrival
3. Provision of clean fresh water
4. Provision of palatable ration, usually it is more advisable to feed long grass hay or any other non legume roughage such as corn silage. Concentrates could be given at the rate of 4 pounds/head/day and such concentrate should consist of 2 pounds grain and 2 pounds protein supplement.
5. Satisfy mineral hunger.
6. Observe, isolate and treat sick animals.

Problems of Feedlot operation

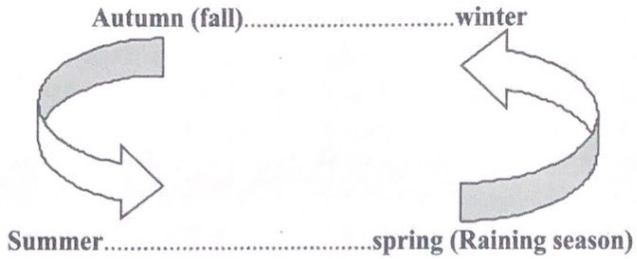
1. Mud
2. Bird: e.g. egret goes about to constitute problems by passing faeces on feed/ water, inflict injury on animal while picking insect on animal body.
3. Flies: causes animal to flash their tail thereby expending much energy.

4. Source of fattener cattle in Nigeria: animals gotten for fattening in Nigeria market are usually old and sometimes unproductive. There is no producer of cow calf (cow-calf operators) in Nigeria so that the market is the only source of fattening cattle which are mostly old and hungry looking.

Semi - intensive beef production in USA

Semi intensive beef production as practiced in agriculturally advanced countries consist of the raising of beef cattle to reach a daily body weight gain of 0.68kg/day to produce about 400-450kg in about 18-24 months of age. Under this condition the animal may be reared partly on grass and partly on straw, roughage and concentrates. Method of rearing will depend on the time of the year the animal is born e.g. Autumn born calf usually spend the first 6months of their life indoors under the traditional system i.e. they are suckled by their dam or fed whole milk plus milk substitute. At the end of the first 6 months they are turned to pasture usually at the beginning of spring. They then spend the period of spring and summer on pasture and return indoor at the beginning of autumn.

This time they are fed silage, hay and concentrate to fatten them up. They are ready for market at the beginning of next spring when they would be about 18months old; usually in Europe beef is expensive around this time.



Beef production in Nigeria

The Nigeria beef is produced under 2 main systems

1. Semi intensive or ranching
2. Traditional system

The traditional system is the major source of supply of beef in Nigeria. It involves the use of natural grassland in the savanna areas of Nigeria. These grasslands are un-improved, no special care to improve the productivity of the pasture. No supply of nutrient to animal under this system. Rainfall is limited to 2-4 months hence pasture growth is limited to this period. The cattle producers tend to live the trans-humans type of life i.e. moving their cattle in response to variations in rainfall and climates. To some extents their movement is also controlled by tsetse flies. Under this system objectives are not set. For example growth rate are not determined, desirable age at maturity are also not determined and known minimum age and weight are

slaughtered and not determined. Under this system the herdsman takes part in the local arable farming by providing manure for the land in exchange for grazing of crops or grains or crop residues in the local peoples' farms. This system has some inbuilt hazards particularly as there is increasing pressure on the available land for grazing and for arable farming as a result of increasing population. For the fact that the animals are constantly exposed to diseases such as trypanosomiasis, water supply particularly during the dry season in the Sudan and Sahel savannah zones has been a great problem. In the derived savannah and forest zones where the people are not traditionally livestock farmers the traditional meat production are very much on the hand of the Fulani's.

In the derived savannah where we have the Keteku breed of cattle, farmers group themselves together and employ Fulani herdsmen to look after their cattle. This is the same practise in the forest zone where we have the Muturu cattle as the main breed. In this area a whole village would make a fenced courtyard where the animals come to rest for the night after roaming about for their feed during the day. The practise of building this yard is a precaution to prevent the animals from wandering into crop farms at night and thus destroying crops. The animals are easily fed during the raining season because they are able to get some grass by roaming about. They are also fed crop residue like kola nut pods, plantain peel, cassava peels, etc. As in the nomadic cattle these animals are not raised with any objective; no slaughter age are determined. The animals are mainly raised for occasional slaughter.

Ranching: This is an attempt made at organised beef production in Nigeria. Under this system we have the breeding and multiplication centres. This attempt simulates the semi-intensive beef production as practised in developed countries. The objectives include the production of an animal that would attain a marketable weight depending on the breed as early as possible. Therefore the animals are weighed regularly, age at slaughter is determined and body weights are determined also. The system aims at securing a live weight gain of 0.5-1.0 pounds or 0.23-0.45kg per day using improved pasture, conserved grassland product and bush grazing. Therefore under the system N'dama cattle would be expected to attain about 300kg in 3yrs.

Muturu cattle	227kg in 3 years
Keteku cattle	272kg in 3 years
Zebu cattle	400kg in 3 years

Breeding and multiplication system

Multiplication centre has similar objectives as the ranching centre because these animals are regularly weighed so they know their age at various weight, they are breed for quality. All management practices which include improved feeding, breeding, castration are practiced on these farms, there is record of breeding, and animals are regularly culled whether as a result of diseases or poor performance. Such centres include Ado LIBC, Fasola farm, Obudu, Upper Ogun cattle ranch,

Akunnu cattle ranch, Western Livestock Company (Akunnu cattle ranch, Ogboro cattle ranch, etc. Under the Federal government we have fattening station such as Mokwa cattle ranch and Bauchi meat factory where beef cattle are bought from the range for slaughter.

Small holders fattening scheme: This is a traditional cattle fattening practice which has been operating in Nigeria for the past years but was recently given attention by the Nigerian Agricultural and Cooperative Banks (NACB) and the Federal Livestock Project Department (FLPD). In collaboration with the World Bank by NACB and FLPD, they collect loans from World Bank and given to farmer.

The system utilizes crop residues such as sorghum, millet, maize cob and as well as groundnut and cowpea hay. More recently groundnut cake, cotton seed cake, palm kernel cake, wheat offal, brewer's grain and molasses are now in use. This project is being financed by the World Bank and the federal government through the Livestock Project Department. The financing agent is the Nigerian Agricultural and Cooperative Bank (NACB). The project involves selecting some farmers who are given short term loans with which they purchase 4 or 5 cattle and supplementary feed to fatten them over a 4 months period. The FLPD organizes the finance, procure the feed and drug in bulk and supervises the disposal of the stock and repayment of the loans, principal and interest.

Technical aspect of small holder fattening stock project

Technically applicants for small holder fattening loan must fulfill the following criteria:

1. Locate source of cattle
2. Good supplies of crop residues and grazing areas
3. Locate water source
4. Have a fenced up area
5. Labour

Cattle selection and fattening period

It is envisaged that the cattle fattens out in 4 months. The scheme aims to finish up lean but well grown healthy, large framed animals. Because the intention is to provide an improved nutritional plane, compensatory growth on gain are expected in the animals. The supervisors of FLPD therefore guide the loan beneficiaries in the selection of his animals depending on size, conformation, age, health and price.

Operational problems of small holders fattening scheme

1. Selection of beneficiary: beneficiaries are scattered all over the country and so not easy to reach.
2. Supply of inputs: feeds and drugs are erratic with a lot of delay of meals, but now FLPD organises bulk purchases which tends to reduce delays, ensure balanced ration and ensure drug dosages.
3. Inexperience of holders: beneficiaries are not very experience in cattle

handling, marketing etc so FLPD might need to organise periodic business seminars.

4. Supervision: this is difficult because the supervisors from FLPD cannot be present at all purchases.
5. There is no effective marketing system. Beneficiary still depends on the traditional marketing system.
6. Beneficiaries are not effectively supervised due to lack of transport. So the project should provide transport for this people (supervisors).
7. Loan repayment: many beneficiaries are defaulting. This can be minimised through better supervision.

Rearing of beef calves

There are 3 main methods

1. Single suckling: Oestrus are delayed (because calf is allowed to run along with cow leading to longer oestrous cycle)
2. Multiple suckling: Calves are weaned and assigned to best milk dam,milker e.g. assign 5 calves to each dam.
3. Batch rearing: This is done usually in dairy farms where calves are bucket fed.

Techniques for establishing a beef ranch

A beef ranch could be established in any part of Nigeria; wherever it is to be established the project must be planned. Problems associated with such establishment must be identified, such problems include:

1. The climate: Temperature, rainfall, vegetation. Rainfall pattern determines the length of pasture growth and an indicator of water supply.
   When establishing you have to contend with certain diseases such as streptotricosis, trypanosomiasis, etc which are common in the rainforest and dry savannah zone. Ticks and worm infestation are common all over the country, so in planning aim at controlling the parasites.
2. Breeds of cattle: Most Nigerian breeds should receive attention first before any other breeds. This is on account of adaptability to prevailing environmental and disease problems. Most of the Nigeria breeds will respond to improved management in terms of weight gain and feed utilization. Exotic breeds with ideal conformation can only be tried on experimental basis, therefore a commercial beef producer should not insist on animals with ideal conformation since the Nigerian beef market is not specialized and the beef breeds have not been tested. The government needs to be advised to have a program of research in the area of using tested breeds in other tropical areas of the world to be tested in Nigeria.
3. Land: Since beef is traditionally produced on the range it is not necessary for land for beef production to be near urban centre. Lands unsuitable for other agricultural production ventures are suitable for beef provided they can support pasture. The land should be well drained and soil should be responsive to

fertilizer application. As to hectarage (size) it depends on the system of production and capital at hand. For extensive system 4 hectares (10 acres) is required for 1 head of cattle. If semi-intensive (ranch) system you require 4-5 acres or 1.6 ha/cattle. For intensive system you require 2-3 acres or 0.8-1.2 ha/head. The intensive system will require pasture as well as land for grain production.

4. Pasture: Pasture establishment will depend on the system of production. The extensive system will not require pasture. The semi intensive and intensive requires pasture and other facilities. When establishing pasture this should be done between 6 months to 1 year before the animals comes in.

Fences for pasture and rangeland: Fences are required to restrict cattle movement to specific areas e.g. preventing cattle from breaking into and grazing newly established pastures, preventing a bull from breaking into herds where it is not required. Fences could be made of stones, wood posts with barbed wires. Under the present Nigeria condition wood post or live post might appear cheaper than angled iron. Wire sizes that are 9, 12, 12, 13, or 14 thickness gauges could be used, but the larger the gauge the smaller the diameter the stronger the wire. Other fencing materials include staples, clips and braces. Staples are for holding the wire to fence posts. Nails could be used instead of staples for wood posts. Braces could be made of wood or metal and are generally needed to stabilize the post at the corners.

Fence construction: Good material will increase the life of the fence and decrease the maintenance cost. Gates could be of metal as well as of wood.

5. Cattle processing facilities: These are specialized handling facilities which should be accorded priority during planning e.g. Corrals.

Properties of a corral should be:

1. It should be accessible both to livestock and vehicles.
2. Corrals should be near the farmhouse with direct access of all pasture subdivisions.
3. Location should be convenient and labour saving.
4. Location should be well drained to prevent muddiness during raining season.
5. Corral fence usually could be made of wood or metal. The general arrangement of a corral should give serious thought to the use. Cattle associate pains such as dehorning with certain areas of the farm facility, this makes it unwise to inseminate in the same chute or pen where cows are dehorned. A good corral should have the following handling facilities;

1. Crowding area
2. Walking chute
3. Squeeze chute or head gate
4. Loading ramp
5. A dip
6. A weighing scale

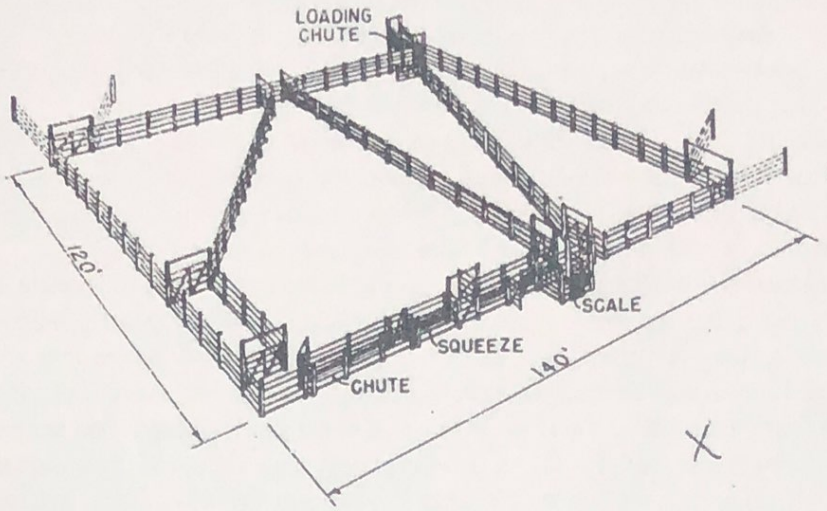


Figure11.1 Corral system

CHAPTER TWELVE
SHEEP PRODUCTION

Origin and domestication:

Sheep was first domesticated in an age referred to as the new Stone Age. Historical records show that sheep provided primitive pastoralist with meat, milk, wool and skin.

Sheep belongs to the genus Ovis. Domestic sheep are thought to descend from the wild stock the Moufflon which comprises *Ovis musimon* and *O. orientalis* and the Asiantic Urial known as *O. vignei.*

The Asiantic Moufflon or *Ovis orientalis* is found in the Asian minor while *Ovis musimon* is native to Europe. Both of the Moufflon stocks are considered as ancestors of the domestic sheep. The Asiantic Urial is a smaller race than the Moufflon and it is native to the grassy open plains of central Asia. It lives in large flock and it is much less a mountain animal than the Moufflon which is a mountain animal. Most of the familiar breeds of Merino are thought to be descendant of Asiantic minor. Most of the Nigerian breeds are thought to be of Moufflon origin.

Breeds

Broadly there are two classes of sheep

1. The wool type
2. The hairy type

The Nigerian breed belongs to the hairy type and there are four of these breed.

1. The West African dwarf Sheep
2. Yankassa
3. Ouda
4. Balami

1. **The West African dwarf Sheep:** These breeds have small body size, short legged, found mainly in the humid zones of the southern part of Nigeria. The breed has various colour combination but black is predominant. The males of this breed have horns while the female are hornless. An observation has been reported of cases whereby some of the males are polled. The mature body weight is between 18-25kg. The breed is often described as trypanotolerant.
2. **Yankassa breed:** This is the breed found in most teaching and research farm. It is the most numerous and widely distributed of the Nigerian breed. It is found in the Guinea Savanna and Sudan savanna. The coat colour is predominantly white with black patches around the muzzle, eye, ear and hoof. Mature rams has curved horns and heavy hairy mane ie hairy region of the chest. The females are hornless. The breed is hardy and of medium body size. The adult body weight is between 30-40kg. It adapts well to intensive production and have relatively high growth rate.

3. **Ouda:** This is a large long legged sheep with a convex facial profile. It is found in the Sudan savanna zone especially the northern part of the country. It has a characteristic coat colour of an entirely black or brown head and fore - quarters and white hind quarter. The ears are large and droopy. Mature males have horns while females are hornless. The breed is particularly adapted to extensive grazing system and is noted for its trekking ability. Mature ones weigh between 35-45kg.
4. **Balami:** This is the biggest of the Nigerian breed of Sheep, found mainly in the dry Sudan and Sahel savanna. It has white coat colour. Mature adult weighs 40-50kg.

Factors favourable to sheep production

As compared to other classes of livestock, sheep has the following natural advantages:

1. They are particularly good in the utilization of more arid type of grazing.
2. They are good at utilizing waste land and are excellent scavengers, gleaning fields and destroying weeds.
3. Compared to cattle they produce more librarily in proportion to what they consume.
4. Some breeds especially the wool type produce 2 products wool and lamb which are available at different periods of the year.
5. The investment returns of Sheep comes quickly as lambs may be marketed 8months after ewe are bred.
6. Sheep droppings are particularly less subjected to waste because of the way they are dropped and trampled into the soil.

Unfavourable factors to Sheep production

1. Sheep are subjected to attack by predators including dogs.
2. They are less- resistant to disease and injury.
3. They are highly susceptible to parasites e.g. worm.
4. For the wool breed, wool in international market has always been politicized, moreover these-days synthetic fibres are in competition with wool.

Starting sheep raising: In starting a livestock enterprise, certain factors such as land, breed of stock and infrastructural facilities and cost needs to be adequately considered.

1. *Land:* Under extensive grazing condition land requirement is 1.6 - 4 hectares per sheep. However under intensive management system a well established pasture of 1 hectare would support 25-40 sheep.
2. *Breeds:* It is advisable to use breeds adaptable to the ecological zones where enterprise is to be set up. For example, the W/African dwarf sheep or Yankassa will be more suitable to the humid zone than the long legged Ouda or balami from the Sudan or Sahel savannah zone. The West African dwarf is also trypanotolerant and thrives efficiently.

3. *Infrastructure:* An office accommodation for a large enterprise, adequate fencing using chain link or close fencing due to the size of sheep is also needed. Chain links are at present very costly so wood post preferably live - post which can be trimmed and barb wire designed to be very close can be adequate. The entire necessary infrastructure should be established before purchasing of stock.

Foundation stock

It should be purchased from reputable sheep breeding farms or government farms such as LIBC (Livestock Investigation and Breeding Centre). This will ensure purity of animal, high genetic quality and freedom from diseases. However, unfortunately the numbers of available reputable breeding farms are limited so the open market becomes the purchasing centre of breeding stock. In purchasing from open market is the need to pay attention to the animals' health, age and physical appearance.

a. Health: All ewes selected must be in thrifty and vigorous condition. They should have every appearance of a useful life before them and give good evidence of been able to raise strong and healthy lamb. It should be free from catarrh, diarrhoea and skin diseases as well as ectoparasites such as tick and fleas.
b. Age: It is advisable to buy sheep of 1 to 3 years old using their dentition to verify their age. The lamb has small narrow teeth known as the milk teeth. At 12-14 months i.e 1yr of age the two central incisors are replaced by 2 broad permanent teeth. At 2-2 years of age 4 broad permanent teeth will replace 4 milk teeth while at 3 yrs it has 6 permanent teeth and at 4 yrs and above it has 8 permanent teeth.
c. Physical appearance: Animals with physical defects such as lameness, blindness and malformed toes should be avoided. Lean and stunted ones should also be avoided. Purchased animals should look active with bright eyes, fine rather than scruffy and rough coat. It is advisable to buy in small batches from as many markets as possible so that foundation stock will have much genetic variability as possible.

Initial health precaution: It is good husbandry practice to quarantine newly purchased animals for 1 month before introduction into herd. During the quarantine period recommended treatment regime are as follows:

Day 1- give prophylactic antibiotic treatment for 3 days.

Day 4 - give broad spectrum anthelmintic and coccidiostat. The coccidiostat should be given for 7 days in water or feed while anthelmintic is given once.

Day 7- spray the animal against tick

Day 28 - repeat anthelmintic and spray against tick. Trim overgrown hoof.

Day 30 - animal can join the main herd.

