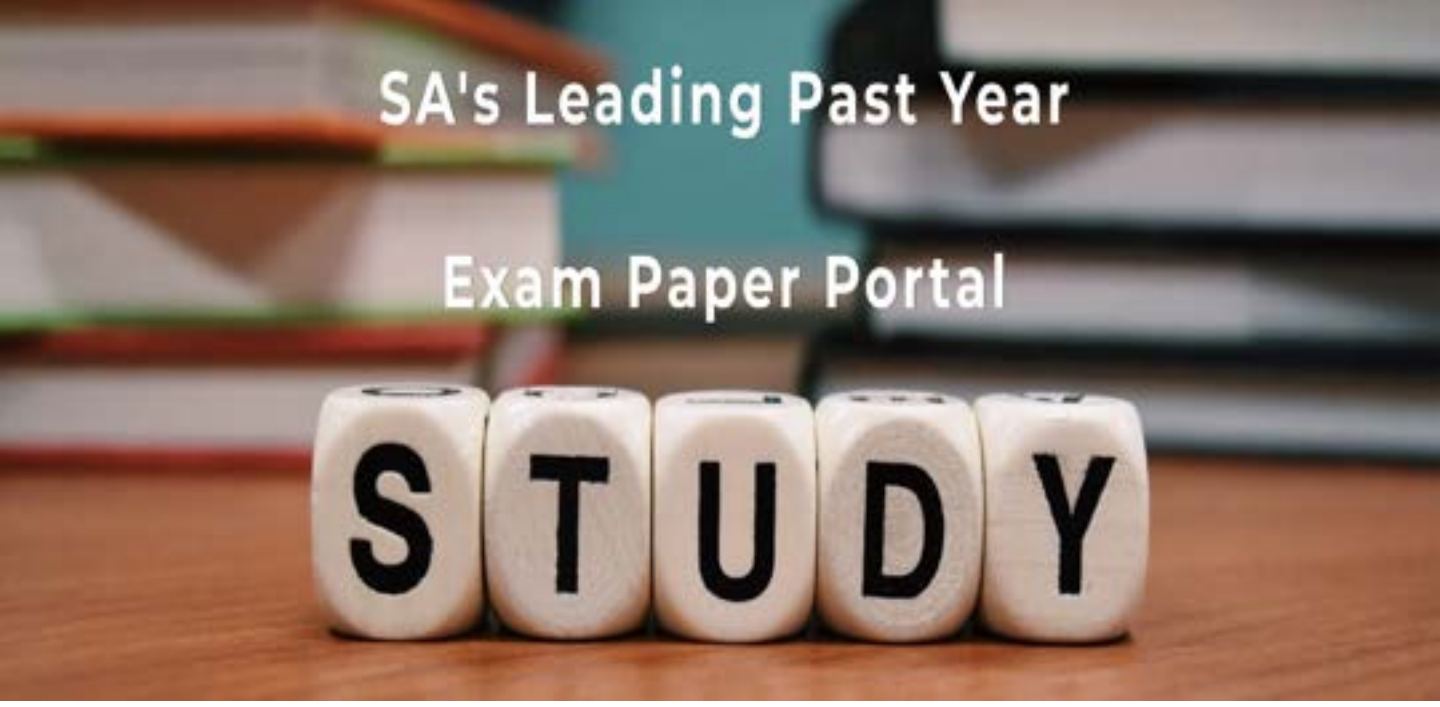

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Via Afrika Agricultural Sciences

Grade 12 Study Guide

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Via Afrika

Our Teachers. Our Future.

Study Guide

Via Afrika Agricultural Sciences

Grade 12

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Contents

Introduction to Agricultural Sciences

Agricultural Sciences is the study of the relationship between soils, plants and animals in the production and processing of food, fibre, fuel and other agricultural commodities that have an economic, aesthetic and cultural value. Agricultural Sciences is an integrated science. It combines knowledge and skills from Physical Sciences, Life Sciences, Social Sciences, Earth Sciences, Engineering, Mathematics and Economics. This subject must be seen within the holistic science framework rather than as an isolated science.

In Agricultural Sciences you will:

- develop an awareness of the management and care of the environment, natural resources and the humane treatment of animals through application of science and related technology
- develop problem-solving mechanisms within the contexts of agricultural production, processing and marketing practices
- be aware of the social and economic development of the society at large through personal development in commercial and subsistence farming enterprises
- become informed and responsible citizens in the production of agricultural commodities, caring for the environment and addressing social justice issues
- be aware of agricultural indigenous knowledge and practices through understanding agricultural sciences in historical and social contexts.

Rationale for Agricultural Sciences

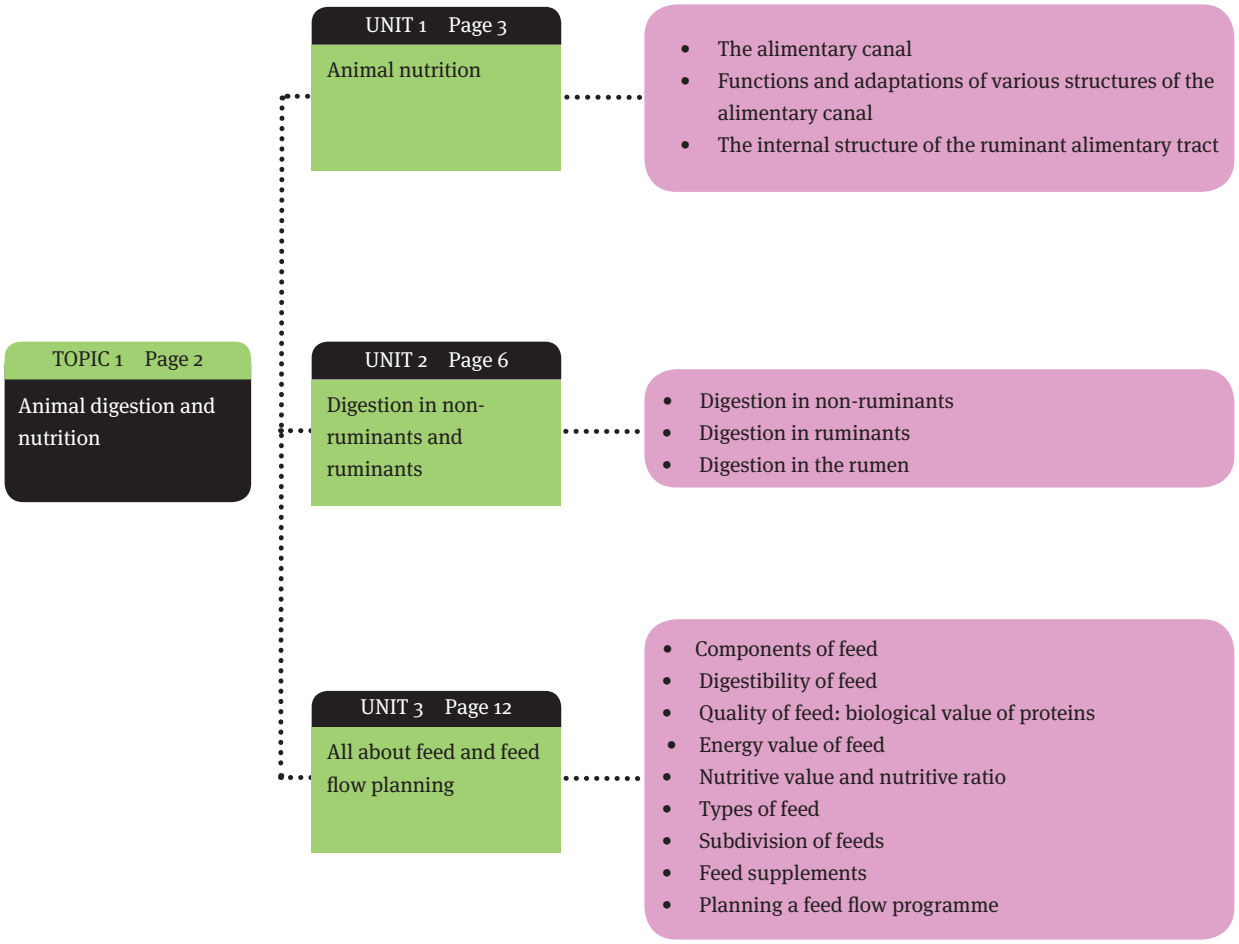
The interdependence of people and natural resources and the increasing demand on the latter has led to a need for proper utilisation, management and conservation of agricultural and natural resources. Relevant education at secondary school levels can contribute to meeting these demands in a sustainable way. An appreciation and awareness of the importance of natural resources and a responsibility towards their preservation should be fostered from an early age through the Natural Sciences learning area.