In the humid zones of Southern Nigeria where PPR (*peste des petit ruminantes*) or kata, a disease of sheep and goat may be a problem. Vaccination against the Disease using PPR antiserum at 4ml to 8ml depending on size of animal, and

given subcutaneously is advisable on day 1 and day 10. TCRV (Tissue Culture Rinderpest Vaccine) should be given subcutaneously in the neck region above the shoulder. Always consult the veterinary doctor for your vaccination program.

Breeding and reproduction management: In any animal production enterprise there are 2 types of breeders:

1. Commercial breeders
2. Purebred breeders.

In sheep production enterprise commercial breeders specialize on securing high percentage of lamb crops with utility feature of the animal and their ability to make efficient use of feeds for fast weight gains. They use purebred rams for their business management while the purebred breeders specializes on production of purebred rams for sale to commercial breeders and the sale of rams and ewe to other breeders for foundation stock. The purebred breeders keep records and his animals are pedigreed, therefore adequate chance exists for anyone who will want to specialize in this area of production in Nigeria.

Rearing of the young: It is good practice to separate ram from ewe lamb after weaning to prevent indiscriminate mating and to facilitate breeding during specific periods of the year. The favourable breeding period of the year is yet to be looked into in Nigeria.

Age at puberty: Sheep attains puberty at 5-8 months of age. Sexual organs of rams are already functioning at this time however rams should not be used before 1years of age while ewe lamb should not be breed before the age of 9-12 months. It is good practice to replace breeding rams with newly selected ones after each breeding season. This is good for commercial breeders but purebred breeders will want to utilize the quality for as long as possible. A minimum of 6 rams should be in a flock of about 100 ewes. Feeding of breeding rams should be improved 6 weeks before breeding season.

Oestrous cycle : The oestrous cycle in ewe is 16-17 days. Oestrus duration is 20-42hours approximately 1 to 2 days, average being 30 hours. Ovulation occurs in the ewe from about 24-30 hrs after the onset of oestrus. If the ewe is not bred or fails to get pregnant following breeding, it returns to oestrus after 16-17 days. There are no visible signs of oestrus in the sheep except the acceptance of ram or teaser which can be a vasectomised ram or an aproned ram. The acceptance of the ram is the only external signs of oestrus in ewe. In flock mating ram should be left for 6 8weeks in flock to ensure about 3 oestrus cycle during which the ewe can be bred after which the ram is withdrawn.

Ram should be joined with ewe at 2 weeks after lambing. The ewe will be nursing lamb at this time but this does not prevent it from being pregnant. Batch lambing could be ensured by synchronization using progesterone intra-vaginal sponges which is left in the vagina for 12 days. Ewes lambing within 2-3weeks can be

synchronized for batch mating. This consists of inserting the progesterone implant into their vagina for 12 days. Introducing ram to treated ewe 2 days before vaginal sponges removal to promote high ovulation rate. Mating does not begin until sponges' removal. Oestrus normally spread 4 days following sponge removal.

Gestation period in ewe is about 5months (152 days). Repeated breeding ewes weaning poor weight lambs and old ewes (i.e. those about 7 years old) should be culled. Twining starts around the 3rd lambing.

Nutrition: Nutrition exacts some effect on the reproductive function of the sheep. The practice of flushing ewe (i.e. feeding ewes more generously) at 2 to 3 weeks before breeding will improve lamb crop by about 15-30% and re-breeding of ewes is easier. Flushing could be accomplished by feeding concentrate or lush pasture or range. Fat ewes are conditioned by exercise.

Nutrition and pregnancy: Under nourishment of ewes during late pregnancy may cause pregnancy toxaemia (a metabolic disorder), low birth weight and poor lamb survival. Undernourishment during lactation and re-breeding may result in depressed lactation, delayed oestrus, lower ovulation rate and poor fertility. Survival rate and weaning weight of lamb from under- nourished ewes are generally poor. Good nutrition and management ensures 80% lambing rate of bred ewes and 25% twining rate.

Identification: Identification of individual animal facilitates management and breeding operations such as record keeping, selection of replacement stock and culling of unproductive animals. Metals or plastic tags are available for identification purposes. Wooden tags with numbers painted on them could be improvised where metals or plastic tags are not available. This could be hung on the animals' neck and must not be hung too loosely to avoid dropping off or tightly to avoid strangling the animal to death.

Feeding: Roughages is the natural food for ruminants and the cheapest food for sheep. Roughages could come from range lands, fallow lands, sown pastures or crop residues. For intensive sheep production, pasture establishment is a good investment. Well established and managed pasture will provide good quality feeds such as fresh grasses, legumes or hay or life poles of *Glyricidia sepium*. Availability of this feeds definitely reduce the quantity of concentrate fed. A well managed and well established pasture will support 25-40 sheep per hectare during the raining season or 5-10 sheep during the dry season. Sheep should be allowed 6 hours grazing time a day or should be offered 1.5-2.5kg of good quality hay per head per day. Animals should be supplemented with 0.2 to 0.5kg of concentrate feed on daily basis. Concentrate feeds are now in 25-50kg bags sold by millers all over the country.

Water: Sheep requires about 2-6 litres of water per day. This will vary with the age, physiology of the sheep, type of feed and the ambient temperature. Both water and mineral salt lick should be available librarily to the animal.

Housing and other facilities

\Housing:

Husing is an important requirement for intensive sheep production enterprise. Housing is essential for overnight shelter and provides security against predators of the sheep. Also it provides protection against rain and cold. Provision of housing leads to overall improvement in the performance of the animals.

Housing type: Sheep houses can vary from a low mud wall building with thatch roof to a brick or concrete wall with corrugated iron or aluminium sheet roofing. Also corrugated iron wall building could also be used. Plank wall can also be used, such houses should be located on a well drained soil and houses should be highly ventilated to avoid dampness. The floor can be of cement or rammed earth. It should be easy to clean and should be covered with good bedding materials such as shrub and wood shaven which could be changed from time to time. The building may be divided into pens. Floor space requirement for lamb and adult sheep is about 0.4 and 1.7 m^2 respectively. There should also be additional space for water and feeding trough. There should be a minimum of 3 large pens depending on flock size, one for ewe, one for ram and the other is the sick pen. Ideally and depending on flock size there should be more pens to provide for weaners or more buildings for different classes of animals. There should be a store which may be one of the buildings. There must be a hay barn and silage pit. Water supply can be from wells, boreholes, rivers or ponds. The water must be clean and in sufficient quantity. Feed and water troughs should be provided in all pens. They could be inbuilt or movable. A rectangular trough measuring 4 by 0.3 by 0.15m is adequate for 10 adult sheep.

Simple feeding troughs should be made from cutting drums lengthwise with the edges made blunt to prevent injury to animals; large plastic basin can be used as water troughs since they have the advantage of not corroding. A footbath is essential to prevent and treat foot-rot cases common with sheep on wet ground. The most common one is the walk through type which is a shallow long receptacle. With small number of sheep a bucket or basin could be used. A dip is essential on a sheep farm. The walk-in short swim type is the commonest. In this type the animal enters the vat through a walk down ramp into a deep section of the vat which contains the dipping solution and swims out. Dip vat are best made with concrete. A vat of 6 by 1.2 by 0.75m has a capacity of 2000 litres of solution. A roof over the vat is necessary to prevent rain diluting the chemical solution. A 200 litre drum opened at one end could be used for small flock. Animals in this case are individually handled and immersed into the solution for 30 seconds. Also a knapsack sprayer can also be used to individually spray the animal.

Flock health management is very important in intensive sheep production system if mortality should be kept reasonably low, seek veterinary advice during planning.

Common diseases of significance in sheep production are as follows:

1. Southern zone: *Petit des petit ruminantes* (PPR) or Kata
   Pneumonia
   Trypanosomosis
   Helminthiasis
   Coccidiosis
   Bacterial infection/ ectoparasites
2. Northern zone: Pneumonia
   PPR
   Helminthiasis
   Sheep & Goat pox
   Bacterial diseases
   Ectoparasites, coccidiosis and skin diseases (mange)

The following precaution should be taken for proper health management

1. Maintain good sanitation in pens
2. Control internal and external parasites by regular deworming, spraying against ticks and other ectoparasites such as dermatitis mange
3. Isolate sick animal and seek prompt veterinary assistance and treatment.
4. Keep proper health record
5. Quarantine newly purchased animals for 30 days.
6. Provide salt-lick and clean water regularly
7. Ensure adequate nutrition
8. Where pasture is established, rotational grazing should be enforced to prevent parasitic build-up on pastures and hence provide good nutrition.
9. Trim hoofs or horns when necessary.

Feedlot ram production

Intensive sheep production offers an attraction for feedlot large scale ram production for sale during festivals when they are normally sold at high prices. Before going into the business of ram fattening there is the need for careful planning if the venture is not doomed to fail. Important points to consider include:

1. Source of ram
2. Health care and housing
3. Feeding and the market

In planning for an efficient feedlot fattening you have to start early enough by buying rams during low market price.

1. ***Source of ram:*** Rams could be bought from the market or from the farm flock. It is advisable to purchase at the time of low prices. Time the buying period precisely to allow fattening for 3 to 4 months. Remember the selection rule when buying. Essentially festival rams should be free of any deformity and

should have well grown horns and should be 1-4 years old. Well grown large rams are especially attractive during festival periods; avoid very young or very old animals.

Remember to quarantine and practise the routine management rules. Feed supplies and feeding practice exert some considerable influence on weight gain and consequently profit margin. It is therefore essential to feed animals adequately both in terms of quantity and quality. Feedlot rams should be given good quality grass or legume hay at a daily rate of 1 to 2.5kg depending on the size of the ram and the type of hay, if it is good quality hay you can offer 0.2 to 0.5kg of concentrate ration for sheep.

The following ration combination will be adequate.

Ration A	**Ration B**	**Ration C**
Maize 25%	Wheat offal 40%	Wheat offal 25%
Cotton seed cake 25%	Cotton seed cake 25%	Palm kernel cake 25%
Wheat offal 30%	Brewers dry grain 25%	Brewers grain 25%
Brewers dry grain 20%	Molasses 10%	Molasses 10%

When labour is cheap ration may be offered in equal installment 2 or 3 times daily, otherwise rations could be offered once daily. Water and mineral salt-lick should be provided *ad-libitum*. Where rams for fattening are from the farm flock, weaned lambs should be kept in groups and fed high quality chopped hay preferably legume hay. The feeding should be *ad-libitum* until the lamb weighs 20kg each; thereafter they should be transferred to the feedlot pen and fed as it is right above. Washing of feedlot ram with soap and grooming 4 days before sale make the rams attractive to buyers.

CHAPTER THIRTEEN
GOAT PRODUCTION

Nigerian breeds of goats include the West African Dwarf goat, Sokoto red and Kano brown.

West African Dwarf goat (WAD): It is widely distributed throughout the humid and subhumid zones of West and Central Africa. In Nigeria, it is found in the South and Plateau and Kaduna States of the North. It is of small body size with short legs and a mature liveweight of about 30kg. It is reputed to be trypanotolerant. A milk yield per lactation of 35kg with lactation length of 126 days and peak yield/day of 686g with birth weight of 1.4kg and age at first parturition of 507.7 days with parturition interval of 249 days and a weight of 5.8kg at 3 months has been observed. It has a preweaning growth rate of 64g/day for up to 12weeks of age.

Sokoto red goat: The Sokoto red goat is the predominant goat breed in Nigeria with good dairy potential. It is mainly found within the northern subhumid and semi-arid zones of the country. The coat colour is mainly red or reddish brown. It is of medium body size with long legs and has a mature liveweight of about 30 - 40kg. Milk yield/lactation of 60.4kg with lactation length of 92d ays and peak yield/day of 850g has been observed. Birth weight of 1.6kg at first parturition age of 425.5 days and parturition interval of 222 days with weight at 3months being 6kg has been observed. In general, Nigerian goats have higher litter size (1.4 - 1.6) than their Sheep counterpart (1.2- 1.3).

Table 13.1 Summary of the performance of Nigerian goat breed

Traits	West African Dwarf	Sokoto Red Goat
Milk yield/lactation(kg)	35	60.4
Lactation length (days)	126	92
Peak yield/day (g)	686	850
Birth weight (kg)	1.4	1.6
Age at first parturition (days)	507.7	425.5
Parturition interval (days)	249	222
Weight at 3months of age (kg)	5.8	6.0

Reasons for rearing goats in West Africa

1. For meat (food) production
2. For skin production
3. For milk production
4. Highly prolific; producing twins & triplets 2 times a year
5. Hardy animals which are exceptionally healthy
6. Easier to keep
7. High economic value/ feeding cost is low
8. For festivals and sacrificial offerings

9. For prestige purposes
10. For income
11. For employment
12. For educational purpose e.g. teaching and research

Advantages of extensive system for rearing goats

1. Low cost of labour
2. Low cost of feeding
3. Low capital investment e.g. housing
4. Ensures fair distribution of manure/ manure (waste) is used for fertilizer.

Disadvantages of extensive system of rearing goats

1. It is difficult to implement a planned breeding programme
2. There is little effort to control pests
3. Animals fall victim to thieves and predators
4. It is difficult to control disease outbreak
5. Lot of effort needed in controlling the animals as it destroys vegetation/ hasten soil erosion.
6. Productivity of animal is low i.e. low growth in meat and milk production.

Selection for milk production: Goat keepers in Nigeria give little or no consideration to the quality of animal used for breeding. In this way the unbeneficial faults of their goat as well as the good points are kept in the herd. Through careful selection of breeding animals the production potential of a herd can be greatly improved, if other factors such as nutrition, shelter and health are kept at optimum level. Breeding improvements can be done by careful selection of young does to replace the old ones and culling less productive doe. Select only does that are in good health, with large udders and strong legs. Use bucks that are healthy and are descendants of good milkers for breeding. Bucks not needed for breeding should be castrated or slaughtered.

Notable Points (traits) in selecting a doe

1. **The body:** The body should be of a medium to large size but not fat. Fat goats are usually not good dairy animals. A wide and deep rib cage is a good sign of a strong animal.
2. **The udder:** A good udder is most important. A large size usually means a large yield. The teats should also be large, and balanced in size/shape for easy milking. Avoid lumpy udder which are often a sign of disease. A large milk vein seen or felt as a ridge on the centre of the does belly towards the udder is a good sign of doe that could give a high milk yield.
3. **The legs:** Does legs need to be strong/straight, especially the hind legs. Animals with short legs may be difficult to milk. Hooves should not be deformed. Limping or lame animals should not be used for milking.
4. **The face/mouth:** Healthy animals usually have bright eyes and alert face. Teeth should not be loose or worn, which is a sign of old age. A young goat

will have few permanent teeth (up to six). Using their dentition, the age of the goat can be known (2 broad permanent teeth replacing the central incisors - 1 year; 4broad teeth - 2 to 2 ½ years; 6 broad teeth - 3 years; 8 broad teeth - 4 years, etc. Like most other ruminants goats do not have any upper incisor teeth.

5. **Health:** Selected goats should be free from catarrhal, diarrhea, skin diseases or ectoparasitic infection. It should have fine coat and not scruffy and rough coat.

Routine health care

1. Daily checking of all animals and administration of appropriate treatments.
2. Vaccination against *Peste de petits ruminants* (PPR) with tissue cultured rinderpest vaccine (TCRV).
3. Dipping or washing every three months (against lice, mange, etc) with Gamatox at the dilution rate of 1:500 for adults and 1:1000 for the kids (follow manufacturers recommendation). Care must be taken to make sure the animals do not swallow the dipping solution.
4. The young animals should be provided with clean dry beddings and source of warmth for the first 30 days at least. This is important especially during the cold or wet periods of the year. This measure will minimize the incidence of pneumonia among kids.

Systems of management

There are four major systems of goat production in the tropics - extensive, intensive and semi-intensive. In subsistence production a few goats are kept to meet domestic needs for meat and milk. These goats may range or be tethered. It is essentially a peasant enterprise.

Extensive systems are generally practiced in regions where the land is not immediately suitable for agricultural improvement and/or is too difficult or costly to fence. They can be used to assist in bush clearance as practiced in some part of Nigeria. Some form of housing is sometimes provided for the goats. A carrying capacity of about three to twelve goats per hectare is common.

Intensive production, usually used for dairy goat production involves continuous housing or 'zero-grazing' while semi-intensive production combines extensive and intensive management but usually involves controlled grazing of fenced pastures with some supplementary concentrate feeding. Intensive goat production on slatted floors more than doubles live weight per doe per year from 10.9kg to 24.2kg. Slats could be of split bamboo, whole bamboo or wooden. The wooden slats floor are the strongest and most durable, but very expensive. The split bamboo slat floor is the cheapest but holds a major risk of trapping kid's leg between its irregular openings, but can be reduced if well constructed. The whole bamboo type is in-between but more expensive than the split bamboo and it's less hazardous. Uncovered run should

be attached to kids' pens to ensure an adequate daily dose of sun-light to prevent rickets.

Due to the individualistic character of a goat (which is not a 'flock' animal) and the heterogenecity within a group of doe as far as aggressiveness and social ranking is concerned, pens of 2 x 5m should be constructed to house 6 does and a buck including water/feed trough. One buck should be allocated to 12 does, so the buck should be rotated daily between two pens of 2 x 5m each housing 6 does to ensure adequate breeding . In Indian it has been recommended that up to 10kids can be kept in loose stalls which measure 1.8 x 1.8m and 1.2m high, while buck stalls should be 2.4 x 1.8m. Goats can jump great heights, so fences should be at least 1.5m high, and should be made of strongly constructed wood or fine wire mesh because goats will try hard to get through any small opening.

Feeding: Goats are endowed with special feeding habits. Their prehensile tongues enable them to graze very short grasses and to browse on foliage not normally eaten by other ruminants. Goats have higher crude fibre digestibility and can utilize nutrients much better than many other ruminants. The crude protein content of tropical grasses is adequate for moderate levels of animal production for only a few months of the year when the grass is young. Protein supplementation of grass diets when crude protein of the grass is less than 7% will increase of feed intake and animal performance. Supplementation with the foliage of tree legumes has been shown to improve the growth rate of goats between the ages of 4 -10 months (Minson and Milford, 1967; Eys van *et al.,* 1986). Feeding is the most important factor affecting milk yield of goats. Allow dairy goats to graze in the morning and evenings between milking, and supplement with concentrate at the rate of 1% of body weight. Common salt should be added to the ration at the rate of 1% of the total feed to produce high milk yield. Dual-purpose (meat and milk) goats should be provided with limited grazing and guinea grass (*Panicum maximum*)*ad lib*, together with 0.45kg of concentrate mixture per head per day.

General Management

Reproduction: Sexual maturityin the goat is achieved at 4 - 6 months of age but mating should be delayed until the doe is 12 months old so that first kidding occurs at about 18months of age. The duration of oestrous cycle is 18-21 days and the duration of oestrus is about 24-36 hours (oestrus occurs every 18-21days, lasting 24-36 hours). Gestation length is about 146 days (145 - 148 days). Kidding interval is about 167- 206 days.

Ovulation occurs towards the end of oestrus, therefore mating is best arranged at that time i.e. about 12 hours after oestrus is first observed. As the time of mating can affect the number of kids born, double mating (the second service following 24 hours after the first) should be done. Twinning is common in goats and it increases with age.

Adult doe that is giving milk should be mated about 3 months after kidding so that it can have kids three times in two years. This is more productive (for meat and milk) than kidding only once each year. Healthy (but not fat) doe will become pregnant more easily. The dam's weight influences litter size and doe that are heaviest at kidding tend to produce large litters, the significance of proper nutrition during pregnancy being obvious.

Signs of heat: The signs of heat in a doe are

- Excited behavior by the doe.
- Frequent bleating.
- Frequent wagging of the tail.
- Doe will sometimes mount each other, but it is usually the doe being mounted that is on heat.
- Swelling or redness of the vulva.
- Mucous thread hanging from vulva.

Sign of Pregnancy: If a doe does not come into heat three weeks (oestrus interval) after mating, this is usually a sign that she is pregnant. Two or three months later the vulva will appear swollen and the belly will become larger.

Duration of pregnancy: The length of pregnancy will be just less than five months (between 145 to 150 days). It is good to keep breeding records indicating mating date so that date of birth can easily be predicted to enable proper preparation for kid arrival.

Drying off: Six to eight weeks before kidding, a milking doe should be "dried off" (should stop giving milk). The reason for this is that the unborn kid needs the food which usually goes into milk production. If milk production continues until the time of birth, the unborn kid might not grow properly. Naturally, most doe dry-off at the right time. With other high milk yielding doe, it should be encouraged to dry-off by gradually reducing the volume of milk collected by milking once daily instead of the normal twice daily milking and the udder should not be completely stripped. After a week or two, milking should be done once every two days and eventually stop milking altogether. If a doe continues to give milk despite less milking, it may be possible to dry-off the doe by reducing her feed.

Doe should be given more feed about 3-4 weeks before kidding to prepare it for the next milking season and to feed unborn kid. Plenty of water and mineral salts should be provided *ad libitum*. Pregnant doe should be allowed normal exercise and hooves should be trimmed to prevent lameness. Deworming could also be done at the time of drying-off.

Kidding and kid management: A few days before birth the following signs are likely to be observed-

The kid, because of its weight, moves downward, within the doe. Until now the doe has been developing a large round shape; this shape now seems to drop, leaving a

hollow on either side of the tail.

- The udder will become full of milk.

When these signs are observed the doe should be taken to the house or shelter prepared for kidding. On the day of kidding the following signs will be observed

- The vulva will become swollen and a small amount of clear fluid may come from it.
- The doe becomes restless, scrapping at its bedding with hooves, bleating incessantly, perhaps lie down and get up a number of times, and then starts straining.
- A balloon-like skin (water sac) appears at the vulva and naturally breaks resulting in a rush of fluid.
- The birth process has now started, and the front feet of the kid will appear at the vulva with the kid's head resting on them. The doe continues to strain and this pushes the kid out of the vulva.

Iodine or antibiotic powder should be applied to the navel cord to prevent infection. The kid should be encouraged to suckle within 2hours of birth for colostrums. If kid does not want to suck, milk should be directed from the teat into the kid's mouth by hand. This will teach the kid what to do. Kid and doe should stay together for at least four days. Weaning can be done at any time from birth to six months. Early weaning is done in dairy goats. Milk substitute should be provided when weaning is done before kid is 3months old. Female kid requires 1kg milk substitute while males requires about 1.5kg/day for adequate tropical growth. Male kids not required for breeding should be castrated early after birth. Kids can also be disbudded early and tagged for identification purposes.

Bottle feeding: Feeding kids from bottles though not necessary can be done to have much milk available for human use. Rubber teats from baby's bottles can be used by widening the holes in the teat. Kid should be provided solid feed alongside milk feed as from two weeks of age. A single kid will need a box of about 0.5metres square for protection from cold winds, rain, and direct hot sunshine especially in the first two months. Straws or leaves should be provided in the kid box to lie on.

Special attributes of goat's milk

- Tubercle bacilli are rare.
- Has high proportion of smaller fat globules which facilitate easy digestion.
- It possesses anti-allergic properties.
- Goat milk is recommended for ulcer patients.
- Its nutritive value does not differ appreciably from that of cow's milk.

Table 13.2 Average composition of goat's milk compared with cow milk

Parameters	Indian Cows	European Cows	Goats
Butter fat	4.8	3.7	4.9
Proteins	2.8	3.4	4.3

Parameters	Indian Cows	European Cows	Goats
Lactose	4.6	4.8	4.1
Minerals	0.74	0.74	0.89
Solid Non-fat	8.1	8.9	9.3
Total Solids	13.5	12.7	14.2

Factors affecting milk yield

1. **Breed of animal:** Some breeds have the potential to produce more milk than others. The Red Sokoto goat appears the most promising for development as a dairy breed and has been reported to produce a milk yield of 75kg per lactation of 100days, with a peak yield per day of 850ml.
2. **Body size:** Larger goats usually produce more milk than smaller goats, but they also eat more feed.
3. **Udder size:** Large udders mean a greater potential yield than smaller udders.
4. **Age:** Does give most milk between 4 - 8years of age after which yield gradually decrease.
5. **Feed:**This has the greatest influence on making actual yield reach the potential of an individual goat. Increasing feed will almost certainly increase milk yield.
6. **Stage of lactation:** Goats give the highest yields between the second and the tenth week after kidding. After which yield will gradually get less. The length of lactation largely depends on the amount of feed provided and the time of mating. If plenty of feed continues to be given to the doe, it will continue to give milk for up to about 10months, though the daily yield at the end of this time is likely to be small. If doe is mated, she will usually dry off during pregnancy. It is good practice to mate doe about 12weeks after kidding to produce three kidding in two years and have a greater total yield (per year) than one kidding every year.
7. **Health:** Healthy goats give more milk than sick goats.
8. **Stress:** Goat will produce less milk if the weather is very hot or very cold, or if they have to travel long distance to get feed and water. Also, like any other animals, goats are most productive when they are content. Goats like to be treated calmly; like the company of other goats; like space to move about; and they like something to do (something to chew at, something to rub against, etc). If all these are provided it will give high yield in return.
9. **Milking technique:** A regular milking time, cleanliness, fast but not rushed milking, stripping the udder will allow most milk from doe.

Milking of goat - It is desirable to have a goat milking parlor or a platform made of wood or iron (0.5 to 0.7m high, about 1m long and 0.5 to 0.6m wide with walk up

ramp). It must have a feeding box and a tethering post. Goat milk can easily absorb odours, therefore milking should be done outside the shed, preferably clean, ventilated environment. Milking should be done at regular times usually morning and evening. Changing milking time will reduce milk yield.

Prior to milking, the udder and teat should be washed with disinfectant solution and wiped dry with a piece of clean cloth. This is to prevent mastitis and contamination of milk with bacteria or feed. Doe should be milked from the side, not from behind to prevent contamination with dung or urine. It is good practice to discard the first few squirts of milk from each teat. This helps to reduce the bacterial content of milk.

The goat is then rapidly milked by hand as outlined below:

- The top of the teat is gripped between the thumb and forefinger.
- The second finger is then squeezed.
- The third finger is then squeezed.
- The little finger is then squeezed until the milk stops flowing.
- The hand is now relaxed to let the teat fill with milk.

Note that the teat is squeezed, not pulled, and that the whole hand is used, not just the fingertips.

If the doe is feeding a kid, some milk should be left for the kid in the udder after milking. One teat may be left while the other is milked. Udder should be stripped if doe is not feeding a kid. Stripping the udder is made easier by giving the udder a firm push with the palm of the hand. This action is similar to the kid pushing the udder and it encourages the doe to release the last drops of milk. Stripping is important for high milk yield. Milk should be weighed and recorded. The milk should be removed from the milking area to a separate room and filtered through a sieve into glass or plastic containers. The milk should be covered and refrigerated to reduce bacterial growth. The milking equipment should be of stainless steel or plastic and should be thoroughly washed and rinsed in hot water after milking. Goat milk can be used for making milk products such as cheese where the flavor is desirable.

Health Management

Diseases are conditions that impair normal functioning of the body. It is a generally limiting factor to a successful animal management after nutrition. Successful medication and vaccination is needful in intensive goat keeping. Foundation stock should be quarantined for twenty-eight (28) days immediately after purchase as outlined below:

Table 13.3 Reception schedule for quarantined goats

Period	Treatment
Day 0	Newly purchased goats tagged/ transferred to isolation unit.
Day 1	Prophylactic treatment with hyper-immune PPR antiserum.
	Prophylactic antibiotherapy for three (3) days.

Period	Treatment
Day 4	Broadspectrum anthelmintic (e.g. Panacur) and coccidiostat (e.g. Duocoxin® 30g/100L water during the first 7days).
Day 7	Washing with acaricide e.g. Gamatox, Asuntol, etc
Day 10	Tissue culture Rinderpest vaccine (TCRV) vaccination.
Day 28	Repeat acaricide and anthelmintic treatment.

Some common diseases associated with intensive goat production and treatment

Rickets: Rickets is a common disease with goats housed in completely roofed barn due to inadequate supply of sunlight for vitamin D production to alleviate the effects of the adverse dietary Calcium to Phosphorus ratio as goats are fed mainly on roughage (*Panicum maximum* and *Gliricidia sepium*) and concentrate supplements, especially during the dry season. This browse has a disproportionately wide Calcium-phosphorus ratio that could be as wide as 10 or 12:1. The liberal supply of vitamin D would be required for a proper utilization of dietary Calcium and phosphorus particularly when the ratio of the two elements is above the optimum 2:1. Since rickets is noted often in kids of 4 - 7 months of age, uncovered run should be attached to kid pens to ensure an adequate daily dose of sunlight or replacing some asbestos roofing material with transparent material through which sunlight could pass or supplementing with vitamin-mineral mix. Liberal absorption of ultraviolet rays helps in conversion of skin 7-dehydrocholesterol to vitamin D.

Respiratory problems: goats are known to be highly susceptible to respiratory problems which may be exacerbated under confinement, owing to cold air drafts and high population density.

Pestes des Petits Ruminants (PPR) or Kata is a viral disease of goats and sheep characterized by fever; nasal discharges (purulent, mucoid, muco-purulent, catarrhal) which may be profuse or slight; going off-feed; sneezing; coughing; noisy, labored breathing; rough hair-coat; general weakness; profuse, fetid diarrhea (PPR); grinding of teeth; erosive lesions on the mouth (PPR); recumbency; crusty exudates at the nostrils; rapid, gasping breathing with respiratory pneumonia and congested mucous membranes. Diagnosis is basically from the clinical signs although laboratory test is advisable to confirm the causative agents. Prophylactic treatment with Tissue Culture Rinderpest Vaccine (TCRV) should be done on yearly basis to all goats older than 3 months.Treatment mostly involves the use of systemic antibiotics like Oxytetracyclines, Streptopenicillin and Sulphonamides. Cases of anorexia can be treated with systemic vitamin B complex and rumen stimulants. Diarrhoea should be treated with antidiarrhoeals that contain antimotility/antispasmodic and absorbent agents. Very weak and recumbent animals should be placed on intravenous fluid therapy. In cases where helminthes are suspected to be the cause of pneumonia, the appropriate anthelmintic should be used. Cases should be isolated and treated.

Contagious pustulo dermatitis (Orf) or Contagious ecthyma (sore mouth) is contagious to man suggesting the use of rubber or plastic glove when treating lesions and handling vaccines. The virus is transmitted by contact and gain entry into the body via skin abrasions. It starts as a small pimples (vesicles) and later develops to a pus-filled blisters which eventually burst leaving a shallow ulcer mainly on the lips and sometimes on the udder and feet. Scabs form over the ulcers and wart-like growths may develop. Secondary bacterial infection can result into dermatitis, mastitis and lameness. Uncomplicated lesions heal within 3 weeks. Orf is usually diagnosed from the clinical signs. Treatment involves the use of systemic antibiotics to prevent or treat secondary bacterial infections. Lesions should be scrapped and 2% iodine solution applied. Orf has been observed in kids aged 1 to 2 months on the average, with a range of 2 weeks to 5 months in contrast to previous observations of mild cases in adult goats. Once cured an animal acquire a life-long immunity. A simple homemade vaccine prepared from a 10% emulsion of crusts from the lesions in glycerin-gentian violet and applied by scarification to the inner lateral side of the thigh substantially has been noted to reduce morbidity and severity in affected kids. The shelf-life of the vaccine stored at room temperature is unknown but daily swabbing of lesions with gentian violet led to rapid recovery.

Trypanosomiasis: Although goats and sheep often accompany nomadic cattle, and both sheep and goats are usually kept by rural dwellers in tsetse-infested areas, these small ruminants seldom suffer from trypanosomiasis. The reason for this appears to be due to the fact that sheep and goats are seldom fed upon by tsetse flies. Evidence suggests that those in tsetse-infested areas are trypanotolerant although trypanosomiasis has been observed in goats. The clinical signs of the disease caused by *Trypanosome brucei*, *T. congolense* and *T. vivax* in sheep and goat in both natural and experimental infections include anaemia, chronic wasting, testicular degeneration and death. Goats cross-bred with exotic breed are more susceptible to the effect of trypanosomiasis than indigenous goats. Thus, treatment with trypanocides such as diaminazine aceturate (Berenil) and homidium compounds (Novidium and Ethidium). Chemoprophylaxis with isometamidium may be attempted in improved breeds of goats that are under continuous trypanosomiasis risk. These measures are, however, inadequate without effective control of the vector (tsetse-flies).

Parasitic gastro enteritis and coccidiosis are reduced in goats kept on slatted floor. There are many anthelmintics that are safe for goats such as thiabendazole and levamisole. Routine deworming with two doses at 2 weeks apart could be done at periodic intervals to control stomach and intestinal worms in worm endemic area.

Infestation of coccidia is marked by lack of appetite (anorexia), chronic diarrhea (often bloody) and anaemia, all of which can make the animal lose weight, become

dehydrated and die. Secondary infections including pneumonia are common complications. Coccidiosis is usually limited to kids under 4 months of age although older animals that have not previously been exposed will display symptoms 2 to 4 weeks after exposure. All adults can carry and spread coccidia without showing any symptoms, hence young goats should be kept separate from older ones. Treat all adults to prevent them from shedding coccidia. Administer 110mg sulphadimethoxine per kg body weight the first day and 55mg per kg body weight on the second, third and fourth days. Sulphonamides and nitrofurazones are excellent coccidiostats to be best applied before stress factors are encountered; they retard the growth but do not kill the parasite. This allows the animal to develop its own resistance. These coccidiostats can be administered in the feed or water. It is unrealistic to try to eradicate all coccidia from goats kept in confinement.

CHAPTER FOURTEEN

FEEDING SYSTEMS

Feeding system is divided into ruminant and non-ruminant feeding system.

Non-ruminant feeding system

1. *Ad libitum* (continuous): It is allowing animals' free unrestricted access to feed/ water. It a method used in fattening animals or increase growth rate. It is used for all animals.
2. Restricted feeding: It is a feeding system where animal feeds are regulated. It is divided into two -
   a. Rationing - Is a system whereby the required amount of feed of an animal is calculated and that amount is given, not more or less.
   b. Skip-a-day method - It is usually used when raising growing pullet. It is not a popular method. Growing pullets (young female chicken between 8 to 20 weeks of age) are disallowed from reaching the mature weight at a faster rate to disallow small egg laying.
3. Controlled feeding: Is a system whereby animals are allowed to eat low quality feed as much as they can i.e. low quality feed *ad libitum*. It is commonly used for growing pullets.
4. Cafeteria or Selective feeding: It is a system whereby different types of feed ingredients are provided and the animal is allowed to choose the one it desires. It is used both for ruminant and non-ruminant. It is a popular system where birds are raised under semi-intensive system. It is also used in raising calf.
5. Forced feeding: It is used when animal is sick or under experiment. A special syringe can be used to force or pump feed into the animals' mouth. It is unpopular.

Ruminant feeding system-

1. Grazing system: It is a system whereby animals are left to feed on grass and /or legume forages. There are about five different grazing systems
   a. Uncontrolled grazing-In this system animals are left to graze freely, especially on paddocks.
   b. Controlled continuous grazing here animals are left on the field to graze freely on their choice grass and when the choice grass is consumed the animals are taken to other paddock.
   c. Deferred grazing - Is a method whereby paddocks are divided into 3 or 4 units and animals are allowed to graze in two, the remaining is left to seed for next planting season. After harvesting the seeds, animals are then left to graze in it.

d. Rotational deferred grazing-Here animals are allowed to graze for a third of the season in the entire paddock e.g. if the season is 9 months and there are 3 paddocks, animals are allowed 3 months in each paddocks.
e. Rotational grazing - Here paddocks are divided into many units and animals are left to graze in the different paddocks at a particular time. The time is not specific.

2. Zero grazing: It is a system whereby animals are fed grasses in confinement. It is normally used where animal is to be fattened. Other supplements are given in addition to the grasses to balance for nutrient requirement of the specie.
3. Flushing: It is a system used for breeding animals when they are close to mating time whereby they are given highly nutritive feed *ad libitum* at about 2 weeks to mating. Usually used for sheep and pigs. It is used for the female to condition them to produce more ova for fertilization so that animals have multiple births.
4. Fattening: Is a conscious or deliberate way of providing highly nutritive feed at greater quantity for animal to accelerate their growth rate than normal. It is usually used for sheep, goat, cattle, but more commonly for cattle.

Feeding of young animals

1. Suckling: Is a system of providing milk for the young by the mother during which the young is given access to the teat of the mammary gland or udder.
2. Fostering: Is a method of feeding the young when its mother is dead, sick or refused to feed its young. The young is bucket or nipple fed or introduced to another mother with young ones by a scientific method that will allow the foster mother to accept them.

FEED PREPARATION

Objectives of feed preparation

1. To get feed ingredients together in a balanced form whereby all required nutrients are made available in the required quantity e.g. mash (mixture).
2. To make food more digestible e.g. grinding of corn.
3. To make the food more palatable and acceptable e.g. cooking of swill or garbage (left-over food given to pigs) to make it palatable or adding of molasses to hay, etc.
4. To remove toxins or destroy harmful organisms in the feed e.g. by boiling cassava to reduce hydrocyanic acid (HCN) content, boiling /parboiling swill to remove harmful organisms.
5. To preserve feed from deterioration or damage so as to be able to keep the feed for a long time e.g. hay and silage.
6. To protect feed from wastage especially by wind e.g. pelleting.
7. To save storage space e.g. by bailing (compacted and tied together).

Factors determining feed preparation

1. The type of livestock: Preparation for ruminants feed is different from that of monogastric, that for young animals feed is different from that of adult.