To fulfil the increasing demand for food and fibre and to meet the aspirations of communities, the acquisition of relevant knowledge, skills, attitudes and values is of vital importance.

Topic 1

Animal nutrition and digestion

Overview



Unit 1

Animal nutrition

1 The alimentary canal

The alimentary canal is the passage along which food passes through the body.

- The canal contains a series of organs of the body involved in digestion.
- The alimentary canal also absorbs water and excretes parts of food that cannot be digested.
- The external structure of the alimentary canal of ruminants and non-ruminants is different.

DIGESTION IS THE PROCESS IN WHICH FOOD IS TAKEN IN AND PROCESSED TO TURN IT INTO BASIC NUTRIENTS THAT CAN BE ABSORBED INTO THE BLOODSTREAM.

Alimentary canal of a ruminant: External structure

Cows and sheep are examples of ruminants. Their alimentary canal consists of the following organs: mouth, oesophagus, forestomach, the abomasum and the large intestine.

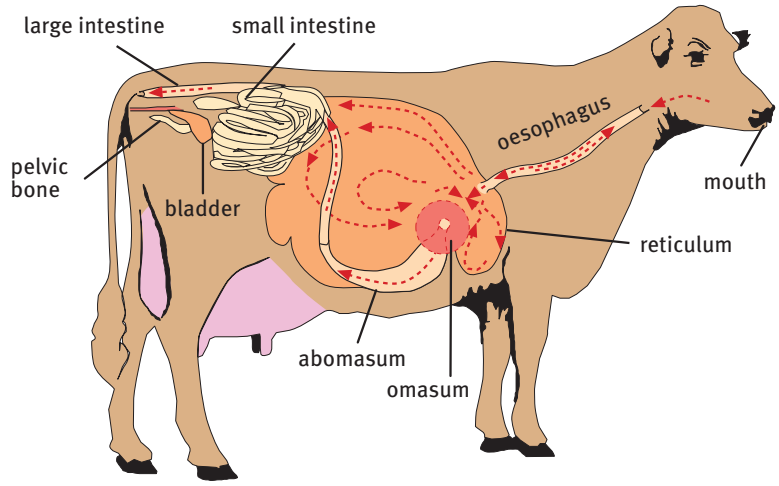


FIGURE 1 The external structure of the alimentary canal of a cow (ruminant)

Alimentary canal of non-ruminants: External structure

The main difference between the structure of the alimentary canal of ruminants and non-ruminants is that non-ruminants do not have forestomachs.

The alimentary canal of a pig

The pig is a typical non-ruminant. It has a true stomach and no forestomach (i.e. it has no rumen, reticulum or omasum). The alimentary tract contains these organs: mouth, oesophagus, stomach, small intestine and the small intestine (it can be sub-divided into the duodenum, jejunum and ileum).

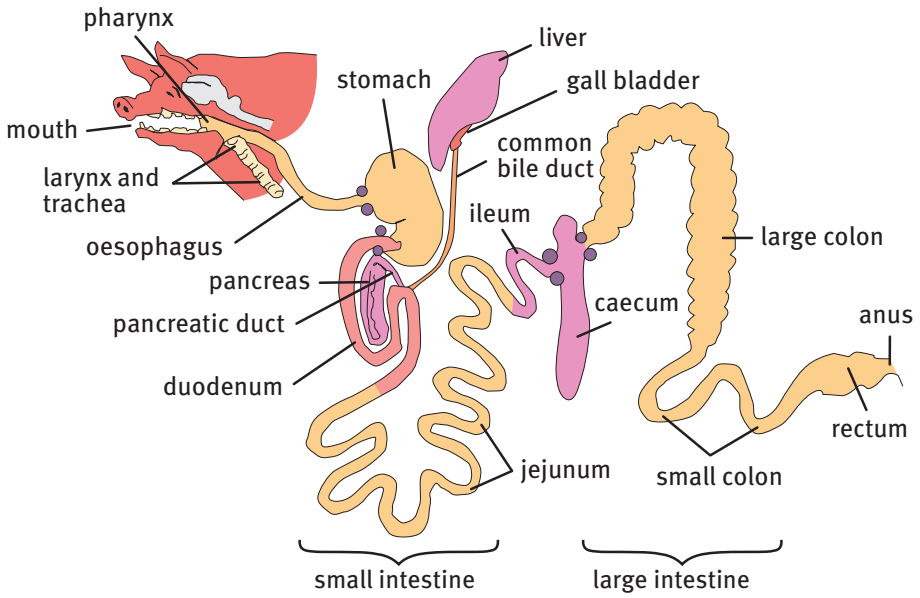


Figure 2 The external structure of the alimentary canal of a pig (non-ruminant)

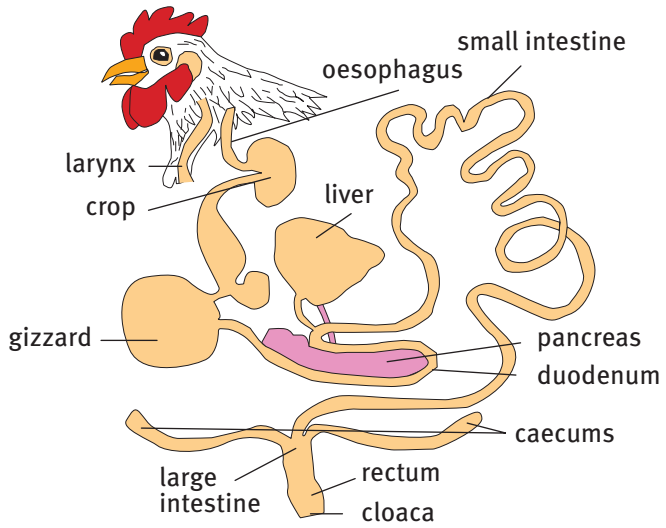


Figure 3 The external structure of the alimentary canal of a fowl (non-ruminant)

The alimentary canal of a fowl

The chicken is a non-ruminant so it does not have a forestomach. Instead, the oesophagus and stomach are modified to process the kind of food that fowls consume. The digestive tract of the chicken contains these organs: mouth, oesophagus, crop, stomach or gastric complex (divided into two distinct compartments, called the proventriculus and the gizzard), small intestine and large intestine.

The differences in the external structure of the alimentary canal of non-ruminants and ruminants is summarised in the table on the next page.

Differences in the external structure of the alimentary canal of non-ruminants and ruminants	
Alimentary canal of non-ruminants	**Alimentary canal of ruminants**
No forestomach	Forestomach (made up of rumen, reticulum and omasum)
Single simple stomach (or gastric complex in birds)	Abomasum functions as the simple stomach of non-ruminants
Small intestine is relatively short	Small intestine is very long

2 Internal structure of the ruminant alimentary tract

The alimentary tract of a ruminant is made up of the rumen, the reticulum, the omasum, the abomasum and the small intestine. This tract has some special internal modifications to assist digestion. These modifications can be seen in the structure of each organ.

- Internal structure of the rumen: The inside wall of the rumen is covered with small, tongue-like protrusions or papillae that can be seen with the naked eye. These papillae are specially adapted to absorb the breakdown products of microbial digestion, which are mainly volatile fatty acids. The papillae develop when the young ruminant begins to feed on forage and grain.
- Internal structure of the reticulum: The reticulum has a distinctive honey-comb appearance that helps to form fibrous food, such as grass, into lumps or boluses. These boluses are returned by the oesophagus to the mouth (regurgitation) where they can be chewed into finer particles. This process is known as chewing the cud or rumination.
- Internal structure of the omasum: The internal structure is composed of about one hundred folds, or leaves, which are arranged against each other like the pages of a book. The function of these folds is to squeeze water from the contents of the forestomach so it can be passed into the abomasum.
- Internal structure of the abomasum: The abomasum of ruminants is similar to the simple stomach found in non-ruminants like the pig. It has a smooth, slippery internal surface. The oesophagus enters the abomasum at the upper part. The upper part of the abomasum contains glands which produce hydrochloric acid, and the lower part contains glands which produce gastric enzymes.
- Internal structure of the small intestine: The small intestine of ruminants is moist. It appears to be smooth, but the small intestine actually contains microscopic, finger-like projections called villi. The villi increase the absorptive ability of the intestines.