2. The type of feedstuff: It may be concentrate or roughages, grains or grasses.

Methods of feed preparation

1. Mixing e.g. mashes (mixture) -it's a method of getting mixture.
2. Crushing/ grinding crushing means breaking into pieces while grinding is changing from coarse to fine texture (powder) e.g. grains, oyster shell, bones, cakes (Groundnut, cotton seed, soybean, palm kernel), etc.
3. Cooking or parboiling e.g. cassava, swill or garbage for pigs.
4. Roasting e.g. soybean
5. Pelleting, crumbling and waferization.
6. Soaking or wetting
7. Ensiling
8. Fermenting is a process through which brewers grains are made
9. Drying e.g. hay (hay is baled), straw (unbaled hay), blood meal, etc.
10. Chopping e.g. cutting hay to small pieces.
11. Blocking e.g. salt-lick
12. Artificial colostrums

Factors affecting feed utilization by animals

1. Availability of nutrients in the feed for absorption (lack of inhibitors).
2. Amounts of fibre in the feed especially for non-ruminant stocks.
3. Method of feed preparation e.g. grinding of maize for easy digestion/absorption.
4. Age of animals and types of feed: Young animals will cope with less fibrous feed than older ones.
5. Amount of nutrient in feed: The lesser the nutrient in feed the lesser the utilization. On the other hand surplus nutrient is wasted.
6. Health of livestock: Healthy animals utilize feeds better than sick ones.
7. Purpose of keeping the livestock: Beef cattle require feed for fattening while dairy animals utilize feed for milk production, apart from maintenance and pregnancy.
8. Moisture content of feed or amount of drinking water available: water is needed for digestibility.
9. Age and quality of feed: Contaminated feed is less utilized by animals. Some can even cause diarrhea and other stomach upsets.
10. The balance of nutrients in feed: Some nutrients assists in the utilization of others e.g. Calcium to Phosphorus ratio and Calorie to protein ratio.

Economics of Livestock feed

For economic feeding the following points should very important

1. Feed must be adequately prepared and must be provided in the right quantity to meet the need of the livestock.

2. Wastage must be avoided i.e. in terms of quality and quantity.
3. Feed must be balanced in nutrient for maximum utilization.
4. Feed must be well prepared against deterioration.
5. Adequate clean water must be provided.
6. Least cost rations make for economic feeding e.g. boiling of swill for pigs and the use of cheaper more available feedstuffs in ration formulation.
7. Animals must be well housed and kept healthy to utilize feed economically.

HAY PRODUCTION

Hay is an animal feed produced by dehydrating (drying) green forage to a moisture content of 15 - 23%.

Objectives of making hay

1. To preserve green forage at the time of plenty for the time of scarcity.
2. To preserve forage when it is about highest in nutrient content for animal feed.

Goals to have on mind when preparing hay

1. Reduce the moisture content of the green forage to such a level that will ensure effective storage without deterioration due to fermentation or mold growth.
2. To cut the green forage at such a time when the plant has the optimum nutrient and optimum yield e.g. a green plant has highest nutrient when young but does not have the optimum yield because of its small leaves, so should be left till about the flowering time.
3. To use forage or crops with thin rather than thick stem because thick stem takes longer time to dry e.g. maize plant is not suitable for hay unless at the young stage.
4. To dry the hay at such a time when weather is very suitable to prevent browning as it makes hay nutrients to be lost.
5. To preserve as much leaves as possible on the forage because leaves contain more nutrients than the stem, leaves constitute 50% of the whole plant and contain 70% plant protein and over 90% carotene. Usually during hay making at good weather about 35 - 40% leaves are lost due to drying and fall off the stem.

Properties of good hay

1. Thinness of stem and succulence of leaves rather than being woody and lignified.
2. Preservation of substantial amount of leaves on the hay.
3. Preservation of green colour as much as possible.
4. Freedom of hay from weed and poisonous plants.
5. Freedom from molds and dust.
6. Freedom from offensive odour but rather possession of a good aroma.
7. Having low moisture content for good preservation.

Common problems of hay making

1. Loss of leaves especially from leguminous hay due to shattering (falling off) and overdrying (making them to crumble when held).
2. Fermentation and overheating with possible combustion due to high moisture content of hay. During fermentation sugar and starch are converted to CO_2 and H_2O which are lost and so fermentation reduces energy of the hay and destroys carotene (vitamin A). The high moisture content in the hay causes mold and bacteria growth which also aid fermentation. Excessive heat is produced due to fermentation and this leads to nutrient loss especially denaturalization of protein. Browning also occurs as a result of high moisture content. Quick drying prevents fermentation.
3. Bleaching this leads to discolouration of hay. Sunlight destroys chlorophyll in the green plant and thereby change the colour, carotene is thereby destroyed which affect vitamin A availability.
4. Leaching of forage nutrients due to rain - hay is mostly prepared during the raining season and so heavy downpour leads to leaching.
5. Lignifications of forage due to age - when forage is producing seeds most of its nutrients are used for seed production and the plant stems become lignified and less nutritive.

Types of Hay

a. Legume hay- hay from pueraria, centrosema, stylosanthes, usually the richest in nutrient.
b. Non-legume hay - from grass e.g. elephant grass, higher in carbohydrate
c. Mixed hay - mixture of legume and non-legume

Hay making process

1. Select suitable plant/ plant material for hay and cultivate it (pasture production).
2. Cutting the forage at the proper stage of maturity, usually at the onset of flowering. It can be done manually or with mower.
3. Conditioning - this is not a popular method but it is sometimes use to break or crush plant stem using a machine called crumpers.
4. Curing (primarily drying) - the length of drying depends on weather condition and moisture content of forage. Proper drying can be ascertained by twisting a small amount of the hay on the hand, if the stem breaks with little or no juice then it is sufficient.
5. Raking, packing or baling - it can be done manually; for baling use hay bailing machine (hay baler). Baling entails packing, compressing and tying into bales.
6. Storing the hay - It can be stored as baled hay, loose hay or chopped hay.
   Hay can be artificially dried, mainly under commercial production and this has more nutrients than naturally dried ones. Hay can also be made into pellets.

SILAGE PRODUCTION

Silage is the products of fermentation of green forage which has been compressed and stored under anaerobic condition. Anaerobic bacteria produce acid from sugars present in the green forage during the process of fermentation and this acid preserve the stored forage i.e. the idea is to generate acid and prevent oxygen from the silage. The container where silage is preserved is called silo.

Requirement for making good silage

1. Suitable crop that is high in sugar, low in moisture content and protein: If protein is high, the action of anaerobic bacteria on protein produces ammonia which neutralizes some of the acidity of the silage thereby stimulating decomposition because the silage stays preserved at low pH.
2. Suitable Silo: The storage chamber must be air-tight. If it is a pit-silo, it must be located in an area where the water- table is low. It is good to have a covering (roof) over the silo to prevent rain water seeping into silage pit thereby neutralizing the acid.

Procedure for silage making

1. Plant the crop: Almost any types of forage crops are suitable for silage even some that is not suitable for hay e.g. maize. Crops that are high in moisture and protein are usually difficult to ensile. Maize and guinea corn are very suitable for silage making. When grasses and legumes are used for silage they are referred to as hay-crop silage, because they are most popular for making hay.
2. Prepare the silo for making silage: The types of silo available include
   a. Upright or Tower silo - They are usually cylindrical structures constructed with concrete, metal or wood. It can be a massive structure as high as 15m and as wide as 10m in diameter. An upright silo of very wide diameter is called tub-silo.
   b. Horizontal silo (Trench, pit or bunker silo) - Trench or pit-silo is a shallow horizontal pit where grass is preserved. Bunker silo is a concrete or plank walled pit.
   c. Clamp silo - This consists of a shallow trench with raised wall above the ground level. The wall can be raised with soil or plank.
   d. Temporary (or portable) silo - These are silo made with plastic sheet or silage bags. The plastic sheet is to prevent entrance of oxygen. The bag will accommodate about 50kg of silage as a small quantity.
   e. Stack silo - This is when grasses are placed on a concrete floor, compressed and covered up with polythene sheet.
3. Harvesting of the forage: This is done when the forage is not too young or too old. If it is done when too young it usually has high moisture content and protein and when too old it is lignified and unpalatable for animal. The crop will be suitable for silage when it has flowered.

4. Ensiling process: This involves -
   a. Chopping the long forages into short pieces so that it will be easy to compress.
   b. Packing and stacking the forage in the silo, this should be done rapidly to prevent deterioration, preferably within a day.
   c. Add additives to the stacked forage if necessary: The additives are usually added to improve preservation of the forage. Forages that are high in sugar, low in moisture content and protein usually demands no additives. Additives can be classified as follows-
      1. Those that supply readily fermentable carbohydrate e.g. molasses and sugar syrup.
      2. Mineral acids to keep the pH low and stable e.g. mixtures of Hcl and H_2SO_4.
      3. Organic acid e.g. lactic acid, which usually helps to achieve a low and stable pH.
      4. A culture of lactobacilli which helps to increase the rate of anaerobic fermentation to release lactic acid for silage preservation.
   d. Compress the stacked forage with a roller or drive tractor on it.
   e. Seal off the compressed forage with thick polythene or plastic sheets from atmosphere to prevent oxygen from entrying. For trench silos mark the area for easy identification.
   5. Leave the ensiled material until needed during the dry season.

The Ensiling Process within the Silo

1. Continued respiration of plant cells until trapped oxygen within the sealed silo is used up and CO_2 is generated and respiration ceases. Since there is no fresh oxygen supply into the silo, mold growth is inhibited.
2. Anaerobic fermentation begins:
   a. Bacteria on forage especially lactobacilli multiplies to effect fermentation. This anaerobic bacterium attacks the plant sugars in the fermentation process to produce the following organic acids - acetic, lactic, butyric and propionic acids. Acetic acid is first acid produced and it lowers the pH of the silo from 6 4.2, the production of this acid declines after the third day. Formation of lactic acid starts after the third day and continues for 2 weeks. It is the most important and most abundant acid formed in the silo. This acid brings the pH to 4 and stabilizes it at 4. Bacteria action and hence fermentation stops when pH reaches 4. Butyric acid is usually formed if there is excess moisture in the silage. It is not a desirable acid. Excess moisture stimulates clostridia (a species of anaerobic bacteria) to produce butyric acid which causes decomposition or rottening of the silage. Propionic acid is produced in very small quantity.
   b. Other fermentation products are formed e.g. ethanol and fermentation gases like CO_2, CO, CH_4, NO_2 and NO.

3. Silage temperature increases.
4. Normal fermentation process stops when pH is stable at low level (pH 4). Normally fermentation can last up to 21days. The silage remain preserved as lactic acid as entered into the plant juices and pH is stable at about 4, and oxygen is not allowed to enter the silage. Corn silage has been reported to keep for 12years and above.

Silage and Haylage: When silage have 50 -70% moisture content, it is called silage and when it has 40 - 50% moisture content it is called haylage (a dry silage).

Merits of silage over hay

1. It is not easily affected by weather (e.g. rain or heat) since it is closed up.
2. There is no risk of catching fire like in hay.
3. More forage crops can be ensiled than it is possible with hay.
4. Silage yields more nutrients than hay because it experiences minimum losses from shattering of leaves and bleaching. Silage preserves 85% of feed energy while hay at best condition preserves 80% and it can be as low as 50 - 60 %. It is a better source of protein and carotene than hay.
5. It requires less storage space than hay.
6. It is palatable and slightly laxative than hay.
7. Ensiling ensures better storage for a longer time.

Demerits of silage over hay

1. It usually requires a silo.
2. It contains less vitamin D than hay.
3. Additional expenses are often involved in buying additives.
4. It is more difficult to handle because it is wet.
5. Exposure of silo during feeding predisposes it to deterioration.
6. Poorly fermented silage usually gives a foul odour and may be rejected by animals, making the whole effort of ensiling to constitute a waste.
7. It is more difficult to transport silage from one farm to another due to its heavy weight resulting from the moisture content.
8. Unconsumed silage (left-over) easily gets spoilt.
9. Animals need to consume more silage to derive the same dry matter and energy than hay.

CHAPTER FIFTEEN
AGRICULTURAL MARKETING

Agricultural marketing covers the services involved in moving an agricultural product from the farm to the consumer. Numerous interconnected activities are involved in doing this, such as planning production, growing and harvesting, grading, packing, transport, storage, agro- and food processing, distribution, advertising and sale. Some definitions would even include "the acts of buying supplies, renting equipment, (and) paying labor", arguing that marketing is everything a business does. Such activities cannot take place without the exchange of information and are often heavily dependent on the availability of suitable finance.

Marketing is one of the four activities of management (production, finance, marketing and personnel). It is a key element in the success of any enterprise, whether selling physical products or rendering services such as consultancy, television/ radio stations, etc. It is no use producing what cannot be sold and there is no point selling if profit is not accruing. Before the production of goods, there is need to first discover the needs of the people and the price they will pay for the need to be met. When there is a profit margin per unit i.e cost of producing less than the cost of sale, the more sale the larger the gross profit. If the farm is able to manage its selling and minimize cost, net income will be larger.

PRICE = COST + PROFIT;

PROFIT = PRICE - COST

One of many problems faced in agricultural marketing in developing countries is the latent hostility to the private sector and the lack of understanding of the role of the intermediary. For this reason "middleman" has become very much a pejorative word. Promoting market orientation in agricultural advisory services aims to provide for the sustainable enhancement of the capabilities of the rural poor to enable them to benefit from agricultural markets and help them to adapt to factors which impact upon these. Marketing ensures the deposition of product in place, time and form of utility. It involves the delivery of goods in exchange for some medium of payment. In marketing there is determination of objectives and policies, analysis of selling functions and use of market research. There is need to develop effective sales procedure and force, estimates sales organizational structure or motivation of sales personnel, use of adequate sales promotion (television, radio, sponsoring conferences/ beauty pageants, customized T- shirts, key-holders, calendars, bill-board and effective use of advertising). If any business carries out mass production of goods, it must develop sufficient out-let for the goods. This may stretch the company to international level through participation in trade fairs, leading to the development of a multinational company.

Marketing stimulates demand by making people want the product. There is a difference between marketing and sale. Marketing is intellectual and goes before and beyond, including sales while sales is the physical exchange of goods for money. Marketing generate interest and awareness for product. Marketing looks everywhere for potential customers, knows the tastes/ preferences of consumers. Marketing also ensures that prices are moderate so that buyers are willing to part with their money. If a product as failed, marketing can be used to revive it e.g. trade name and taste of the product can be changed to attract new market as was the case when Top bear failed and it was changed to Baron with a different tastes, or a different brands of biscuit being produced from the same company. Marketing breaks new ground by discovering new users through demonstrations and free gifts of samples for trials like the "buy two and have one free" adverts. All such efforts are geared towards capturing buyers. The risks involved in business are critically tilted towards marketing. The loss in value of product due to shrinkage, spoilage, drop in prices, obsolescence, etc indicates the risks that can be avoided if sales takes place punctually and some of these risks can be passed on to the wholesalers, retailers and at times speculators who buy for the future. There is need to set the marketing objectives clearly.

Marketing is the way by which consumers' needs are discovered, developing products to satisfy the needs, putting the appropriate price for this product, communicating the product and price to consumers and delivering these goods and services to the consumers at the place and time they are required. This gives rise to the 4Ps of marketing Price, Product, Promotion and place. Marketing is getting the right goods/ services to the right people at the right place and at the right time at the right price and then at the right communication and promotion. It is the performance of business activities that directs the flow of goods/ services from producers to consumers. It is human activities that is directed at satisfying needs and wants through exchange processes.

Marketing evolution or philosophies

The stages or steps in the evolution of marketing are listed below

1. Production concept (the concept put more emphasis on quantity)
2. Product concept (put quality into consideration)
3. Selling concept (put goods/ services or ideas into consideration)
4. Marketing concept
5. Societal concept (put the general welfare into consideration)

1. Production concept: Production concept is a management orientation that assumes that consumers will favour those products that are **available and affordable** and therefore the major task of management is to pursue improved production and distribution efficiency.

2. Product concept: Product concept is a management orientation that assumes that consumers will favour those products that offer the most **quality for the price** and therefore the organization should devote his energy to improving product quality.
3. Selling concept: Selling concept is a management orientation that assumes that consumers will either not buy or not buy enough of the organizations product unless the organization makes substantial effort to **stimulate their interest** in his products.
4. Marketing concept: Marketing concept is a management orientation that holds that the key to achieve organizational goals consists of the organizations **determining the needs and wants of target market** and adapting itself to delivering the desired satisfaction more effectively and efficiently **than its competitors**.
5. Societal concept: Societal concept is a management orientation that holds that the key task of the organization is to determine the needs, wants and interest of target market and to adapt the organization to delivering the desired satisfaction more efficiently and effectively than its competitors in a way that will serves and enhances the consumers and societal wellbeing.

The marketing concept and marketing systems

Marketing is not simply an extension of the production process but its only purpose as Adam Smith emphasized when, in his text *The Wealth of Nations* (1776), he said that "Consumption is the sole end purpose of all production; and the interest of the producer ought to be attended to only so far as it may be necessary for promoting that of the consumer."

Dixie (1989) relates what he describes as a definition of marketing as "the series of services involved in moving a product (or commodity) from the point of production to the point of consumption."

This is a definition which many organizations, and governments, would recognize as describing their own activities in commodity marketing. Indeed in many developing countries it aptly describes, or in some cases, did in the past describe, the functions carried out by marketing parastatals with respect to staple foods. However, as Dixie himself points out, the definition omits two key elements of any definition of marketing production to effuse the marketing concept, i.e. a customer orientation and inbuilt sustainability. Gaedeke and Tootelian (1983) offer an alternative definition which overcomes the problems caused by these two omissions:

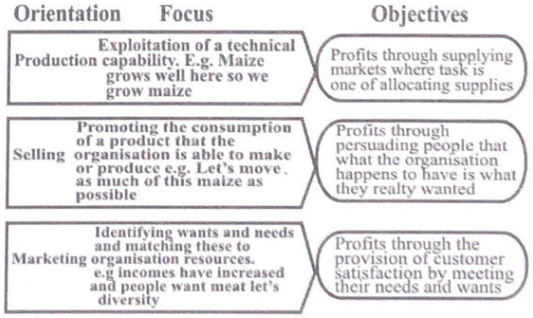
"Marketing is a management orientation focusing all the activities of the organization on satisfying customer needs and wants, thereby helping achieve the organization's long-range objectives."

This definition promotes a customer orientation and since the organization's long-term objectives will include its own continued existence it takes account of the need

for sustainability. Moreover, this definition of the marketing concept does not preclude non-profit making organizations. Marketing is just as relevant to development projects, aid agencies, extension service organizations, and the like, as it is to commercial enterprises. Thus the marketing concept is that an organization achieves its goals through the provision of customer satisfaction. Put another way, marketing is the integrative force that matches production to customer needs and satisfaction. Marketing is not an activity to which an organization turns its attention at the end of the production phase of operations. Rather marketing needs to be directing production in accordance with clear signals from the marketplace as what is needed by customers.

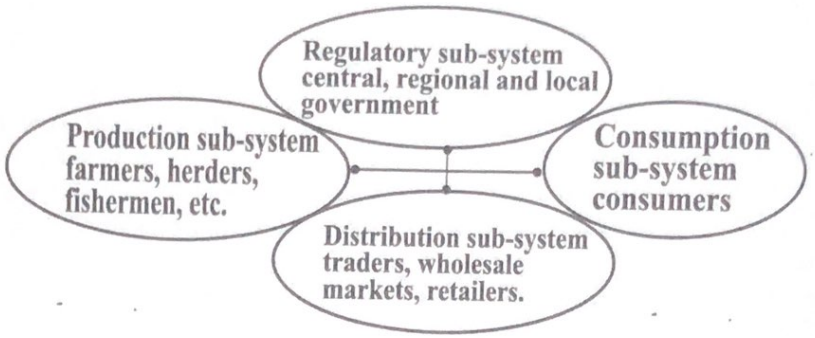
The marketing concept must be adopted throughout not only the entire organization, but the entire marketing system. A system is a complex of interrelated component parts or sub-systems which have a defined common goal. Thus, an agricultural and food marketing system comprises all of the functions, and agencies who perform those activities, that are necessary in order to profitably exploit opportunities in the marketplace. Each of the components, or sub-systems, is independent of one another but a change in any one of them impacts on the others as well as upon the system as a whole.

There is a danger that the marketing concept will be adopted by some parts of the system but not others. Thus, for example, a food manufacturer may be trying hard to implement the marketing concept and offer products that meet the precise needs of a target market. If, however, the manufacturer has to rely upon a farming community that is still very much production oriented, for raw material supplies, then the overall marketing objectives may be frustrated. In the same way, if only some functions are performed according to the marketing concept then the system as a whole may not achieve a market orientation. For instance, the marketing department may set out to serve the market for a high quality fruits and vegetables, for which it can obtain premium prices, but if transportation is performed using the same open-topped bulk carrying wagons used to ship grain and other aggregates then it is unlikely that the enterprise will deliver the product in the right condition for the target market.



If the decision has been made to adopt the marketing concept, then consideration has to be given to the implications for each of the participants and the functions performed within the marketing system. Where one or more elements of the system are found to be other than market orientated, then either a change towards the marketing philosophy has to be introduced in those elements or a change in the configuration of the marketing system has to be implemented.

Rosson (1974) conceives of agricultural and food marketing systems as consisting of 4 main sub-systems - production, distribution, consumption and regulatory.



The key players in the chain of activities that connect food and agriculture are the farmer (or other 'producers' such as fishermen), intermediaries, the food processors, and the consumer. In practice they each see the agricultural/food marketing system from a perspective of self-interest and these interests are sometimes in conflict.The farmer's interest is focused on getting the best return from his produce, which usually equates to maximum price for unlimited quantities. Manufacturers want least cost, best quality produce from the farmer so that he can sell it at competitive, but profitable, prices. Traders and retailers want high quality and reliable supplies from the manufacturer or farmer, at the most competitive prices. Consumers are interested in obtaining high quality products at low prices. Clearly, there are conflicting interests here.

Case Study: Venezuela Is Overrun By Elephants!

It is said that when a senior member of his court seriously displeased him, the King of Siam would make that individual a gift of a white elephant. The white elephant is both rare and, in Siam, was considered sacred. Siam tradition did not permit white elephants to be worked and so the hapless owner could make no economic gain from ownership of this sacred animal. In fact, ownership of a white elephant usually led to financial ruin since the owner had to feed the sacred animal on a special diet and elephants tend to have rather a large appetite.

In the 1970s Venezuela invested US$20 million in 6 cassava processing plants with a view to dehydrating cassava, already grown locally, and using it as an ingredient in animal feed. The intention was to substitute the local product for 21,600 tonnes of imported cereals (chiefly maize and sorghum) and create over 600 jobs. Moreover, cassava could bring marginal lands into production as this crop can flourish on soils that are too poor

for sorghum or maize. All 6 cassava processing plants became 'white elephants'.

Government was pursuing an incongruous pricing policy. Manufacturers were being supplied with government subsidized imported feed grains, in order to keep retail meat prices down grains, in order to keep retail meat prices down. Local farmers could not compete since imported sorghum was delivered to the feed mills at US$142 per tonne while domestic supplies were US$151 per tonne. The situation got worse when the government announced a 30 percent increase in farmer prices.

Venezuelan feed manufacturers could obtain cassava pellets from Thailand at a lower cost than they could from local mills. Moreover, feed manufacturers who could buy sorghum at US$150 per tonne were not inclined to purchase locally produced cassava pellets at US$250 per tonne.

From the outset it was evident that the investment in cassava processing would be marginal in economic terms. The feasibility study suggested that after the tenth year the rate of return would reach 11 percent and the internal rate of return would be only 7 percent. However, Venezuela had become an oil-rich country and capital was not in short supply. This perhaps explains why it was decided that the most technologically advanced equipment, from leading manufacturers, would be bought for the processing plants and that fuel oil would be used for drying rather than sun drying as in the most of the world.

Inadequate attention had been paid to the questions of raw material supply. In a 213 page report only 1 page touched on this issue. After all, Venezuelan farmers had a long history of growing cassava. However, there was no appreciable increase in the hectarage of cassava and farmers who could sell cassava for human consumption at US$75 per tonne refused the best offer that the cassava processing mills could make of US$45 per tonne.

Venezuela's cassava processing plants failed and became 'white elephants'. The planners of the project took little account of the marketing concept nor the nature of the marketing system. The needs of both the raw material suppliers, the farmers, and the feed manufacturers ought to have been carefully studied before the project was designed. There was no attempt to market the project to the farmers who continued to demand the same price for cassava destined for animal feed as they obtained for cassava processed for human consumption, even though the economics of the two sectors are quite different. No programme was instituted to promote the idea of planting additional areas of cassava. The economics of feed manufacturing were similarly ignored and so the cassava processors had difficulty in selling their pellets. Perhaps with a more appropriate level of technology the costs of producing cassava pellets could have been reduced to a point where they could compete with imported cassava pellets, sorghum and maize[5].

Note: Elephants are not indigenous to Venezuela. The 'white elephant' is however found in virtually all countries of the world.

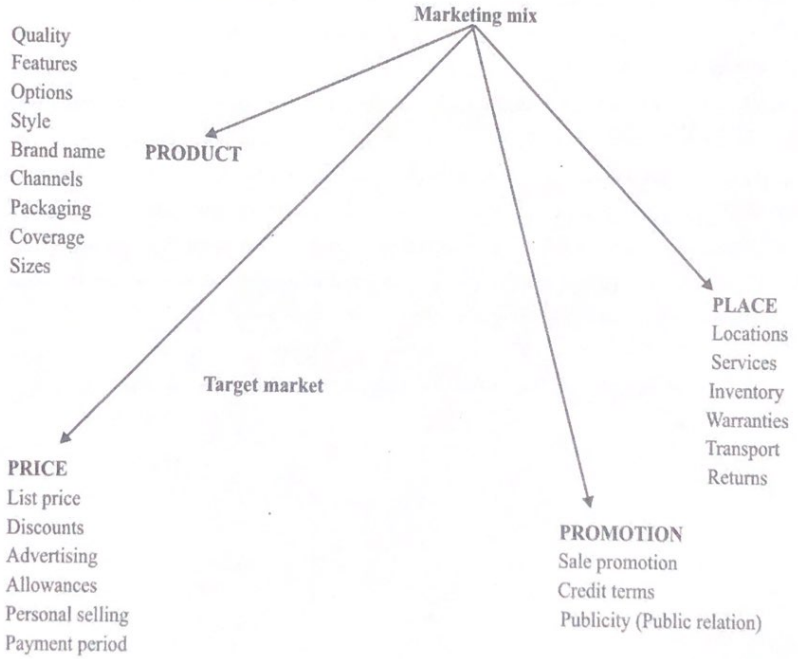
In an ideal world there should be some form of strategic partnership between these key players. It is obvious that, in the long run, any one of the four groups would find it difficult to survive if the others do not. However, in real life, attitudes are not those of the ideal world or of the longer term. It is focused more on the shorter term and in preserving the interests of each group. Only by allowing each group to take care of its interests, can a balanced longer term relationship evolve. This must be borne in mind when considering what the food industry expects from agriculture. Moreover, those expectations will vary according to the level of sophistication of the markets the food industry itself is attempting to serve.

The Marketing mix

The marketing mix is the particular blend of the controllable marketing variables that the firm uses to achieve its objectives in the target market. The controllable marketing variables are the 4Ps of marketing according to McCarthy-

1. **Product**
2. **Price**
3. **Place (distribution)**
4. **Promotion**

These variables have other variables within them. They can be manipulated to achieve objectives. They can be manipulated to increase demand for goods. Marketing mix is that set of marketing tools that the firm uses to pursue its marketing objectives in the target market.



Warranties - a kind of guarantee, a liberal way of doing things. A kind of authority that if a particular thing happens this thing will be given.

Penetration strategy - is a way of cutting down price to encourage people to buy.

Skimming strategy - is a way of raising price high to entice buyers to see some specialities in it e.g. some buy goods because of its high price.

Advertising - is a non-personal means of communication with an identified sponsor and it is paid for i.e. it is not directed to one particular person e.g. Pepsi was advertised for the parent company by sponsoring league matches. Advertisement is done in a way to capture as many audiences as possible.

Sales promotion - cutting down prices to make people buy more e.g. Trade fair, bringing musician to a hotel conference hall to sponsor a beer.

Personal selling - this is one in which people carries the message from one place to another like in preaching in a bus.

Publicity - this is not paid for but it is a normal way used by government to secure favourable mention of some goods.

Marketing functions

A little earlier it was said that a marketing system has two distinct dimensions. One of those dimensions is the institutions, organizations and enterprises which participate in a market and the second is the functions that those participants perform. Kohls and Uhl (1990) have classified the functions involved in agricultural and food marketing processes as under three sets of functions of a marketing system

A. Exchange Functions	1. Buying
	2. Selling
B. Physical Functions	3. Storage
	4. Transportation
	5. Processing
C. Facilitating Functions	6. Standardisation
	7. Financing
	8. Risk Bearing
	9. Market Intelligence

Each of these functions adds value to the product and they require inputs, so they incur costs. As long as the value added to the product is positive, most firms or entrepreneurs will find it profitable to compete to supply the service.

Exchange functions

Buying: The marketing concept holds that the needs of the customer are of paramount importance. A producer can be said to have adopted a market orientation when production is purposely planned to meet specific demands or market opportunities. Thus a contract farmer who wishes to meet the needs of a food processor manufacturing sorghum-based malted drinks will only purchase improved sorghum seed. He/she will avoid any inputs likely to adversely affect the storage

and/or processing properties of the sorghum and will continually seek new and better inputs which will add further value to his/her product in the eyes of the customer. In making his/her buying decisions his underlying consideration will be the effect upon the attractiveness of his/her output to the markets he/she is seeking to serve.

The buyer's motive is the opportunity to maintain or even increase profits and not necessarily to provide, for example, the best quality. Improving quality inevitably increases the associated costs. In some cases the market is insensitive to improvements in quality, beyond some threshold level, does not earn a premium price. Under such circumstances, the grower who perseveres and produces a 'better product', is not market oriented since he/she is ignoring the real needs of the consumer. The most successful agribusiness is the one which yields the largest difference between prices obtained and costs incurred.

Selling: Of the nine functions listed, this is probably the one which people find least difficulty in associating with marketing. Indeed to many the terms marketing and selling are synonymous.A **market** is a set of all actual and potential buyers of a product. Kotler (1988) suggests that:

"Most firms practice the selling concept when they have over capacity. Their immediate aim is to sell what they can make rather than to make what they can sell."

There is no denying that 'high pressure selling' is practiced, where the interests of the consumer are far from foremost in the mind of the seller. This is not marketing. Enterprises adopt the marketing philosophy as a result of becoming aware that their own long term objectives can only be realized by consistently providing customer satisfaction. Whereas selling might create a consumer, marketing is about creating customers. The difference is that marketing is about establishing and maintaining long term relationships with customers.Selling is part of marketing in the same way that promotion, advertising and merchandising are components, or sub-components of the marketing mix. These all directed towards persuasion and are collectively known as marketing communications; one of the four elements of the marketing mix.

Physical functions

Storage: An inherent characteristic of agricultural production is that it is seasonal whilst demand is generally continuous throughout the year. Modern technology and husbandry practices mean that food manufacturers need not have their production schedules dictated by the seasons.Hence the need for storage to allow a smooth, and as far as possible, uninterrupted flow of product into the market. Because he is dealing with a biological product the grower does not enjoy the same flexibility as his manufacturing counterpart in being able to adjust the timing of supply to match demand. It would be an exaggeration to suggest that a manufacturer can turn production on and off to meet demand - they too have their constraints- but they have more alternatives than does the agricultural producer. A manufacturer can, for example, work overtime, sub-contract work, and over a longer time horizon, the

manufacturer can increase or decrease productive capacity to match the strength of demand.

In agriculture, and especially in less developed countries (LDCs), supply often exceeds demand in the immediate post-harvest period. The glut reduces producer prices and wastage rates can be extremely high. For much of the reminder of the period before the next harvest, the product can be in short supply with traders and consumers having to pay premium prices to secure whatever scarce supplies are to be had. The storage function is one of balancing supply and demand.Both growers and consumers gain from a marketing system that can make produce available when it is needed. A farmer, merchant, co-operative, marketing board or retailer who stores a product provides a service. That service costs money and there are risks in the form of wastage and slumps in market demand, prices, so the provider of storage is entitled to a reward in the form of profit.

Transportation: The transport function is chiefly one of making the product available where it is needed, without adding unreasonably to the overall cost of the produce. Adequate performance of this function requires consideration of alternative routes and types of transportation, with a view to achieving timeliness, maintaining produce quality and minimizing shipping costs.Effective transport management is critical to efficient marketing. Whether operating a single vehicle or a fleet of vehicles, transportation has to be carefully managed, including cost monitoring - operations on different road types, fuel and lubrication consumption and scheduled and remedial maintenance and repair. Skillful management of all aspects of vehicle operations can also make a substantial contribution to efficient marketing especially with respect to optimum routing, scheduling and loading and off-loading; maximization of shift hours available, maintaining the vehicle fleet at an optimum size, taking account of time constraints on delivery, and collection times and judicious management of vehicle replacement and depreciation. Transport managers also have to weigh the advantages and disadvantages of owning, hiring or leasing transport.A manufacturer who has invested heavily in building up his brand will be very keen to get reliable supplies in terms of quality, timing and cost. Producers of agricultural produce will be increasingly judged on their reliability in all of these respects.

Processing: Most agricultural produce is not in a form suitable for direct delivery to the consumer when it is first harvested. Rather it needs to be changed in some way before it can be used. Kohls and Uhl (1990) observe that "the processing function is sometimes not included in a list of marketing functions because it is essentially a form changing activity."However, it is for this very reason that processing ought to be included as a marketing function. The form changing activity is one of that adds value to the product. Changing green coffee beans into roasted beans, cassava into gari or livestock feed, full fruit bunches into palm oil or sugarcane into gur increases

The value of the product because the converted product has greater utility to the buyer. How the form of produce is to be changed and the methods to be used in bringing about such changes are marketing decisions. For example, some years ago when Ethiopia was looking to expand its tea business, a prototype manufacturing plant was established. The plant was capable of curing the tea and packing it in individual tea bags. At that point, tests were undertaken in which the product was compared with others already on the market. The results were encouraging. However, in the course of the marketing research, it was also discovered that ninety percent of the black tea consumed is blended and not the pure variety placed in tea bags by the Ethiopians. By going past the point of changing green leaf into high quality black tea, the Ethiopians were entering a nice market which is not what they intended at all. Timely marketing research would have directed Ethiopia to stop the form changing activity short of bagging since, at that time; Ethiopia did not have the acreage of tea, nor the resources, to develop a tea blending facility of its own. In the same way, a producer of fresh fruits may have pulping and/or canning facilities but if potential buyers want the flexibility of using the fruits in a variety of ways, then these stages of processing serve to reduce utility and value, rather than increasing them.

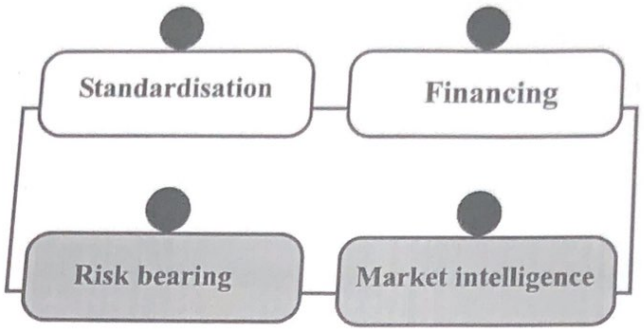
Ease of processing will become an increasingly important expectation of the food industry. Like all industries, reductions in the costs of capital equipment, wages and inventories are important objectives. For example, farmers who can deliver on the 'just-in-time' principle will contribute towards reducing a manufacturer's working capital and space requirements. Farmers who can do part of the secondary processing and/or performing functions such as the post harvest treatment of the crop or transporting will be adding another advantage. Crops that are specially bred or designed to facilitate processing (e.g. seedless fruits, featherless chickens, coffee beans without caffeine, low cholesterol meats) are another type of advantage that the food industry could expect from agriculture. In short, the competitive advantage will rest with those able to add most value and can differentiate what they are offering from that of other suppliers.

Of course, processing is not the only way of adding value to a product. Storing products until such times as they are needed add utility and therefore add value. Similarly, transporting commodities to purchasing points convenient to the consumer adds value. In short, any action which increases the utility of the good or service to prospective buyers also adds value to that product or service.

Facilitating functions

The facilitating functions include product standardization, financing, risk bearing and market intelligence. Facilitating functions are those activities which enable the exchange process to take place. Marketing, in simple terms, is the act of supplying products to someone in exchange for something perceived to be of equal or greater value, (usually, but not always, a given sum of money). Facilitating functions are not a direct part of either the exchange of title or the physical movement of produce.

The facilitating functions is shown in the figure below



Standardization: Standardization is concerned with the establishment and maintenance of uniform measurements of produce quality and/or quantity. This function simplifies buying and selling as well as reducing marketing costs by enabling buyers to specify precisely what they want and suppliers to communicate what they are able and willing to supply with respect to both quantity and quality of product. In the absence of standard weights and measures trade either becomes more expensive to conduct or impossible altogether. Among the most notable advantages of uniform standards, are:

- price quotations are more meaningful
- the sale of commodities by sample or description becomes possible
- small lots of commodities, produced by a large number of small producers, can be assembled into economic loads if these supplies are similar in grade or quality
- faced with a range of graded produce the buyer is able to choose the quality of Product he/she is able and willing to purchase.

A quality difference in agricultural products arises for several reasons. Quality differences may be due to production methods and/or because of the quality of inputs used. Technological innovation can also give rise to quality differences. In addition, a buyer's assessment of a product's quality is often an expression of personal preference. Thus, for example, in some markets a small banana is judged to be in some sense 'better' than a large banana; white sugar is considered 'superior' to yellow sugar; and white maize is 'easier to digest' than yellow maize. It matters not whether the criteria used in making such assessments are objective or subjective since they have the same effect in the marketplace. What does matter in marketing is to understand how the buyer assesses 'quality'.To build a profitable business, food manufacturers seek to establish a preference for their products by differentiating those products in some way which is meaningful to consumers.