Unit 2

Digestion in non-ruminants and ruminants

1 Digestion in non-ruminants

Digestion in non-ruminants is a combination of mechanical and chemical actions:

- mechanical action breaks food down into smaller pieces
- chemical action breaks the components of feed into their basic chemical constituents.

Intake of feed

Pigs take in their feed with their lips and they grip the food with their canine teeth. The tongue moves the food into the mouth and it is then chewed by the large molars.

The process of digestion

- Mouth
  - Mechanical: Mechanical breakdown of food into finer particles is called chewing. The tongue moves the food around in the mouth and then to the back of the mouth or throat where it can be swallowed.
  - Chemical: Saliva is secreted into the mouth in response to the presence of food. The saliva softens the food. The enzyme known as salivary amylase then begins the chemical breakdown of starch into the sugar called maltose.
- Stomach
  - Mechanical: Food passes from the oesophagus into the stomach. The stomach contracts and moves the ingesta around by muscular force.
  - Chemical: The mechanical action of the stomach mixes the hydrochloric acid (HCl) and digestive enzymes in the stomach with the food so that its chemical breakdown can begin. The hydrochloric acid produced reacts with the enzyme pepsinogen and forms pepsin, which breaks down proteins into smaller components called peptides. The digestive enzyme rennin reacts with the protein in milk, called caseinogen, and causes it to curdle or clot. The enzyme reaction forms the protein casein, which can be digested.
- Small intestine
  - Mechanical: The main function of the small intestine is to absorb nutrients that have been broken down into their basic components. The nutrients are absorbed through the villi by the processes of osmosis and diffusion, which you will learn about in detail later on in this unit. The absorption of nutrients is assisted by the mechanical contraction of intestinal walls.
  - Chemical: Various enzymes are released into the duodenum from the liver (bile) and the pancreas. They break down fats, protein and starches in the small intestine and some chemical digestion takes place.

- Large intestine
  - Mechanical: Most of the nutrients have been extracted from the ingesta once it reaches the large intestine. This organ re-absorbs water by the process of osmosis. The ingesta become harder and drier as it passes through the large intestine. The contents start to resemble the faeces that will pass out through the rectum. The mechanical contraction of the large intestine assists with the re-absorption of water and the movement of its contents.
  - Chemical: No chemical processes take place in the large intestine.

Functions of the accessory glands

Accessory glands play a role in digestion:

- Salivary glands
  - Found in the mouth and neck of animals. They are very important because they secrete saliva (spit), which contains water and mucous. These soften and lubricate the food, and allow it to move smoothly down the oesophagus. Saliva also contains an enzyme called salivary amylase, which breaks down starch to a sugar called maltose. Saliva dissolves the food components and allows the animal to taste the food and decide if it is suitable to eat or not.
- The liver
  - A large gland found in the abdomen. It has many functions in the body, including digestive, storage and metabolic functions.
- The pancreas
  - Lies in the curve of the duodenum in most animals. It produces the hormone insulin, which regulates blood sugar. It also has a function in digestion because it secretes pancreatic enzymes that break down proteins into peptides, starch into maltose, and fats into glycerol and fatty acids. The pancreatic juice also contains sodium bicarbonate, which neutralises stomach acids.
- Duodenal or intestinal glands
  - Glands that are found in the wall of the duodenum of the small intestine secrete various enzymes. The enzymes break down fats, sugars and proteins.
    - Duodenum of the small intestine: This is where bile and the digestive enzymes of the pancreas are secreted, to assist chemical digestion of fats, proteins and carbohydrates. Has glands which produce mucous to help neutralise and protect the intestine from the acidic gastric contents.
    - Jejunum and ileum of the small intestine: Here digestion and absorption take place.

      → Contains glands that secrete enzymes that break down some sugars and peptides.

      → Products of digestion are also absorbed here, through the micro-villi into the villi, where they are then taken up in the blood stream. Fats that are broken down are absorbed by the villi and then enter the lymphatic system.

2 Digestion in ruminants

The forestomach of the ruminant is designed to contain microbes and it provides them with a large storage vat (container) and a large amount of water.

Peristalsis: The wave-like motion of the circular muscles in the oesophagus and the small intestine. These circular muscles constrict behind the food mass that the animal has swallowed, pushing it forward, along the oesophagus or small intestine.

Rumination: Refers to the process in which food is returned to the mouth after it has been swallowed. This takes place so that ruminants can use their large, flat molars and premolars to grind food more effectively. Rumination is the result of regurgitation.

Regurgitation: The process by which food in the forestomach is returned to the mouth in the form of a lump of cud. It takes place by reverse peristalsis. It In this case, the muscular wave-like motion is upwards instead of downwards. As a result, the swallowed food is moved upwards, through the oesophagus, into the mouth.

Intake of food and chewing of the cud

Cattle use their long, mobile, muscular tongues to grasp their food. This is made possible by the rough surface of the tongue.

- The sharp, lower incisors help to cut the grass as it is pulled into the mouth.
- The food forms a loose mass, or bolus, in the mouth, but it is hardly chewed at all before it is moved by the tongue to the back of the throat and swallowed.
    - It moves down the oesophagus by the process of peristalsis, and this process is assisted by the large amount of saliva secreted into the mouth.
    - The food then enters the forestomach where the grass is mixed with water and coated in microorganisms by the contractions of the rumen.
    - The honeycomb surface of the reticulum trap the coarse, long fibres of the grass and squeeze them into a bolus, or lump.
    - The bolus is moved up the oesophagus and into the mouth by reverse peristalsis.
    - The food is then chewed again. Cows chew the cud, or ruminate, for up to eight hours each day. They make up to 40 000 chewing movements a day.

Differences in the digestive tract of mature and young ruminants

- The rumen, reticulum and omasum are all underdeveloped.
- The forestomach of the newborn ruminant is designed to digest milk initially.
- As the young ruminant grows older, it begins to graze and the forestomach also begins to develop. There is therefore a difference in size and functionality between young and mature (weaned) ruminants.

Size of the stomach compartments of mature and young ruminants

A major difference between mature and young ruminants = the size of their stomach compartments.

- At birth the rumen, reticulum and omasum of the calf are small and underdeveloped and the abomasum is the largest stomach.
- The rumen starts to enlarge in size when the calf begins to ruminate and it is functional when the calf is three months old.
- The rumen is the largest stomach compartment in a mature ruminant.
  - It is important to provide the young ruminant with concentrate and hay so that the rumen develops as soon as possible.

Functionality of the four stomach compartments in mature and young ruminants

The milk a newborn calf drinks bypasses the forestomach and enters directly into the abomasum, where it can be digested.

- The milk bypasses the forestomach due to the contraction of a muscular fold of the reticulorumen to form a groove, in response to neural stimuli.
  - This closure is stimulated by the process of suckling, the presence of milk and the anticipation of drinking. This reflex can also be triggered by feeding newborn calves with a bottle.
    - It is therefore important to bottle-feed calves until they can be taught to drink from a bucket.

The abomasum is able to absorb antibodies from the mother's milk and these antibodies enter the calf's bloodstream. But this process only occurs in the first 24 hours of life so it is important for the calf to get colostrum as soon as it is born.

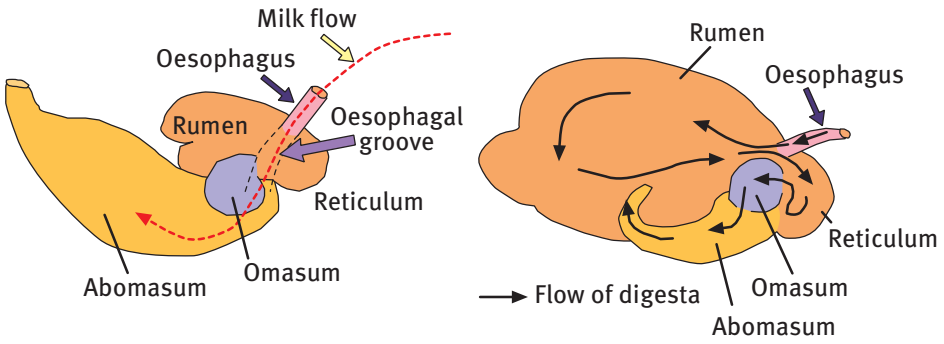


Figure 4 Difference in the route of the feed in a young (on the left) and a mature (on the right) ruminant. In the newborn calf, the closure of a fold in the reticulorumen forms the oesophageal groove down which the milk passes into the abomasum

3 Digestion in the rumen

The rumen is the main part of the forestomach where digestion takes place in ruminants.

- Rumen microbes are microorganism that live in the rumen → able to digest the cellulose of plants into basic nutrient components.
  - Different types of rumen microbes: rumen bacteria, protozoa, and fungi and yeasts.

Functions of the rumen microbes

Rumen bacteria are divided into various groups according to the substance that they break down, utilise or produce:

- the cellulolytic group (that break down cellulose)
- the methanogenic group (that produce methane).

Digestion of cellulose

Ruminants cannot break down cellulose.

- But rumen bacteria and protozoa produce the enzyme cellulase, which breaks down the cellulose in grass and other plants.
  - Cellulose is broken down into volatile fatty acids.

Synthesis of protein

Unlike ruminants, microbial organisms can synthesise amino acids from simple nitrogen-containing substances such as urea.

- The microorganisms use the non-protein nitrogen sources, like urea, to build their bodies.
  - The microbial protein is digested when the organisms die and used by the ruminant.

Requirements for rumen microbes to function normallly

Important requirements for normal functioning of rumen microbes or microorganisms.

- Water A large amount of water is needed in the rumen in which to suspend the microbial soup: about 50 litres (beef cattle) to 70 litres (dairy cows) of water per day.
- pH The rumen functions between pH 6 and pH 7.
- Muscular contractions The function of the rumen depends on regular contraction of the rumen wall muscles, which mixes the contents. The rumen wall contracts once or twice per minute.
- Fibre intake Regular and sufficient fibre intake by animals will keep the rumen microorganisms alive. Even if animals are fed concentrates such as maize, they still need to be fed hay to allow the rumen to function.
- Other nutrients Rumen organisms need a source of nitrogen such as proteins or urea. They also need some dietary carbohydrate.
- Temperature The rumen microbes grow at the body temperature of the ruminant host (37–39 °C.)

Breakdown of dietary protein

The microbes in the rumen break down the dietary protein of the ruminant. This product is then further digested in the abomasum and the small intestine.

Vitamin production

The rumen microbes can produce B vitamins and a small amount of vitamin K. Because of this, the ruminant does not need to obtain these in the feed under normal conditions.

Absorption of food in the rumen

Ruminants can absorb breakdown products of the digestive process, and other substances such as water, directly into the bloodstream through the papillae. Two processes are used:

- osmosis
- diffusion.

Absorption of water in the rumen

The rumen papillae absorb water by the process of osmosis.

- Water moves from the rumen across the membrane into the blood vessels when the water concentration in the blood vessels of the papillae is low.

Absorption of volatile fatty acids in the rumen

The ruminant's main source of energy is VFAs. VFAs are the end product of rumen fermentation.

- As the VFA concentration in the rumen increases, these molecules move across the membrane of the rumen papillae into the bloodstream.

Unit 3

All about feed and feed flow planning

1 Components of feed

The basic nutrients contained in animal feed: water, proteins, carbohydrates, fats, vitamins and minerals. Animals may develop certain diseases if their feed lacks one of these essential nutrients.

Water in feed

All feed contain a certain amount of water. It is not really a nutrient but water is essential for the function of the animal's body because it makes up 50–70% of its total volume. The body needs this high percentage of water to perform certain functions.

Important functions of water in animal feed

- It dissolves and transports chemicals to the cells of the body via the bloodstream.
- It is the medium in which all chemical reactions take place in the body.
- It controls the body temperature through sweating and panting.
- It moistens and lubricates joints and mucous membranes to allow them to function easily.
- It provides a shock-absorbing fluid around the brain to protect it from injuries.
- It allows the excretion of waste products in the urine.
- It provides tensile strength to the cells of the body.
- It allows dairy cows to produce large amounts of milk.

Animals become dehydrated if they do not drink enough water, and then they cannot function normally. Dairy cattle need a particularly high daily water intake.

Water requirements of various farm animals

Species	Frequency of intake per day	Daily intake in litres
Cattle	Twice a day	45 (beef cattle) 70 (dairy cattle)
Horses	Twice a day	Up to 50
Sheep and goats	Twice a day	Up to 10
Pigs	Must always have access	Up to 20
Poultry	Must always have access	0,2–0,5

Dry matter

Although water is vital, high moisture levels in feed can limit nutrient intake. The feed that remains when the water has been removed is referred to as dry matter (DM).

Formula for calculating DM

$$DM\ (g) = Total\ weight\ of\ feed\ (g) - Moisture\ content\ of\ feed\ (g)$$

It can also be expressed as a percentage using the formula:

$$\%\ DM = \frac{DM\ (g)}{Total\ weight\ of\ feed\ (g)} \times 100$$

Functions and importance of proteins in feed

Animals need to take in proteins as a source of amino acids. There are about 20 different types of amino acids which are required by various species. Animals can use these amino acids to synthesise their own proteins.

Functions of proteins in feed

Animals produce thousands of different proteins, each with their own specific function.

- Mechanical strength: Keratin gives strength to the tissues in the body. It is found in hair, nails, hooves, tendons and horns. Myosin is found in skeletal muscle which makes up the meat of the body. Myosin is also found in smooth muscle where it allows the movement of the internal organs such as in the alimentary tract.
- Oxygen transport: Haemoglobin provides the pigment found in red blood cells. It transports oxygen around the body and removes toxic carbon dioxide from the cells.
- Regulation of bodily functions: Hormones regulate or control certain functions. .
- Chemical reactions: A large number of chemical reactions take place in the body. Most of these reactions are catalysed by a special group of proteins called enzymes.

Importance of proteins in feed

Proteins, as well as fats and carbohydrates, can be broken down to provide energy, which powers the functions of the body. Proteins are also a source of amino acids for most animals. Each farm animal species needs particular essential amino acids to stay healthy and these are usually provided by the diet.

It is important to note that the rumen flora of ruminants can synthesise the amino acids that they need. This means that ruminants seldom need high quality protein unless they are very high producers like dairy cattle.

Functions and importance of carbohydrates in feed

Carbohydrates contain carbon, hydrogen and oxygen atoms in a 1:2:1 ratio. There are three main groups of carbohydrates.

Main groups of carbohydrates		
Carbohydrates	**Composition**	**Examples**
Monosaccharides or simple sugars	single monosaccharide or sugar ring	glucose; fructose
Disaccharides	two simple sugars	sucrose is composed of glucose and fructose
Polysaccharides	long chain of simple sugars	starches; cellulose; glycogen

Functions and importance of sugar

- Simple sugars are used as building blocks for other substances in the body.
- Sugars are also an essential source of energy for animals.
  - Chemical energy is released when the chemicals bonds between the atoms of sugars are broken.
    - This chemical energy is used to perform all the functions in the body.

Functions and importance of starch

- Starch is a polysaccharide stored in plants.
- Animals eat starch as part of their diet.
  - It is then broken down into the simple glucose rings which are used for energy.
    - Animals store the excess sugar in their liver as glycogen.

Functions and importance of crude fibre

Crude fibre is the main component of plant materials. It contains the polysaccharide cellulose.

- Cellulose is made up of long chains of simple glucose sugars which are held together by hydrogen bonds. These bonds make the chains very stiff and give grass and plant their structural strength.
  - Ruminants need the help of other organisms to break down cellulose into its glucose components.
    - The rumen microbes produce the enzyme cellulase which breaks cellulose down into its glucose subunits.
      → These are rapidly converted into volatile fatty acids.
      → These volatile fatty acids are the main source of energy for ruminants.

Fats and oils (ether extract)

Fats and oils belong to a group of compounds called lipids.

- Lipids contain mainly carbon and hydrogen atoms, but also some oxygen atoms.
  - Their subunits are called fatty acids which are long chain carboxylic acids.
    - Three fatty acid chains are bonded to a molecule of glycerol to form a triglyceride.

Oils are lipids found in plants and they are made up of saturated triglycerides. Fats are lipids found in animals and they are made of unsaturated triglyceride chains.

Functions and importance of fats and oils in animal production and growth

Fats and oils are better sources of energy than carbohydrates and proteins because they contain more energy per gram.

- Non-ruminants obtain essential fatty acids such as linoleic and linolenic acid from fats and oils.

Steroids are a special group of lipids and they can function as hormones.

- Fats form part of the structure of cell membranes and nerve cells.
- Lipids such as lanolin or wool fat protect the skin from the damaging effects of bacteria by waterproofing it.
  - Fat is laid down in animal tissues when there is an excess of energy in the diet.
    - Fat can be broken down and used when the animal's diet is low in energy.

Bio-chemical functions of macro-elements

Macro-elements are minerals required in large amounts by the animal body to ensure good health. They play a very important role in animal metabolism.