Then, in order to enable consumers to recognize the differentiated product, manufacturers brand that product. Manufacturers can then work on building consumer loyalty to these brands. Brand loyalty is normally only established by delivering high quality consistently. As disposable incomes rise, the market tends to develop more sophisticated needs and the quality of the raw material becomes even more critical. Where agriculture is seeking to serve a food industry, that itself is seeking to meet these more sophisticated needs and wants, it can expect to face increasing emphasis on quality. Equally well, agriculture can expect to share in the better return for innovative improvements in quality.

Product differentiation: In competitive brand marketing, the food industry has to innovate continuously to create new products that are different from and superior to existing ones of their own or competitors. The scope of innovation has traditionally been at the processing stage. Whilst this will continue to be an important area for innovation, manufacturers will increasingly tend to look for innovative changes in the agricultural produce itself. This may be in terms of novel tastes, improved texture, more attractive shapes, etc.

Health aspects: We have already said that in the more sophisticated food markets, healthy eating can become a priority among consumers. Therefore, farmers will have to consider the health connotations of what they choose to grow. There are two aspects of health to be taken into account. First, consumers may be interested in the food itself i.e. low fat, low/no sugar or low/no salt. It would be a mistake to think that health issues are confined to the more sophisticated food markets or to the wealthier segments of the community. Nutrition is important in all segments of the market. Even where the poor receive adequate amounts of food to fend off starvation, they are often malnourished. Thus farmers have to be concerned about the nutritional value of the produce they grow. Second, the consumer may be more, or equally, concerned about the food production methods i.e. the avoidance of chemicals like herbicides, pesticides etc. This may mean a change to the farmer's husbandry practices with implications for the costs of production. The consumer and the food industry will expect the farmer to produce without potentially dangerous chemicals, but at no extra cost to them. This will be another challenge for agriculture.

Financing: In almost any production system there are inevitable lags between investing in the necessary raw materials (e.g. machinery, seeds, fertilizers, packaging, flavourings, stocks etc.) and receiving the payment for the sale of produce. During these lag periods some individual or institution must finance the investment. The question of where the funding of the investment is to come from, at all points between production and consumption, is one that marketing must address. Consider the problem of a food manufacturer who wishes to launch a range of chilled products in a developing country where few retail outlets have the necessary refrigeration equipment. This is a marketing problem.

It might be solved by the food manufacturer buying refrigerators and leading these to retailers (or evolving a hire-purchase arrangement with retailers).

A common marketing problem, in developing countries, is the low level of incomes leading to low levels of effective demand for many products. The challenge to marketing is to somehow channel what income is available into effective demand. In the case of agricultural equipment marketing this might involve offering hire-purchase schemes where the prospective buyer makes payment in regular installments. During this time he/she is deemed to have hired the machine. If payments are not forthcoming, the machine can be recovered since its ownership remains with the seller up until the final payment is made, at which point the farmer is considered to have purchased the machine. Alternatively, the seller might set up leasing, rather than purchasing schemes where again the farmer is making regular payments but never takes title to the machine. Where a food item is being marketed, to a low income market, the seller can consider reducing the unit price of the product by making the pack or lot size smaller. Another tactic is to make the product more affordable by using cheaper ingredients and/or packaging. Instant coffee can be sold at lower prices by substituting some of the coffee with chicory; the price of meat products is reduced by increasing the percentage of cereals in these products and including less meat and/or making use of less expensive parts of the animal such as entrails, offal, feet and head.

Marketing is also concerned with the financing of the enterprise itself. Here again some creative solutions can be developed. Where internal financing is insufficient for the purposes in view, an enterprise in a developing country can look to several alternatives including:

- development banks
- commercial banks
- shares issues
- credit co-operatives and/or credit unions

Where these sources of finance are considered inappropriate, or are simply not available to a particular enterprise, a strategic alliance in the form of a joint venture could be the answer. These are partnerships formed to exploit market opportunities more effectively and/or efficiently than either party can on its own. An enterprise, in a developing country, may engage in a joint venture with either an indigenous partner and/or with a foreign partner. The agreement between parties to a joint venture normally specifies their respective contributions of resources, share of management control, profit and risk.Whatever the source of finance under consideration marketing has a role to play in evaluating the appropriateness of that source as well as identifying it in the first place. A common requirement is that marketing proposals include a forecast of the payback period. Those responsible for developing these proposals are best placed to evaluate the compatibility between the market opportunity under consideration and the alternative modes of financing it.

of specific interest is the prospect of the investment payback period matching the repayment schedule. Enterprises which finance long term investments through short term sources of finance are either badly misinformed or have adopted a high risk strategy.

Case study: Massey-Ferguson Buys Its Own Tractors

Agricultural equipment manufacturers periodically undertake major revisions of their product lines. This is a very expensive process since the manufacturing plant required to produce agricultural tractors, combine harvesters, seed drills, straw balers and the like costs million of dollars. When the equipment manufacturer Massey Ferguson (MF) came to develop a completely new line of tractors, in the early 1980s, it sold its existing line of tractors to the state owned Polish tractor manufacturer Ursus in order to offset at least part of the cost of the new investment. The arrangement was rather novel for the industry at that time. Ursus was in such poor financial condition that it could not finance the purchase of the Massey Ferguson manufacturing plant and patents, so MF supplied the plant to Ursus and were to buy-back a proportion of the tractors which Ursus manufactured. They would continue to market these under the MF brand name whilst the remainder would be sold under the Polish manufacturer's name. Massey Ferguson planned to supply the older designs to markets in developing countries where these models continued to have a large market share whilst launching the new models in industrialised countries.

The agreement between Massey Ferguson and Ursus was modelled on a similar, and very successful, arrangement between the Italian automobile manufacturer Fiat and Poland's state owned car manufacturer. However, MF's deal never matched the performance of the Polski-Fiat. The failure of the MF-Ursus buy-back package had several causes, but foremost among them was the inability of Ursus to source components of the MF tractors which Massey Ferguson did not either manufacturer itself nor own the patents to. For example, the fuel injectors were manufactured by the British components supplier Lucas Industries. Poland simply did not have the foreign currency reserves, at that time, to import these and other parts.

Consequently, Ursus' tractor plant, on the outskirts of Warsaw, with the potential to produce 77,000 units per annum was able to manufacture around 350 units per year.

Whilst the MF-Ursus buy-back arrangement was not a success it should not be concluded that buy-back agreements are doomed to failure. The Polski-Fiat deal was, after all, a great success. The MF-Ursus failure was due to very specific circumstances. What should be concluded is that it is possible to devise innovative approaches to the financing of business enterprises.

Risk bearing: In both the production and marketing of produce the possibility of incurring losses is always present. Physical risks include the destruction or deterioration of the produce through fire, excessive heat or cold, pests, floods, earthquakes etc. Market risks are those of adverse changes in the value of the produce between the processes of production and consumption. A change in consumer tastes can reduce the attractiveness of the produce and is, therefore, also a risk. All of these risks are borne by those organizations, companies and individuals.

Risk bearing is often a little understood aspect of marketing. For example, when making judgments as to whether a particular price is a 'fair price' the usual reference point is the producer or supplier's costs. However the risks borne are rarely taken into account by those passing judgment and yet, almost inevitably, there will be occasions when the risk taker incurs losses. Stocks will spoil, markets will fall, cheaper imports will enter the country, and consumer tastes will change, and so on. These losses can only be observed if adequate surpluses were generated in previous periods. Risk bearing must be acknowledged as a cost since what is uncertain is not whether they will occur, but when they will occur.

Market intelligence: As for as is possible marketing decisions should be based on sound information. The process of collecting, interpreting, and disseminating information relevant to marketing decisions is known as market intelligence. The role of market intelligence is to reduce the level of risk in decision making. Through market intelligence the seller finds out what the customer needs and wants. The alternative is to find out through sales, or the lack of them. Marketing research helps establish what products are right for the market, which channels of distribution are most appropriate, how best to promote products and what prices are acceptable to the market. As with other marketing functions, intelligence gathering can be carried out by the seller or another party such as a government agency, the ministry of agriculture and food, or some other specialist organization. What is important is that it is carried out.

Marketing channels (PLACE)

Marketing systems are dynamic; they are competitive and involve continuous change and improvement. Businesses that have lower costs, are more efficient, and can deliver quality products, are those that prosper. Those that have high costs, fail to adapt to changes in market demand and provide poorer qualities are often forced out of business. Marketing has to be customer-oriented and has to provide the farmer, transporter, trader, processor, etc. with a profit. This requires those involved in marketing chains to understand buyer requirements, both in terms of product and business conditions. Efficient marketing infrastructure such as wholesale, retail and assembly markets and storage facilities is essential for cost-effective marketing, to minimize post-harvest losses and to reduce health risks.

Markets play an important role in rural development, income generation, food security, developing rural-market linkages and gender issues. Planners need to be aware of how to design markets that meet a community's social and economic needs and how to choose a suitable site for a new market. In many cases sites are chosen that are inappropriate and result in under-use or even no use of the infrastructure constructed. It is also not sufficient just to build a market: attention needs to be paid to how that market will be managed, operated and maintained. In most cases, where market improvements were only aimed at infrastructure upgrading and did not guarantee maintenance and management, most failed within a few years.

Rural assembly markets are located in production areas and primarily serve as places where farmers can meet with traders to sell their products. These may be occasional (perhaps weekly) markets, such as Monday market, bazaars, etc, or permanent such as King (Oba's) market, Neighborhood market, etc. Terminal wholesale markets are located in major metropolitan areas, where produce is finally channeled to consumers through trade between wholesalers and retailers, caterers, etc. The characteristics of wholesale markets have changed considerably as retailing changes in response to urban growth, the increasing role of supermarkets and increased consumer spending capacity. These changes require responses in the way in which traditional wholesale markets are organized and managed.

Retail marketing systems in western countries have broadly evolved from traditional street markets through to the modern hypermarket or out-of-town shopping center e.g. Shoprite. In developing countries, there remains considerable scope to improve agricultural marketing by constructing new retail markets, despite the growth of supermarkets, although municipalities often view markets as sources of revenue rather than infrastructure requiring development. Effective regulation of markets is essential. Inside the market, both hygiene rules and revenue collection activities have to be enforced. Of equal importance, however, is the maintenance of order outside the market. Licensed traders in a market will not be willing to cooperate in raising standards if they face competition from unlicensed operators outside who do not pay any of the costs involved in providing a proper service.

Market information

Efficient market information can be shown to have positive benefits for farmers and traders. Up-to-date information on prices and other market factors enables farmers to negotiate with traders and also facilitates spatial distribution of products from rural areas to towns and between markets. Most governments in developing countries have tried to provide market information services to farmers, but these have tended to experience problems of sustainability. Moreover, even when they function, the service provided is often insufficient to allow commercial decisions to be made because of time lags between data collection and dissemination.

Modern communications technologies open up the possibility for market information services to improve information delivery through SMS on cell phones and the rapid growth of FM radio stations in many developing countries offers the possibility of more localised information services. In the longer run, the internet may become an effective way of delivering information to farmers. However, problems associated with the cost and accuracy of data collection still remain to be addressed. Even when they have access to market information, farmers often require assistance in interpreting that information. For example, the market price quoted on the radio may refer to a wholesale selling price and farmers may have difficulty in translating this into a realistic price at their local assembly market. Various attempts have been made in developing countries to introduce commercial market information services but these have largely been targeted at traders, commercial farmers or exporters. It is not easy to see how small, poor farmers can generate sufficient income for a commercial service to be profitable, although in West Africa attempts to subsidize the cost of such services to farmers are made by charging access to a more advanced feature set of mobile-based farmer-friendly applications.

Recently, New marketing linkages between agribusiness, large retailers and farmers are gradually being developed, e.g. through contract farming, group marketing and other forms of collective action. Donors and non-governmental organizations (NGOs) are paying increasing attention to ways of promoting direct linkages between farmers and buyers within a value chain context. More attention is now being paid to the development of regional markets (e.g. East Africa) and to structured trading systems that should facilitate such developments. The growth of supermarkets, particularly in Africa, Latin America and East and South East Asia, is having a significant impact on marketing channels for horticultural, dairy and livestock products. Nevertheless, "spot" markets will continue to be important for many years, necessitating attention to infrastructure improvement such as for retail and wholesale markets.

AGRICULTURAL MARKETING ENTERPRISES

The three principal forms of enterprise in developing countries are: private companies, co-operatives and marketing boards. This section will rest solely on the private enterprise and its inherent characteristics.

PRIVATE ENTERPRISE: Private enterprise has many characteristics, including a much higher level of financial independence from government than public enterprises. Moreover, private enterprise is able to adapt, rapidly, to changing circumstances and opportunities and is usually able to provide what consumers want at a lower cost than public enterprises. Abbott (1987) highlights several particular strengths of private enterprise, including:

Nothing so concentrates the mind on cost control than

Low operating costs ownership. The private entrepreneur has every motivation to contain costs since to do otherwise erode his/her profit margin.

High levels of equipment utilization	Since private enterprise has as its prime objective, profit, everything is done to maximize the use of capital equipment, and thereby lower unit costs e.g. concern is shown to keep factories operating at high levels of capacity utilization, attempts are made to ensure that the firms' vehicles have economic return loads as well as outward loads etc.
Adaptability	Decision making within private enterprise tends to be quicker, because of the absence of a weighty bureaucracy, than in public enterprise equivalents.

According to Abbott, successful indigenous private enterprises particularly those operated by the owners, have several distinguishing characteristics which include;

Personal initiative	The entrepreneurial spirit is in evidence when an individual shows a willingness to accept calculated risks.
Rapid decision making	Decision making within private enterprise tends to be quicker, because of the absence of a weighty bureaucracy, than in public enterprise equivalents.
Independence of spirit and persistence	Entrepreneurs need a good deal of self confidence i.e. they must be prepared to back their own judgments rather than rely on the views and support of others. Moreover, it often takes a fair amount of time before market demand can be built up and new markets penetrated and hence the need for tenacity.
Willingness to work hard, for long and/or irregular hours	There is a direct relationship between effort and the level of success in private enterprise. Rarely is the entrepreneur able to rely on others covering for him/her and no-one pursues potential business or seeks to solve management problems with as much vigour as the owner.
Relevant experience and/or expertise	Most successful private entrepreneurs have experience and/or expertise which others are willing and able to 'buy'. This could be, for example, the ability to judge the quality and quantity of meat a live animal will yield when slaughtered.

An understanding of agriculture	This of course, relates to agribusinesses and is essential to those seeking to do business with farmers (or fisherman). Knowing how crops are grown and mature and understanding the priorities of producers and the daily/ seasonal pressures they face is invaluable in agribusiness.

Abbott claims to have identified several areas of marketing where private companies tend to perform better than other forms of marketing enterprise.

Perishable Products	This class of product is subject to rapid and extreme fluctuations in supply and demand, and therefore price, as well as considerable variation in quality, both at harvest time and subsequently, due to mechanical, pathological and/ or physiological damage. A private company, with its ability to make quick decisions, in response to an ever changing environment and set of market conditions, is in a better position to prosper in the perishable produce market.
Livestock and meat	Abbott claims that the marketing of livestock and meat is dominated by private enterprise. He says that this is explained by the fact that direct decision making gives private enterprise the edge because of the need for skilled judgment in appraising quality and value when the product is so variable.
Combined purchase of produce and sales of farm inputs and consumer goods	Businesses serving rural customers often have to deal in small quantities of supplies and purchases and this requires a great deal of flexibility on the part of the enterprise. It is usually the smaller, private, enterprise which proves willing and able to conduct business in such a way.
New and highly specialized activities in marketing	The willingness to invest in new and therefore risky ventures or to invest in highly specialized activities is usually the province of the private sector. The French economist J.B. Say (c.1800) is quoted as defining the entrepreneur as one who "...shifts economic resources out of an area of lower and into an area of higher productivity and greater yield". Committees and government bureaucracies are not especially fond of closing down existing economic activities. They are not much better equipped to generate new ideas or indeed to innovate.

COOPERATIVE ENTERPRISE: The co-operative enterprise has its origins in the 19th century and has become one of the most ubiquitous examples forms of business/economic enterprise. Co-operatives exist in all countries of the world and operate under diverse political systems: from communism to capitalism. The majority of these co-operatives are, through their national apex organizations, ultimately in membership of the International Co-operative Alliance (ICA), the representative world body of co-operatives of all types.

The motivation to form co-operatives has three particular aspects:

- the need for protection against exploitation by economic forces too strong for the individual to withstand alone
- the impulse for self-improvement by making the best use of often scarce resources
- the concern to secure the best possible return from whatever form of economic activity within which the individual engages whether as a producer, intermediary or consumer.

It is the belief that each of these aspirations can most advantageously be pursued and secured in concert with like-minded people that provides the stimulus to co-operative action. The underpinning principles with are those of self-help, voluntary participation, equity, democracy, and a common bond of common need and purpose. The cohesion of the group is maintained by ensuring that individual members cannot secure power or gain advantages at the expense of the others. Co-operatives reward participation in the co-operative venture rather than rewarding capital Self-interest is a primary motivator in co-operative enterprises, with economic gain being the primary objective. In these respects, co-operatives differ little from capitalistic enterprises; self-interest is simply pursued in a different way from the capitalist enterprise. Thus, the rate of interest paid on share capital is fixed and limited, and not subject to variation according to the amount of profit made. Secondly the use and distribution of surplus is restricted to one or more of the following purposes:

- allocation to reserves, where it becomes collectively-owned capital and is thereafter non-distributable
- for use on, or donation to, common-good, community project
- distribution to members in proportion to the trade each member has done with the co-operative. In other words, the distribution is made not in relation to capital held, but by declaring a bonus or dividend per cash unit of trade done

The Structure and organization of co-operatives

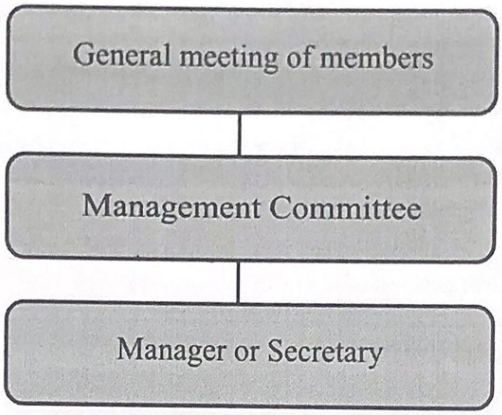
There are two principal forms of co-operative organizations: primary co-operatives and secondary co-operatives. The basic unit in the co-operative systems is the primary co-operative. A primary co-operative is one in which the shareholder are individuals; each of them having an equal share in its control.

Primary co-operatives — In many cases, primary co-operatives will combine several functions e.g. an agricultural co-operative may provide consumer supplies to its members. Primary co-operatives may also own and run subsidiary enterprises related to their main functions, such as a consumer co-operative with its own manufacturing/processing or servicing business.