Summary of macro-elements

Macro-element	Description	Bio-chemical function	Deficiencies
Calcium (Ca)	A metal found in various forms in soil and water. It is taken up by plants, which animals then eat. Green leafy plants (e.g. legumes) are rich sources of calcium; animal meals (e.g. fishmeal and bonemeal) have high Ca levels; inorganic Ca supplements (e.g. ground limestone or di-calcium phosphate) can also be used as a source of Ca.	Gives structural strength to bones and teeth in animals and to the eggshells of birds. Ca is used to help transmit impulses between nerves and muscles and so is essential for them to function effectively. Ca is found in high concentrations in the milk of mammals because it is needed by the young to develop strong bones.	Deficiency may cause rickets in young animals. Dairy cows with a calcium:phosphorus imbalance develop milk fever that causes nervous symptoms and even death if untreated. Piglets may develop spinal cord damage because of bone deformities of the spine. Adult animals may develop osteomalacia Causes soft beaks and bones, eggs with soft shells or a drop in egg production in chickens.
Phosphorus (P)	A non-metal mineral found in soil and water. Plants need phosphorus for growth. P is not always accessible or soluble enough to be absorbed. Soils in South Africa tend to be deficient in P and often need to be supplemented in winter. Cereals and feeds of animal origin are usually high in P, while plants (e.g. hays and straws) are usually low.	Phosphorus, together with calcium, is important for bone formation. It is needed by cell membranes to function properly. P also plays an important role in carbohydrate metabolism.	Deficiency tends to cause slow growth, poor appetite and decreased milk production. Animals may develop pica which is a condition in which they chew old bones and tortoise shells. This habit can be harmful since animals may take in botulinum toxin which causes paralysis.

Summary of macro-elements			
Macro-element	**Description**	**Bio-chemical function**	**Deficiencies**
Magnesium (Mg)	A metal found in soil in various forms which can be absorbed by plants. It is usually found in abundance except in areas where irrigation or heavy rain has leached the mineral from the soil. Magnesium is found in many types of feed but it is found in a low concentration in grasses.	Needed by enzymes that transmit electrical impulses. It also plays a role in carbohydrate and bone metabolism, and cell osmosis.	Deficiency causes tetany in cattle and sheep. Tetany is a metabolic disturbance of the nervous system. The symptoms are excitability, muscular contractions, lack of coordination and sometimes death.
Sodium (Na)	A metal found in soil in various forms. Grasses and pastures are usually low in sodium while animal-based products have higher levels. Salt (NaCl) is often used to supplement the diet of animals.	Used to regulate osmotic pressure and maintain the pH of the circulatory system. It also helps the nervous system and the kidney to function properly.	Deficiency causes poor growth and protein utilisation in the body. It can also lead to poor egg production and growth results in hens. Sodium and chlorine deficiencies can be corrected by adding salt to the diet or providing salt licks for ruminants. However it is important to note that salt poisoning can occur if the salt intake is too high.
Chlorine (Cl)	Is a gas in its pure state, but it occurs in soil and water as various inorganic compounds called chlorides, e.g. sodium chloride (NaCl). Plants are usually low in chlorine while animal products are richer sources of the macro-element.	Helps to maintain pH balance and osmotic pressure in the body.	Deficiencies of chlorine in the diet of chickens will cause feather picking and cannibalism. Cattle with high production demands such as dairy cows can show appetite and weight loss, and they may also produce less milk.
Potassium (K)	A metal in its pure form; found in soil in various forms which can be used by plants. Potassium levels in grasses are generally very high, but may be low in some soils due to leaching.	Needed to maintain osmotic pressure and regulate pH in the body. It is also required for normal digestion and to transmit nerve impulses to muscles.	Deficiencies are quite rare in most farm animals. Low potassium levels in chickens can cause poor growth, weakness and muscle spasms.
Sulphur (S)	A non-metal found in soil in various forms. It can be taken up by plants.	Is a component of certain amino acids and vitamins. It is needed to produce certain hormones such as insulin. It also forms an important component of wool in sheep.	Deficiencies are rare in farm animals.

Bio-chemical functions of trace elements

Trace elements are inorganic minerals or micro-elements animals require in very small amounts to perform essential bodily functions. A lack of trace elements in the diet may affect animal health and production, while an excess of some may have toxic effects.

Summary of micro-elements

Micro-element	Description	Bio-chemical function	Deficiencies
Iron (Fe)	A metal in its pure form. However, it reacts with oxygen and other elements and it is readily available in soil as iron oxide and other iron compounds. Plants take up iron for their own metabolism.	Essential for the effective functioning of haemoglobin which transports oxygen around the body. Copper is also needed for the effective functioning of haemoglobin.	Causes anaemia in newborn piglets raised in intensive systems on concrete floors. Symptoms of anaemia are pale skin and membranes, weakness, listlessness and sometimes swelling of the head and shoulders.
Iodine (I)	A non-metal. It is found in soil and plants can take it up. The soil is deficient in iodine in some areas in South Africa, while in other areas certain plants or chemicals interfere with iodine metabolism.	The thyroid gland, which is situated in the neck, produces the hormone thyroxin. The thyroid gland requires iodine to produce this hormone.	Causes the thyroid gland to swell and form a goitre. Ewes with a deficiency give birth to lambs with an enlarged thyroid gland. Thyroxin controls growth, so young animals with a goitre show poor or stunted growth.
Zinc (Zn)	A metal in its pure form. It occurs in various forms in soil and is found in grains, yeast and animal products	Required for the health of the skin. It also helps to maintain general body condition and ensure effective testicular growth and function.	Causes parakeratosis, in pigs (skin becomes thick and rough) and in chicks. In chicks, causes stunted growth, foot abnormalities and frizzy feathers.
Selenium (Se)	A non-metal found in soil in various forms and can be utilised by plants. The mineral may be deficient in some soils, especially acid soils in high rainfall areas.	Is needed for the effective formation and function of muscle.	In calves, causes white muscle disease (skeletal muscles and the heart appear pale and abnormal). This causes stiffness of the muscles, but may also affect the smooth muscle of the body, sometimes causing death due to heart failure.
Copper (Cu)	A metal found in soil and water. It is taken up by plants and used for their metabolism. Soils are deficient in copper in certain areas of South Africa.	Needed for the effective functioning of haemoglobin, the protein which transports oxygen in the blood. Also necessary for the normal growth of hair and wool and is essential for the nervous system to function effectively.	In young lambs causes swayback (weak muscles due to poor nerve functioning and a tendency to sway and fall over). In older lambs the copper deficiency causes steel wool (wool is discoloured and lacks crimp).
Cobalt (Co)	A metal found in soils in various forms and can be used by plants. Sandy soils, such as those in coastal areas of South Africa, may be deficient in cobalt.	An essential component of vitamin B12. This vitamin is required for effective digestion of roughage, and normal growth and function of animals.	Causes a wasting disease in sheep and cattle, with symptoms similar to malnutrition. Animals show poor appetite, stunting, weakness, anaemia, decreased fertility, slow growth and poor production of milk and wool.

Vitamins

Vitamins are organic substances needed by living organisms in very small amounts to regulate various body functions.

- Farm animals either make vitamins in their bodies, obtain them from their feed or they can be produced by their microbial symbionts.
- Non-ruminants obtain most of their vitamins from their diet.
- Usually ruminants only need vitamin A from their diet, because their rumen microbes produce the other vitamins they need.

Water-soluble vitamins in feed

Water-soluble vitamins include the B complex vitamins (B1, 2, 6, 12) and vitamin C. Water-soluble vitamins cannot be stored in the body. They must be produced continually or taken in daily to maintain the good health of the animal.

- Vitamin B1 (also known as thiamine): Found in grains, green forage, hay and milk.
  - Functions of vitamin B1: It is a co-enzyme (helper to an enzyme) in the metabolism of energy, and so it is needed for the growth of the animal.
  - Deficiencies of vitamin B1: It causes poor appetite, slow growth and weakening of muscles in chicks. Pigs show poor appetite and growth, and may have lung problems.
- Vitamin B2 (also known as riboflavin): It is found in the same foods as vitamin B1.
  - Functions of vitamin B2: It is needed for various enzyme systems for energy as well as protein metabolism.
  - Deficiencies of vitamin B2: It causes curled toe paralysis in chicks. They walk on their hocks with their toes curled inwards due to nerve degeneration in their feet. Young piglets show poor appetite, retarded growth, vomiting, diarrhoea, and skin and eye problems.
- Vitamin B6 (also known as pyridoxal): It is found in cereal grains (e.g. wheat), legumes, liver and yeast.
  - Functions of vitamin B6: It is essential for amino acid metabolism and the release of glucose from glycogen.
  - Deficiencies of vitamin B6: It causes poor appetite, slow growth and excitability, and convulsions in some cases, in chicks and pigs. There is loss of appetite and reduced egg production in adult birds.
- Vitamin B12 (Cyanocobalamin is a synthetic form of vitamin B12): Good natural sources of vitamin B12 include protein-rich foods such as lucerne (also known as alfalfa), fishmeal and carcass-meal, and fermented products such as silage.
  - Functions of vitamin B12: It is an important co-enzyme in several bio-chemical processes. It is involved in the metabolism of propionic acid in the rumen of ruminants. It also plays an important role in the function of red cell maturation.
  - Deficiencies of vitamin B12: It leads to a lack of hind leg coordination and unsteadiness in pigs. The main symptom in hens is poor hatchability of eggs.
- Vitamin C (or ascorbic acid): Needed to keep blood vessels healthy. It can be synthesised by all farm animals and is readily available in green feed.

Fat-soluble vitamins in feed

The second main group of vitamins is called the fat-soluble vitamins. They can be stored in the liver when there is an excess intake.

- Vitamin A (sometimes called beta-carotene): The vitamin must be ingested, even in ruminants. It is found in green pastures, yellow maize, yellow vegetables, hay and silage.
  - Functions of vitamin A: It is essential for the health of the mucous membranes. This includes the eyes and the reproductive system. Cells also need vitamin A to function normally.
  - Deficiencies of vitamin A: It leads to a rough and dry hair coat, as well as eye problems in cattle. Night blindness can occur in severe cases. Chickens that are deficient in vitamin A can die from bacterial infections.
- Vitamin D (also known as alpha-tocopherol): The action of sunlight on the skin synthesises vitamin D, but it is also available in hay. Young animals raised in houses will become vitamin D deficient if they do not get enough of this vitamin from their feed.
  - Functions of vitamin D: It is essential for normal absorption of calcium and phosphorus from the gut. Vitamin D is also needed for calcium and phosphorus metabolism.
  - Deficiencies of vitamin D: It could lead to rickets in young animals and osteomalacia in adult animals.
- Vitamin E: Contained in whole grains, green forage, good quality hay, and oil seeds.
  - Functions of vitamin E: It is essential for the metabolic regulation of the cell nucleus. It protects phospholipids from oxidative damage.
  - Deficiencies of vitamin E: It can complicate a selenium deficiency in young animals because vitamin E and selenium have similar functions. A vitamin E deficiency causes a muscle problem called white muscle disease which results in muscle stiffness and sometimes heart failure. Deficiency of this vitamin in adult animals may lead to reproductive failure.
- Vitamin K: Some farm animals produce their own vitamin K. But others need to obtain it from green pastures and good quality hay.
  - Functions of vitamin K: It is essential for the formation of prothrombin. The protein prothrombin is essential for blood clotting.
  - Deficiencies of vitamin K: It is seldom found in ruminants as they use microbial organisms to produce their own vitamin K. But a shortage may arise when cattle eat a toxin called dicoumarol found in spoiled sweet clover. Dicoumarol destroys vitamin K which results in slower blood clotting after injuries, and even fatal bleeding in some cases. Chickens suffer from this deficiency if they do not get enough vitamin K in their diet. In birds the signs of deficiency are anaemia which is noticeable by their pale combs. They may also bleed under the skin.

2 Digestibility of feed

Farmers need to know whether feeds available will meet the nutritional requirements of the animals being fed. There are different ways to measure this.

Digestibility and digestibility coefficient of feeds

- Digestibility of feed refers to the amount of the feed which is not excreted in the faeces and is therefore assumed to be absorbed by the animal.
- It is expressed in terms of dry matter, either as a coefficient or as a percentage.
  - High quality feeds have greater digestibility values which mean that more of their nutrients can be absorbed.

Digestibility coefficient of feeds

The digestibility coefficient is expressed as the amount of dry matter contained in the feed minus the amount excreted in the faeces, as a fraction of the dry matter. The answer can be expressed as a coefficient or it can be converted to a percentage.

Factors affecting feed digestibility

- **Animal species:** Ruminants digest high-fibre feeds better than monogastrics. This is because ruminants have rumen microbes to assist digestion. Both groups digest low-fibre feeds well. Sheep digest whole cereal grains better than cattle do, because sheep chew the grain rather than swallow it whole.
- **Feed composition:** The presence of the woody substance, lignin, decreases feed digestibility. Straw has poor digestibility because it has a high percentage of lignin.
- **Ration composition:** The other foods included in the ration may affect the digestibility of a feed component. For example, the presence of a large amount of carbohydrate in the ration may decrease the digestion of cellulose because of changes to the rumen environment.
- **Processing:** Processing can improve the digestibility of feed. For example, processes which break up the feed into smaller pieces can increase digestibility.
- **Size of the meal:** Large meals pass rapidly through the digestive tract. This will reduce the amount of digestion and therefore lower the digestibility.
- **Age of plants fed to the animal:** Young plants are usually more digestible. This is because older plants contain more indigestible lignin.

Methods to improve or increase feed digestibility

Methods to improve the digestibility of feed involve processes that change the physical nature of a feed.

- Mechanical breaking of feeds
  - Grinding, crushing and rolling are ways of increasing digestibility of grain feed. This makes it easier for older cattle and calves to chew the feed and it improves the taste. Birds raised in intensive systems perform better when their feed is ground. However, feed must not be ground too fine. Grinding roughage reduces the digestibility because it passes through the gastrointestinal tract more rapidly.

- Pelleting
  - Pelleting is another method of improving or increasing the digestibility of feeds, such as lucerne hay. The intake of pigs and poultry improves when they are fed pelleted meal. This is because pelleted meal is easier to eat.
- Heating
  - Another method of improving digestibility of feeds is heating. For example, grain can be boiled or roasted to soften it and expand the germ. This makes the grain more digestible. It is also more palatable than raw grain so animals will eat more. Cooking improves feeds that contain digestive enzyme inhibitors, like potatoes and root vegetables, which contain trypsin inhibitors. This is because the heat of the cooking process destroys these inhibiting factors.
- Additives
  - Additives can be added to feed to improve or increase their digestibility. For example, a NPN source such as urea can be added to carbohydrate-rich feed like grain to increase digestibility in ruminants. This occurs because it provides a nitrogen source for the rumen microbes. Poorly digestible feeds like straw can be treated with an alkali such as ammonia. This improves their digestibility coefficient by separating the lignin and cellulose, allowing microbes to digest the cellulose compound.

Calculating and interpreting the digestibility coefficient of a feed

The formula for measuring the digestibility coefficient (DC) is shown below, with an example of how to calculate DC.

$$DC = \frac{DM\ (g) - DM\ excreted\ in\ faeces\ (g)}{DM\ (g)}$$

Note that the moisture content of the feed and faeces must be known or estimated to do the calculation. This information can be found in agriculture handbooks and on the Internet.

Interpreting of the DC of a feed

A higher the DC or percentage of digestibility means that more nutrients can be absorbed from the feed. It therefore allows us to compare the value of various feeds for a particular species. This is important because each species digests feed differently. It also allows us to evaluate how various processes or additions affect the digestibility of feed.

Calculating the digestibility coefficient of a feed

A cow eats 15 kg of hay which contains 10% water and passes 5 kg of dry matter in the faeces. Calculate the DC of the feed and express it as a coefficient and a percentage.

The hay contains 1,5 kg water (10% of 15 kg). So the amount of dry matter (DM) eaten is 15 kg – 1,5 kg = 13,5 kg. Now you can apply the formula.

$$DC = \frac{13{,}5 - 5}{13{,}5} = 0{,}63$$

You can multiply the coefficient by 100 to express it as a percentage. So the feed digestibility is 63%.

3 Quality of feed: Biological value of proteins

A rough measure of the protein content called the crude protein (CP) content, is used to work out the amount of protein in an animal's ration.

- CP is calculated using the Kjeldahl method which measures the total amount of nitrogen, including non-protein nitrogens (NPN).
  - This method is only relevant for ruminants since they can utilise NPNs. We need other ways to evaluate the protein content for non-ruminants in terms of the amino acid content.

Importance of animal proteins in rations

Animal proteins in rations are needed for three processes in the body.