Secondary co-operatives	While a primary co-operative has individual persons as members, a secondary (or federal) co-operative is one in which other co-operatives are the members. Apart from this basic difference the structure and organization of both types follow a very similar pattern.

The control and management of primary co-operatives

The control structure of co-operatives is made up of three tiers as depicted in the figure below. The General Meeting of Members makes policy and through this meeting members exercise control. In most countries there is a legal requirement to hold an Annual General Meeting which has the particular responsibilities of receiving and deciding upon an audited statement of account, deciding how any surplus shall be used and distributed, and of electing a committee.



The General Meeting of Members delegates the operational control of the co-operative to a management committee (or board of directors), which controls the works of the co-operative on behalf of the members. One member of this committee is elected chairman or president. A manager (or secretary) is appointed by the management committee as the chief administrative officer of the co-operative. He/she is responsible to the committee for the day-to-day control of the business. In small co-operatives he/she may be a member elected to do the work without pay.

Federal or secondary co-operatives

Secondary co-operatives (also variously described as "union" or "federal" co-operatives) can be organized for many different purposes. It is quite possible, and quite common, for a primary co-operative to be a member of several secondary co-operatives, depending on its needs and the local co-operative structure.

Examples of secondary co-operative organization would be:

- a local district union of 3/4 cotton marketing co-operatives to operate a ginning plant
- a federation of 2, or more, consumer co-operatives to operate a bakery
- a national union of agricultural co-operatives to manufacture fertilizer
- a national union of consumer co-operatives to organize wholesaling services and to manufacture merchandise
- a national federation of co-operatives to run a national bank.

Through the device of federation, co-operatives are able to organize very large-scale business operations at the national - or even international - level without detriment to the democratic control of the primary co-operatives by their own members. The secondary co-operative can, because of its larger volume of business or its wider representational base, undertake functions, provide services, and make representations, which would be beyond the capacity of all but the very largest primary co-operatives. Secondary co-operatives are a form of vertical integration providing the opportunity for economies of scale, scope for development and improved administration.

Secondary co-operatives can in turn form other secondary co-operatives - sometimes called tertiary co-operatives. In many countries there is one apex federation representative of all other co-operatives in the country and providing, at the national level, representative, advisory and professional services to the co-operative movement as a whole. These national co-operatives can then be affiliated to international organizations such as the International Co-operative Alliance.

Control and management of secondary co-operatives

The control and management of secondary co-operatives is similar in form to that of primary co-operatives. The share holding members - the primary co-operatives - exercise policy control through the General Meeting and elect a management committee to act on their behalf. The management committee in turn appoints a chief officer to manage the operation under its direction. The bye-laws of secondary co-operatives, as with the primaries, set down the organizational rules and procedures and are subject to the approval of the responsible local authority. The operating surplus of a secondary is also used and distributed following the same principles as a primary co-operative.

The federal co-operative can tend to become the masters of their member co-operatives rather than their servants. This situation can arise two reasons. Secondary co-operatives engaged in manufacture and trade can usually only operate efficiently given a high level of integration between their operations and those of their members. This requires a commensurate high level of discipline or some form of contractual compulsion. Secondly, the operational size and volume of trade of secondary's can be such, compared to individual primaries, that there is a strong tendency for them to

behave as the dominant partner in the relationship. It is a tendency that has to be monitored and, where necessary, checked. The secondary co-operative has as its chief obligation, the provision of services to member co-operatives.

The potential of co-operatives is immense. Co-operatives appear well suited to the economic, social and institutional needs of development in the rural economy. Co-operatives can provide the mechanism to organize and mobilize people for self-help action in providing the services they require as a farming and rural community. As self-administered rural institutions, co-operatives have the capacity to reflect, and to respond to the needs of their members; and, at the same time, to help foster attitudes of self-reliance and self-confidence within a framework of mutual aspirations and mutual action. In the delivery of services to their farmer-members they can provide an essential support to the development objectives of both the farmers themselves, and of national development policy.

As business organizations co-operatives also have the capacity to act directly as development agencies. In their steady accumulation of business assets, the expanding range of their services, the acquisition and use of management skills, the employment of staff, they are involved in a positive and measurable development function. Moreover, the flexibility of co-operative organization, for example through the potential of secondary co-operatives, offers opportunities for collective action in the development of agro-industrial enterprise to help support and strengthen local initiatives, and to give a further boost to rural development. There are few countries where co-operatives are not recognized as potentially important agencies of development.

The weakness of co-operatives

Unfortunately, the potential of co-operatives, and the extent of their development, has, in many cases, fallen for short of expectations. Low standards of performance, bad management, financial failure, corruption and misuse of funds, use of co-operatives for political ends, have been common features of co-operative enterprise in many countries. As a consequence, a great deal of understandable criticism has been leveled at the co-operative system, and many, including some members, have become cynical as to its ability to play an effective role in the development process. There are a number of problems which inhibit co-operative development and adversely affect performance, the more important of which are discussed below.

Realism of objectives: Commitment and purpose are two important ingredients in motivation. Achievement of purpose is equally important. Objectives are expressions of purpose and expectation. To serve as motivators and guides to action they have to be attainable. The resources available have to be adequate to achievement of the objectives, and aspirations must be matched to ability. Neither members nor others should expect too much of co-operatives, including expecting them to expand too quickly.

[illegible] between economic and social purposes: Economic success is basic to the achievement of co-operative purpose for, in the long run, unprofitable enterprises cannot be sustained. However, co-operatives are constrained in the extent to which they can mimic the objectives and practices of capitalist enterprise without abandoning the fundamental values of the co-operative movement. For example, in the pursuit of business growth there can be a strong temptation to weaken member control and concede greater control to professional management, to make the creation of profit a paramount consideration, and to ignore the concepts of equity and fair dealing. The creation of collectively-owned capital by reinvestment of profits (surplus) is a highly important and desirable practice, but has its disadvantages in that if the element of members' share capital as a proportion of the total capital structure becomes so insignificant that professional management can afford to ignore it and so ignore member control in making policy decisions. The outcome is an enterprise largely indistinguishable, except in name, from a capitalist enterprise.

Misuse of co-operatives to pursue political objectives: Attempts to divert the purpose and resources of co-operatives to the support of particular political objectives adversely affects the co-operative movement.

Factional dissension among the group distracts it from the achievement of its economic objectives. Members' meetings can become political forums devoted to the advocacy of opposing views. In these circumstances many members can become disenchanted and lose interest, making it easy for a minority group to take control and to attempt to run the co-operative to serve its own ends.

Co-operative principles require that membership should not be assumed to imply either political commitment or obligation. Co-operative systems organized and tightly controlled by governments as instruments of state economic policy are rarely conducive to the development of democratically-controlled, member-owned co-operatives. They are created to serve the objectives of politicians and planners; objectives which may or may not coincide with those of the members who have little effective control of the enterprise.

Management: There has been a tendency to argue that a major cause of co-operative failure is the constraint imposed on the exercise of management skills and authority by the democratic nature of the enterprise. That being so, it is suggested that the authority of the General Meeting ought to be curtailed, leaving committees and managers to get on with the job of management. However, to do so would deny the purpose of the enterprise that being to enable people to run their own business. The solution lies in increasing and improving the level of member participation, not restricting it. Moreover, the standard of management within co-operatives is often inherently poor. As has already been said, co-operatives often come into being in markets and geographical areas considered as marginal in terms of profit potential by most other forms of commercial business enterprise. This being the case, the salaries, working conditions and work location that they are able to offer fail to attract top quality managers.

Selling arrangements between co-operatives and their members

A principal policy question in co-operatives is the procedure to be used in selling members' produce. The alternatives are: outright purchase from members, or sale on commission.

Outright purchase: In this case members are paid for their produce, at prices fixed by the co-operative, at the time of delivery, and the co-operative takes title to the produce. The co-operative then resells the produce at the most advantageous terms it can secure. Profits made on the transaction will be used first to meet the operating expenses, any surplus balance being used or distributed by decision of the General Meeting. This approach requires the co-operative to have high levels of funds available. Since, in the case of seasonal crops, a lot of produce is being offered within the immediate post harvest period, a serious adverse cash flow situation can arise. This can be alleviated by a two-stage payment system whereby members are paid part of the sale price at the time of delivery, and the balance after the co-operative has

resold the produce. The main objection to outright purchase is that the co-operative carries all of the post harvest risks including: fall-off in demand, price fluctuation, reduction of produce value due to down-grading, deterioration giving rise to loss of quality and so value, failure of transport arrangements, spoilage, fire and theft. Some of these can be covered by insurance but most cannot. Generally, this method is only acceptable where the risks incurred are limited and can be reasonably well assessed. For example, where forward contracts have been negotiated. These risks being taken into account, outright purchase has the advantage of permitting the co-operative to add value to the crop and thereby add to the profits of its members. There are three principal ways in which a co-operative might add value to the commodity.

- Produce can be stored for sale at a later date when prices have improved
- Value can be added through primary processing of the crop. Cotton ginning is a good example of relatively simple and inexpensive process which is best done close to the fields. The value of baled ginned cotton, is normally considerably more than the sum of the value of the raw cotton plus the cost of ginning. And there is the additional value of the cotton seed
- Opportunity for adding value exists in the packing and presentation of the crop, or in the case of livestock, improvement in condition or quality before sale. Graded, washed and well packed fruits and vegetables can attract wider markets and premium prices.

There is a *caveat* which ought to be added. Whilst price advantages gained by adding value are of direct benefit both to the co-operative as a whole and to individual members, the additional investment needed to capture the additional return, can be prohibitive. Apart from the risks incurred, outright purchase, storage, packing, processing, transportation, marketing etc., require substantial financing. Moreover, these more complicated operations call for a high level of management skill and judgment, which is frequently a scarce resource.

Sale on commission: This far simpler, virtually risk-free, operation leaves the co-operative as the producers' agent with no legal title to the goods. All attendant risks therefore remain with the individual producers. The co-operative collects produce from members and sells in the most advantageous markets. It then deducts a commission at a previously agreed rate from the sale price. The co-operative meets the cost of its expenses from its commission income. With the sale-on-commission system the co-operative avoids the need to finance crop buying and it minimises its risks. In addition, much simpler operating procedures are required and expenditure can be more accurately matched to anticipated income.

The main disadvantage of sale-on-commission is that neither the member nor the co-operative is able to exploit possible price improvement. Another is the possible delays in the producer receiving cash for his crop. No payment will be made by a co-operative until it has been paid by the customer.

Apart from the time taken in an 'open market' for crops to be sold, it is by no means unknown for parastatal agencies to be dilatory in paying-out for produce received from co-operatives.

MARKETING BOARDS - both food marketing boards and export marketing boards - usually have the function of intervening in the marketplace to aid the process of efficient and orderly marketing. Very often a marketing board's chief goal is to help improve the income of smallholders.The effectiveness of a particular marketing board is often viewed in terms of three factors:-

- Its contribution to orderly and efficient marketing
- The reduction in the capacity of intermediaries to manipulate margins at the expense of producers and consumers
- The generation of producer-oriented monopoly power

In theory at least, the marketing board contributes to orderly marketing by acting as an agent for improving marketing practices, as a market regulator and as a provider of facilitating services. For instance:

Change agent — Marketing boards can establish marketing practices and procedures for raw and/or processed products.

Regulatory role — Marketing boards may act as "watch-dogs" over agreed marketing practices and procedures e.g. credit arrangements, weights and measures, quality control etc.Marketing boards may try to control the system by issuing licenses to individuals or agents.

Facilitator — Marketing boards may provide all or some of the facilitating services e.g. credit, market intelligence and risk management. The last of these usually takes the form of the guaranteeing of prices. In the case of tree crops prices are announced in advance of harvest. Prices for annual crops are normally made known before planting or sowing.

Marketing boards generally handle durable products. A marketing board can expect to be judged in terms of its contribution to orderly and efficient marketing, the extent to which it counters the monopolistic practices of market intermediaries and the transference of the balance of power, in the distribution channel, in favour of producers. As a generalisation it has been concluded that agricultural and food marketing boards have failed to achieve expected results in developing countries. It would appear that this is due to social objectives compromising commercial objectives, government's use of the boards as instruments of fiscal policy, manipulation of the marketing board's prices to encourage increased production and contain retail prices for staple foods, and the placing of political appointees to the

contain retail prices for staple foods, and the placing of political appointees to the management of the boards.

Review Questions

From your knowledge of the material in this chapter, give brief answers to the following questions below.

1. Highlight the main conflicts of interest between the key players in agricultural and food marketing system.
2. What are the 3 physical functions of a marketing system mentioned by Khols and Uhl?
3. How is value added to a product or service?
4. What is the principal goal of the standardisation of weights and measures for agricultural products?
5. According to Adam Smith what is the purpose of production?
6. Name the 4 sub-systems that Rosson suggests comprise agricultural and food marketing systems.
7. In the past, what has been the main function of marketing boards in developing countries?
8. Explain the term 'enterprise'.
9. What are the difficult commercial circumstances in which co-operatives often find themselves?
10. Explain the term 'tertiary co-operatives'.
11. What are the 2 ways in which co-operatives purchase produce from their members?

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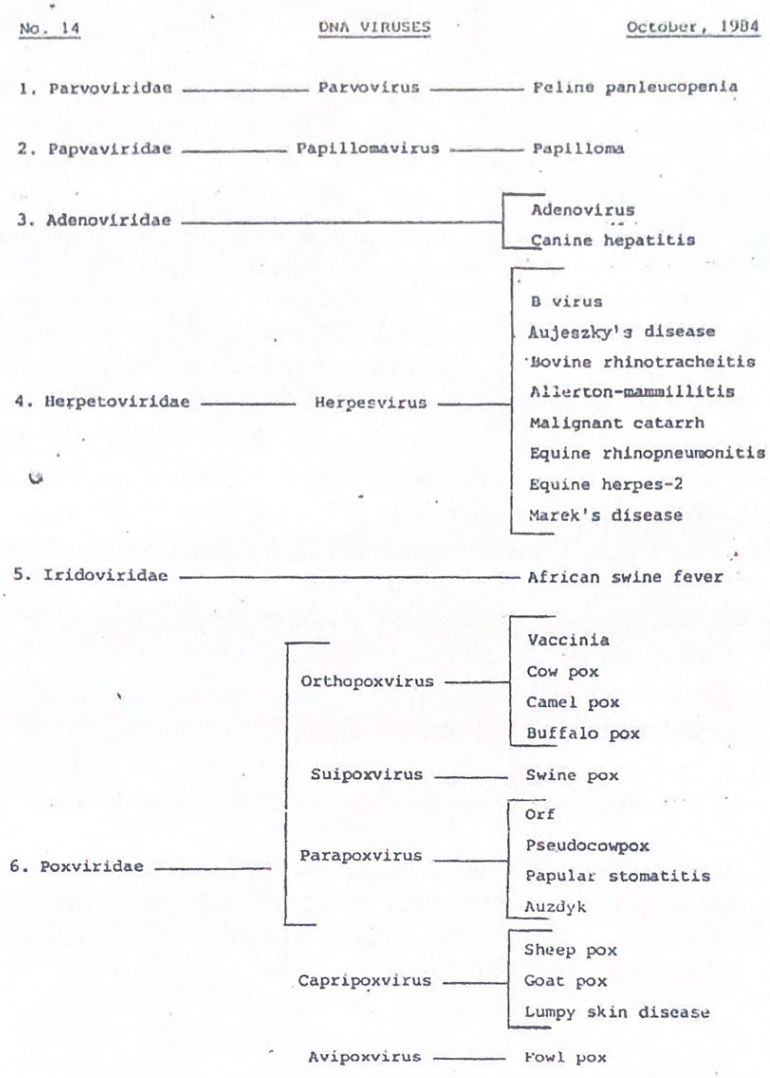
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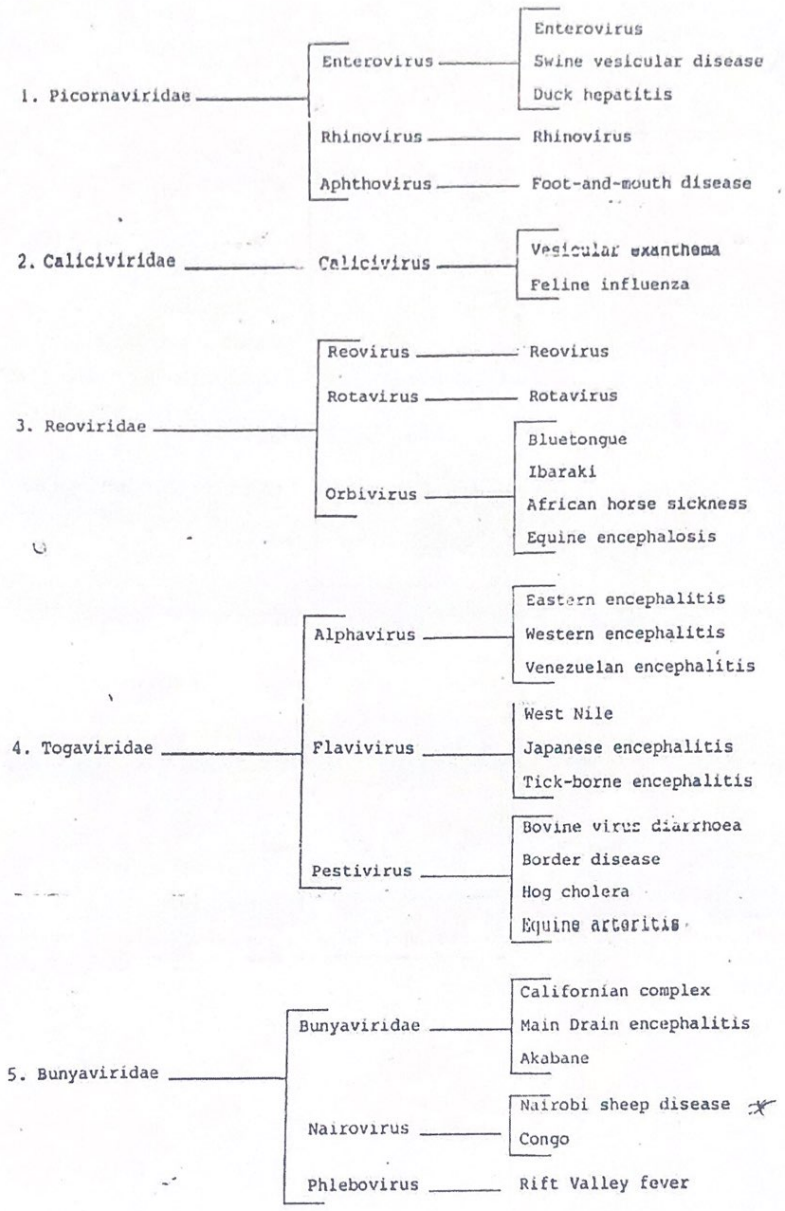
Classification of viruses