- Growth: Young animals need protein for tissue growth.
- Production: The production of milk, eggs and meat requires an extra intake of protein in the diet.
- Reproduction: Animals require additional proteins to produce and feed their young.

Evaluating quality of protein in feeds

- Biological value (BV):
  - BV refers to the ability of a specific feed protein to fulfil the nutritional needs of an animal. It is a measure of how much nitrogen is available for metabolism and growth. A feed with a high BV provides all of the amino acids needed by the animal, whereas a feed with a lower BV does not.
    - The BV is determined by measuring the amount of nitrogen retained by the body. This is equal to the amount of nitrogen in the food ingested minus the amount of nitrogen excreted.
- Essential amino acid index
  - This index is the ratio of the amount of the 10 essential amino acids contained in a feed relative to the amount of amino acids in egg protein.
    - The ratio is calculated relative to egg protein because eggs have the ideal amino acid content.
- Ideal proteins
  - An ideal protein supplies all essential amino acids in the right amounts. This means that the protein has the optimal nutritional quality.
    - An example of an ideal protein is the protein found in eggs. It is used as a standard for comparison with other proteins.

Evaluation of biological value of feed protein

The BV of egg protein is considered to be 100. This is because it contains all 10 essential amino acids, in the right proportions. The BV of milk as a feed protein is also relatively high, namely 80. It is richer in the amino acid lysine than egg protein, but its nutritional quality is limited by a deficiency of the sulphur-containing amino acids methionine and cysteine.

4 Energy value of feed

Most of the ration is used to provide energy for the animal.

- Energy can be obtained from carbohydrates (including fibre in the case of ruminants), fats and proteins.
- Food contains chemical energy which can be converted into mechanical energy.
  - The mechanical energy is used to power muscular action (movement), as well as for the chemical powering of basal metabolism (maintenance), and growth and production of meat, milk and eggs.
    - Excess energy can be stored in the body as glycogen in the liver or as fat in and around the muscles and organs of the body.
    - Some food energy is lost in the form of radiant heat (into the environment). Energy is also lost when urine and faeces are excreted.

Units in which energy value is expressed

Energy contained in feed is expressed in joules (J). One joule of energy is defined as the amount of energy needed to perform the work needed to exert a force of one newton over a distance of one metre.

To understand the flow of energy from feed through the animal body you need to understand some terminology.

- Gross energy
  - Gross energy (GE) is the total amount of chemical energy contained in feed. It is determined in a laboratory using an apparatus called a calorimeter.
    - The gross energy of food is not the total amount of energy available to the animal because energy can be lost in various ways.
- Digestible energy
  - Digestible energy (DE) is the energy available after subtracting the energy lost in the faeces from the gross energy contained in the feed.
- Metabolic energy
  - Metabolic (or metabolisable) energy (ME) is the energy available in feed after the energy lost in the excretion of urine and methane gas production has been subtracted from the digestible energy.
    - Metabolisable energy is measured in megajoules (MJ). It used to be referred to as total digestible nutrients or TDN.
- Nett energy
  - The nett energy value of feed is the quantity of energy that remains after the energy lost in the form of heat has been subtracted from the ME.
    - It is the proportion of energy from the feed that is available for the animal to do work, grow, fatten, reproduce, lay an egg, produce milk and keep itself warm.

Purpose of calculating energy value of feed

The energy value of feed is calculated:

- to ensure that animals are given a balanced feeding programme
  - that provides them with sufficient ME so that
    - they have adequate nett energy to carry out functions, such as body maintenance and reproduction.
- The flow of food energy through the animal can be represented schematically, as shown below.

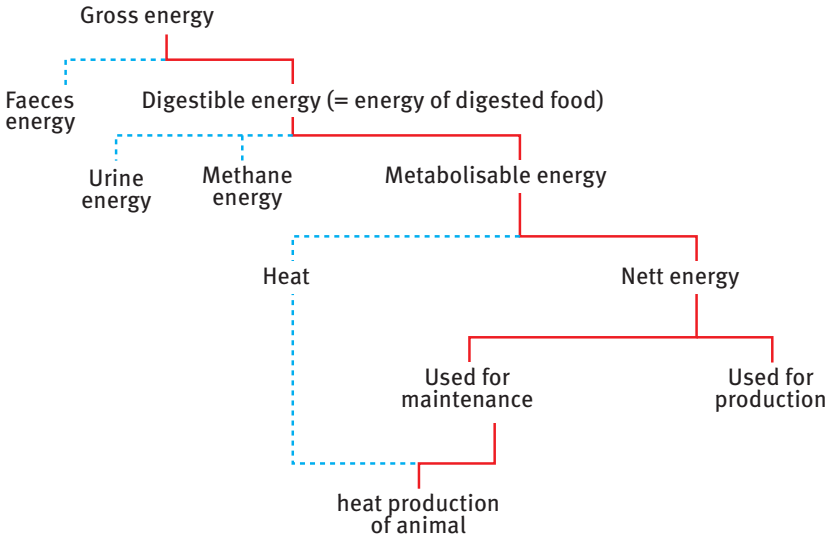


FIGURE 5 Schematic representation of energy flow in an animal

Calculation of feed energy flow and interpretation of the results

The formulae below, which used gross energy (GE) as total energey intake, can be used to calculate the:

- digestible energy (DE)
- metabolisable energy (ME)
- nett energy (NE).

DE = GE – Energy in faeces

ME = DE – Energy in urine and methane gases

NE = ME –Heat energy lost

Nett energy represents most accurately the energy that is available to the animal for maintenance growth, production and warming.

5 Nutritive value and nutritive ratio

Animal feeds vary in the amount nutrients they contain. Nutritive needs of livestock differ, depending on their production cycle.

- It is therefore important to know the nutritive value of a feed and the requirements for each domestic animal species in each of their production cycle phases, such as:
  - reproduction, lactation and growth.

Nutritive value of fishmeal	
Nutrient	**Value**
Calcium	20 g/kg
Crude protein	730 g/kg
Oil	70 g/kg
Phosphorus	15 g/kg
ME: Ruminants ME: Poultry	17,8 MJ/kg DM 14,9 MJ/kg DM
DE: Pigs	19,6 MJ/kg DM

- A nutritive ratio (NR) is used to express the relationship between various components in a ration.
  - The most commonly used ratio is the relationship between digestible protein and the total non-protein energy in the feed or ration.
  - It is used to determine whether or not a feed is suitable for:
    - a specific animal species during a specific phase of its production cycle OR
    - the fattening phase during the production cycle of a specific animal.

Calculation of the nutritive ratio of a feed

$$NR = \frac{\textit{Percentage digestible carbohydrate + percentage of fat – \% digestible protein in the feed}}{\textit{Percentage digestible protein}}$$

e.g. $1: \frac{63\% + 9\% - 8\%}{8\%}$

$= 1: \frac{64\%}{8\%}$

$= 1: 8$

Interpretation of nutritive ratio in a feed
Ration or feed that contains a protein: Total non-protein NR of 4 to 5 is usually suitable for growth as it has high protein while a feed with an NR ratio of 7 to 8 will be best suited for the fattening phase.

Other ways of determining and expressing this important ratio are:

- NR = 1: carbohydrates + $\frac{\text{fats}}{\text{proteins}}$, or
- NR = 1: $\frac{\%\text{Total Digestible Nutrients (TDN)} - \%\text{ Digestible Protein(DP)}}{\%\text{DP}}$, or
- NR = 1: $\frac{\text{non-nitrogenous energy}}{\text{digestible protein}}$.

6 Types of feed

Animal feeds can be subdivided into roughages and concentrates based on their origin and fibre content.

- Roughages are bulky feed of plant origin with a high weight to volume ratio, because of its relatively high fibre content.
- Concentrates have a low weight to volume ratio because they are low in fibre and weigh less.
  - They have a high percentage of either protein or carbohydrates.

The characteristics of roughages and concentrates

- Roughages (often called forage or fodder). Roughages are mainly used to feed ruminants as they contain cellulose, which only rumen microbes can digest.
  - Contain various amounts of plant fibre, which depends on the type and age of the plant. Roughage is high in young pasture grass and legume pastures, but low in straw and hulls.
    - Some roughages contain as much as 50% crude fibre.
    - Their protein and mineral content also varies.
    - Roughages can be rich in protein, such as legume pastures like lucerne, but they are usually low in energy.
    - Examples of roughages include veld grass, browse (trees or shrubs), planted grass pastures, hay, plant residues and silage. Concentrates
- Concentrates can be of plant or animal origin. Both ruminants and non-ruminants can be fed concentrate diets.
  - They have high levels of protein or carbohydrates, depending on their type.
    - Carbohydrate-rich concentrates include grains such as maize, barley and sorghum.
    - Oil seed cakes and seeds like groundnuts and soybeans are protein-rich concentrates.