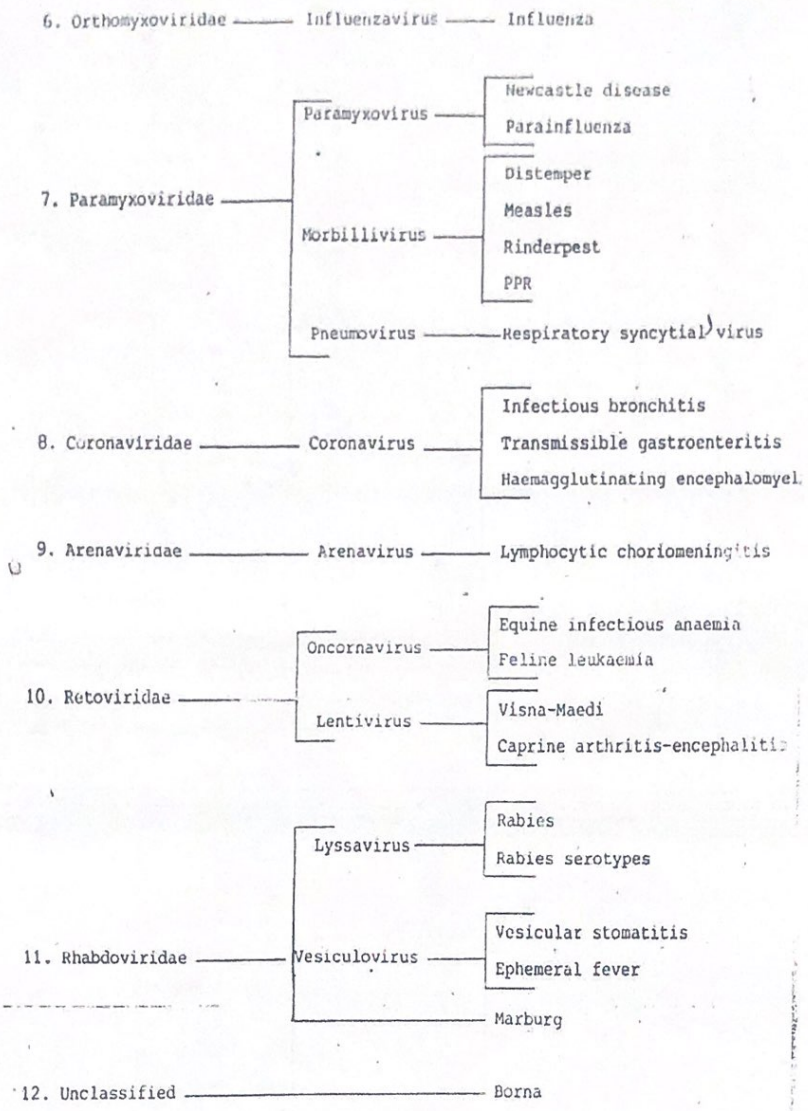


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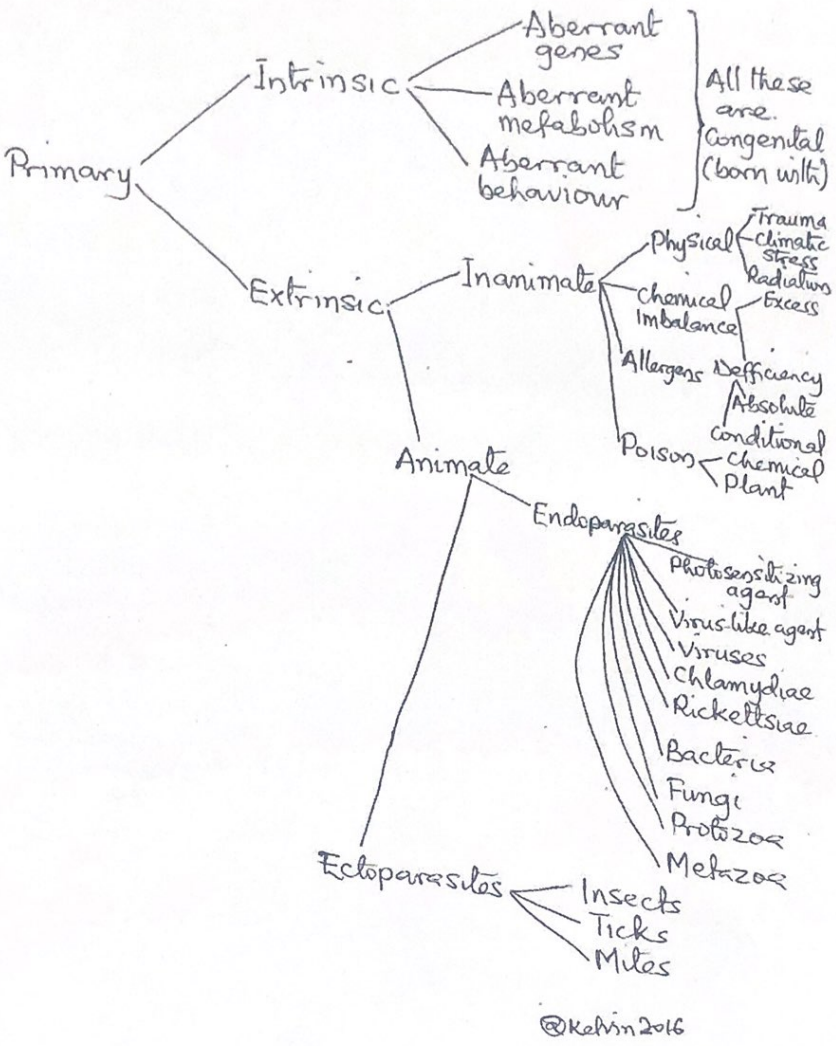
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1. Picornaviridae
Enterovirus
Enterovirus
Swine vesicular disease
Duck hepatitis
Rhinovirus
Rhinovirus
Aphthovirus
Foot-and-mouth disease
2. Caliciviridae
Calicivirus
Vesicular exanthema
Feline influenza
3. Reoviridae
Reovirus
Reovirus
Rotavirus
Rotavirus
Orbivirus
Bluetongue
Ibaraki
African horse sickness
Equine encephalosis
4. Togaviridae
Alphavirus
Eastern encephalitis
Western encephalitis
Venezuelan encephalitis
Flavivirus
West Nile
Japanese encephalitis
Tick-borne encephalitis
Pestivirus
Bovine virus diarrhoea
Border disease
Hog cholera
Equine arteritis
5. Bunyaviridae
Bunyaviridae
Californian complex
Main Drain encephalitis
Akabane
Nairovirus
Nairobi sheep disease
Congo
Phlebovirus
Rift Valley fever


6. Orthomyxoviridae
Influenzavirus
Influenza
7. Paramyxoviridae
Paramyxovirus
Newcastle disease
Parainfluenza
Morbillivirus
Distemper
Measles
Rinderpest
PPR
Pneumovirus
Respiratory syncytial virus
8. Coronaviridae
Coronavirus
Infectious bronchitis
Transmissible gastroenteritis
Haemagglutinating encephalomyel
9. Arenaviridae
Arenavirus
Lymphocytic choriomeningitis
10. Retoviridae
Oncornavirus
Equine infectious anaemia
Feline leukaemia
Lentivirus
Visna-Maedi
Caprine arthritis-encephaliti
11. Rhabdoviridae
Lyssavirus
Rabies
Rabies serotypes
Vesiculovirus
Vesicular stomatitis
Ephemeral fever
Marburg
12. Unclassified
Borna

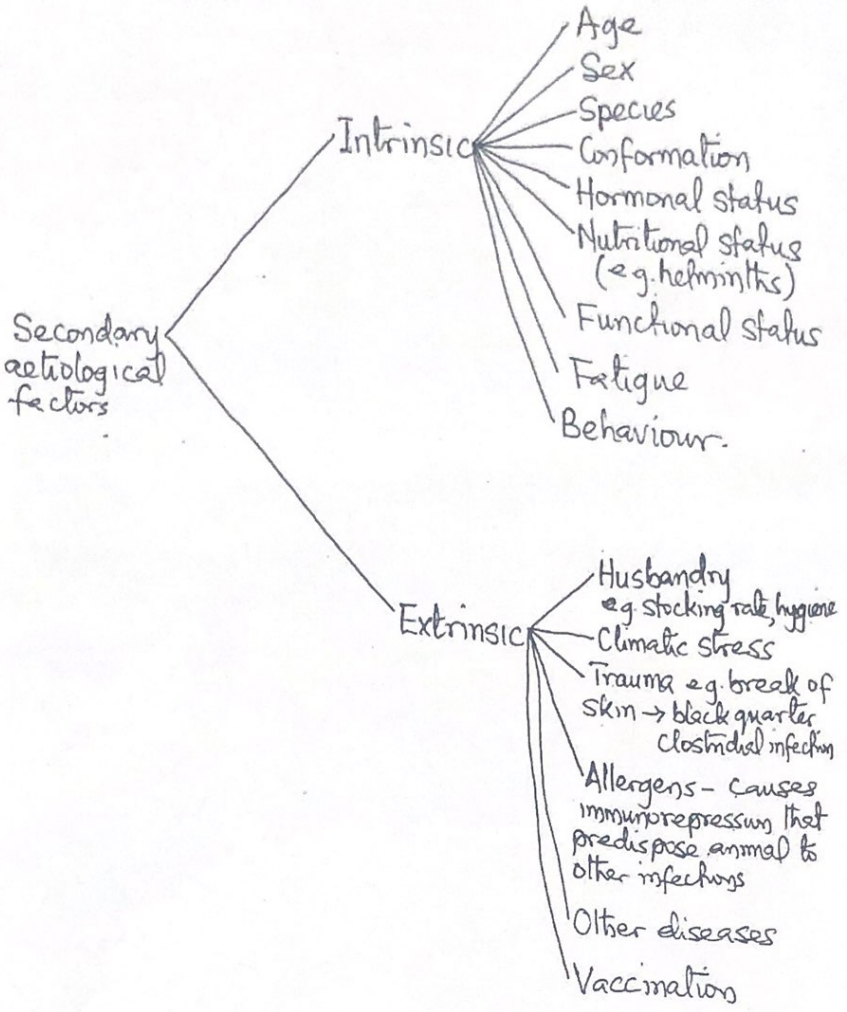
AETIOLOGICAL FACTORS OF DISEASE

- May be primary or secondary
Most diseases are due to primary actiological factors. However, some secondary actiological factors may be as essential as the primary ones.



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AETIOLOGICAL FACTORS OF DISEASE (CONTINUED)



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SUBJECT INDEX

Agricultural Marketing 284
Agricultural Marketing Board 311
Agricultural Marketing Enterprises 301
Agricultural Marketing, cooperative enterprise 303
Agricultural Marketing, market evolution or philosophies 267
Agricultural Marketing, marketing channels (PLACE) 300
Agricultural Marketing, marketing concept/marketing systems 286
Agricultural Marketing, marketing function 291
Agricultural Marketing, marketing information 300
Agricultural Marketing, marketing mix 290
Agricultural Marketing, private enterprise 301
Beef cattle production 237
Beef cattle production, breeds/characteristics of 239
Beef cattle production, classification of climate 243
Beef cattle production, conformation of Nigerian breeds 243
Beef cattle production, feedlot operations 248
Beef cattle production, government effort at improving 238
Beef cattle production, management of feedlot 249
Beef cattle production, Nigerian breeds of 241
Beef cattle production, properties of a corral 255
Beef cattle production, ranching 252
Beef cattle production, systems of 244
Beef cattle production, techniques for establishing a beef ranch 254
Beef production in Nigeria 251
Biotic Communities in Nigeria 31
Biotic Communities, Geopolitical zones in Nigeria 31
Biotic Communities/ Distribution of Livestock in Nigeria 30
Breeds of Cattle 9
Breeds of Cattle, Characteristics of West African Breed of Cattle 15
Breeds of Cattle, Classification based on use36
Breeds of Cattle, Ruminant animal 9
Breeds of Chicken (Fowl) 26
Breeds of Duck 28
Breeds of Goats 19
Breeds of Guinea fowl 27
Breeds of Guinea pig 29
Breeds of Pig 22
Breeds of Pig, Types of pig 21
Breeds of Rabbit 29

SUBJECT INDEX

Breeds of Sheep 17
Breeds of Turkey 27
Carbohydrate 74
Carbohydrate, classification 74
Carbohydrate, glycosides 75
Carbohydrate, importance 75
Characteristics of Nigerian Livestock industry 4
Diseases 161
Diseases, bacteria 177
Diseases, bacteria diseases 178
Diseases, bacteria physiology 169
Diseases, categories of ticks 307
Diseases, classification of bacteria 177
Diseases, components of a bacterial cell 169
Diseases, concept of culturing disease organisms of farm animals 166
Diseases, control 165
Diseases, development of microbial infection 175
Diseases, enzootic 216
Diseases, epidemiology 216
Diseases, exit of disease agents 164
Diseases, factors that influence success of transmission 165
Diseases, fungal diseases 213
Diseases, fungi 213
Diseases, general defense mechanism of the body 175
Diseases, health 161
Diseases, helminthes parasites 225
Diseases, inflammation 176
Diseases, lifecycle of tapeworm, liverfluke and roundworm 229
Diseases, livestock parasites 215, 225
Diseases, management of 161
Diseases, mode of transmission 161
Diseases, parasitic gastroenteritis complex 226
Diseases, pathology 174
Diseases, portal of entry of disease agents 163
Diseases, predisposing factors of 162
Diseases, prevalence 216
Diseases, principles of sterilization/disinfection 172
Diseases, protozoa 217
Diseases, protozoa diseases 217

SUBJECT INDEX

Diseases, rickettsial 210
Diseases, tick borne protozoa 218
Diseases, ticks 223
Diseases, types of disease transmitters 215
Diseases, types of inflammation 176
Diseases, viral 195
Diseases, viruses 195
Enzymes, characteristics of 63
Enzymes, classification of 64
Enzymes, Coenzymes and Vitamins 62
Enzymes, factors affecting action 67
Enzymes, functions of 63
Enzymes, uses66
Factors influencing the demand for meat/ meat products 7
Feeding Systems 277
Feeding Systems, economies of livestock feed 278
Feeding Systems, ensiling process within the silo 282
Feeding Systems, factors affecting feed utilization 278
Feeding Systems, feed preparation 277
Feeding Systems, feeding of young animals 277
Feeding Systems, hay production 279
Feeding Systems, silage and haylage 283
Feeding Systems, silage production 281
Feeding Systems, types of hay 280
Goat production 126,265
Goat production, breeds of 126
Goat production, factors affecting milk yield 271
Goat production, general management 268
Goat production, health management 272
Goat production, milking of goat 271
Goat production, reasons for rearing 265
Goat production, routine health care 267
Goat production, selection for milk 266
Goat production, special attributes of goat milk 270
Goat production, systems of management 267
Importance of livestock to Nigerian Economy 3
Lipids 85
Lipids, importance 87
Lipids, ketone bodies 90
Livestock production systems 114

SUBJECT INDEX

Livestock production systems, modern production/management of beef cattle 115
Management of Agribusiness 155
Management of Agribusiness, activity 157
Management of Agribusiness, characteristics of 157
Management of Agribusiness, communication 157
Management of Agribusiness, factors against communication 158
Management of Agribusiness, formation of a company 158
Management of Agribusiness, objective of management 156
Management of Agribusiness, process or functions of management 156
Metabolism of Carbohydrate76
Metabolism of Lipid 87
Metabolism of Protein 94
Metabolism, anabolism and catabolism 73
Metabolism, basal (BMR) 108
Metabolism, energy 96
Metabolism, Glycolytic pathway 76
Metabolism, oxidative phosphorylation 98
Metabolism, Tricarboxylic Acid (TCA) cycle 79
Metabolism, types of chemical reactions 97
Metabolism, urea (Ornithine) cycle 95
Metabolism, variation in blood sugar level 82
Minerals 71, 112
Minerals, chelated complexes 72
Minerals, classification 71
Minerals, function 72
Minerals, requirements for vitamins/minerals 111
Morphology of Farm Animals 35
Morphology, Conformation Standard 38
Nutrition 54
Nutrition, apparent digestibility 110
Nutrition, Behavior of Development46
Nutrition, biological value 110
Nutrition, chemical composition of the animal body 58
Nutrition, digestibility of feedstuff 102
Nutrition, factors affecting digestibility 104
Nutrition, Feedstuffs, Feed, Ration and Diet45
Nutrition, partitioning of dietary protein 109
Nutrition, partitioning of food energy 106
Nutrition, Proventriculus55
Nutrition, ruminant gastrointestinal tract 56

SUBJECT INDEX

Nutrition, Ruminants, Non-ruminants and Herbivores 46
Nutrition, Specific species ingestive behavior 49
Nutrition, total digestible nutrients (TDN) 106
Nutrition, true digestibility 110
Nutritional value of feeds, evaluation 99
Objectives and Policies for increasing the supply of animal products in Nigeria 2
Pig Enterprise 121
Pig production 233
Pig production, flushing of pig 122
Pig production, house in pig management 233
Pig, creep feeding 171, 120
Pig, flushing 173, 120
Pig, swine production system 125
Pig, system or methods of mating 123
Poultry Enterprise 135
Poultry Enterprise, brooder guard 147, 141
Poultry Enterprise, feeder/drinker spaces141, 128, 153
Poultry Enterprise, formula for stocking 137
Poultry Enterprise, growth restriction for growing pullets 154
Poultry Enterprise, heater 140
Poultry Enterprise, housing/floor space requirements 152
Poultry Enterprise, management of chicks 135
Poultry Enterprise, management of growers 152
Poultry Enterprise, management practices during brooding 147
Poultry Enterprise, methods of growth restriction 154
Poultry Enterprise, possible causes of mortality during brooding 150
Poultry production 127
Poultry production, battery cage system 132
Poultry production, characteristic features of a good layer 130
Poultry production, classification of poultry feeds 127
Poultry production, common diseases of 135
Poultry production, deep litter system 133
Poultry production, disadvantages of using saw-dust as litter 133
Poultry production, management systems 128, 131
Poultry production, poultry housing orientation 133
Poultry production, preparation for receiving day old chicks 134
Poultry production, sanitation in intensive poultry management 134
Problems of livestock production in Nigeria 5
Protein 90
Protein, requirements for protein 111
Proteins, classification of 92

SUBJECT INDEX

Proteins, importance 92
Proteins, properties of 93
Proteins, properties of amino-acids93
Rabbit production 234
Rabbit production, breeding 28
Rabbit production, diseases 321
Rabbit production, feeding 235
Review Questions 420
Sheep production 257
Sheep production, breeding/reproduction management 260
Sheep production, breeds of 257
Sheep production, factors favourable to 258
Sheep production, feedlot rams production 263
Sheep production, housing/other facilities 262
Sheep production, initial health precautions 259
Sheep/Goat management 16
Sheep/Goat management, steam-up 260
Specie s9
Species of Domestic Poultry 26
Summary of Livestock Terminology 7
Vitamins 68, 111
Vitamins, classification 68
Vitamins, names in currents/previous nomenclature 69
Water metabolism 58
Water, functions 60
Water, routes of water losses 62
Water, sources of body water 61
What is Breed? 9