> Forage refers to plants that are eaten where they grow, whereas fodder refers to plants which are harvested and taken to animals.

Description of types of roughages

- Forage
  - **Veld grass:** It is the most commonly grazed roughage. Young grass is softer and contains less fibre than old grass which becomes hard and dry towards the end of the season.
    - Veld grass can also be mowed to dry it and used as a hay. It is then classified as fodder.
  - **Trees for browsing:** Cattle browse the leaves of trees and shrubs in the veld. Some exotic trees like leuceana, carob and mesquite have been planted to feed livestock because their leaves are rich in nutrients.

- Fodder
  - **Planted grass pastures:** Kikuyu grass can be grazed or it can be cut to use as a hay feed.
    - Legumes like lucernes are pastures with very high protein levels.
  - **Acacia pods:** *Acacia* trees produce protein-rich pods which can be used to feed animals in the winter.
    - The pods must be collected when they are dry as some green pods can be poisonous.
  - **Crop residues:** Examples of crop residues include maize cobs and stover (leaves and stalks), husks of peanuts and peanut hay which is made from the plant after the peanuts have been harvested.
    - Most crop residues are high in fibre and low in energy.
  - **Vegetable residues:** Examples of vegetable residues include rape, pumpkins, sweet potatoes and cassava. These can be used to feed non-ruminants such as pigs and poultry. Free-range hens, in particular, need some green feed to supply them with vitamin A. This will give their yolks a deep yellow colour.
    - Kitchen waste can also be fed to free range non-ruminants like pigs and chickens.
  - **Silage:** This is plant material which is placed in a silo where it undergoes bacterial fermentation.
    - Various plant materials such as grasses, legumes, maize, and fruit and vegetable residues can be used to produce silage.
    - The advantage of silage is that it can be stored for long periods and then used for winter feeding when other feeds are less available.

Description of types of concentrates

Feed concentrates are dried forms of animal feed that have had their water removed.

- **Plant protein concentrates**: They are derived from legume seeds such as soybean and chickpeas.
  - Oil seed crops such as groundnuts and sunflowers are an important source of protein for animal feeds.
  - The oil is extracted from these crops and the protein-rich remains are made into a type of cake to feed animals.
- **Animal protein concentrates**: They contain a higher percentage of proteins than plant concentrates. For example:
  - fishmeal contains 60% protein whereas the plant protein concentrate soybean meal only contains 45% protein.
- **Carbohydrate concentrates**: They come from cereal grains such as maize, wheat, sorghum and oats. They are usually mixed with other feed to make rations.
  - They contain less than 10% crude protein but contain a high percentage of digestible carbohydrates.
    - Cereal grains have to be crushed so that animals can digest them.

- **Mixed feeds:** They are the main type of feed that is used for non-ruminants. Farmers either make mixtures or feed companies sell them.
  - Different formulations are made according to the animal species, age and stage of production.
    - Mixed feeds are available as meal, cubes, pellets, cakes, mash or crumbs.

The schematic representation of different types of animal feeds

Animal feeds are derived from various sources. The schematic representation below shows the origins and derivations of the various types of feed.

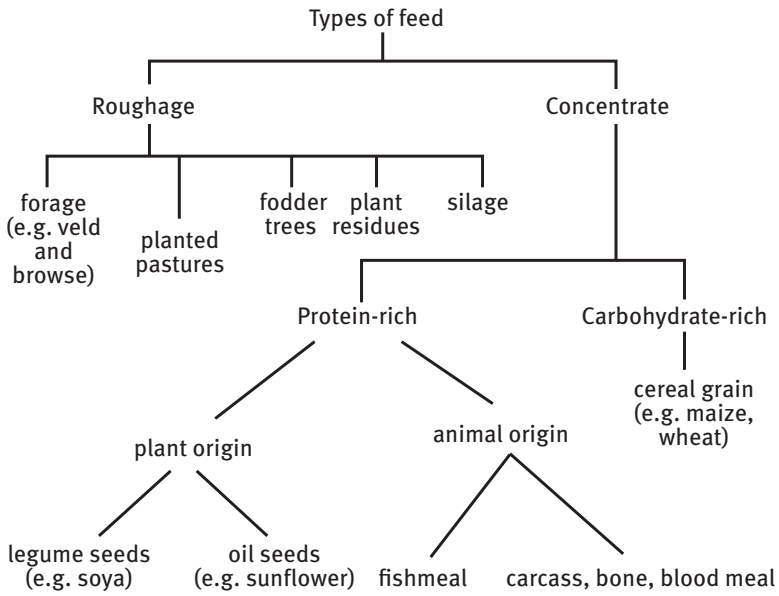


FIGURE 6 Schematic representation of different types of animal feeds

The functions (importance) of roughages and concentrates

The two categories of feed, roughages and concentrates, have different roles to play in the nutrition of farm animals.

The functions (importance) of roughages	The functions (importance) of concentrates
Roughage is the main source of feed for ruminants raised in extensive conditions. However, even ruminants raised for intensive production need a certain amount of roughage to maintain the rumen function. Except for vegetable residues, roughages do not make up a large portion of the non-ruminant diet because they cannot use the fibre for energy as ruminants can.	**Protein-rich concentrates** are a very important food source for non-ruminants such as pigs and poultry. These concentrates supply essential amino acids which the animals need from their diets. The protein in these concentrates can also be utilised by ruminants. The ruminants break down protein concentrates and use them as an energy source. **Carbohydrate-rich concentrates** are an important source of energy for non-ruminants, but they are also used for high-producing ruminants. These concentrates are used as additional feeds for dairy animals, feedlot cattle and beef calves that need to be fattened.

7 Subdivision of feeds based on nutritive content

Feeds can be subdivided into two groups based on their main source of energy, namely carbohydrate-rich and protein-rich type feeds.

Comparison between protein-rich and carbohydrate-rich type feeds

Type of feed	Main energy source	Food sources
protein-rich	high protein levels	animals: milk powder, fishmeal, carcass-meal, blood meal; plants: legumes (lucerne and clover), beans (soya)
carbohydrate-rich	high carbohydrate levels	cereal grains (maize, wheat, oats) and oil-rich seeds (sunflower)

8 Feed supplements

A supplement refers to a nutrient (e.g. mineral; vitamin) which is added to the ration to improve its quality. Supplementation of rations is required under certain conditions.

Mineral supplements

Mineral supplements are needed when soils and thus the plants that animals eat are deficient in certain minerals. Here are some examples of mineral supplements used in livestock farming.

- **Calcium and phosphorous supplementation:**
  - Given to cattle in late summer and winter to supplement the low phosphorus in veld grass at this time of the year.
  - It can be supplied in the form of a lick, to which salt is added to make it attractive to animals. The salt component of the lick also supplements the sodium and chlorine levels which are usually low in veld and pastures.
    - Licks must always be kept dry, and animals must have access to drinking water at all times to prevent salt poisoning.
- **Iron injections:**
  - These are given routinely to day old piglets in piggeries to prevent the development of anaemia.
- **Mineral supplements:**
  - They can be given to correct rare cases of copper, cobalt and iodine deficiencies.
    - This must be done with caution to prevent poisoning.

Vitamin supplementation of rations

Non-ruminants on a poorly balanced diet may need supplementation when vitamin deficiencies occur. Cattle and sheep fed on dry hay or winter forage may need vitamin A supplementation. Add vitamin A to their feed or, preferably, give them regular vitamin A injections as directed by the manufacturer.

Commercial feeds for non-ruminants like pigs and poultry contain all the essential vitamins needed to ensure a balanced diet.

Non-protein nitrogen (NPN) as supplements

The protein content of forage like veld grass drops is too low to sustain production during the winter months.

- So ruminants must be given NPN like urea because their rumen microbes can use this to synthesise amino acids.
  - Urea is a white crystalline powder that is made by combining air with water and it contains about 46% nitrogen.
  - It can be given in the form of a solid commercial lick block or as a mixture made up by the farmer. The mixture contains the energy sources molasses or maize meal, as well as urea, salt and di-calcium phosphate.
    - The urea mixture must be made up carefully because urea poisoning can occur if an excess of urea is given.

Growth stimulants

Growth stimulants are chemical compounds which can be added to feed or given by injection to improve the growth of various farm animals.

Note that all growth stimulants must be used with care and in consultation with a veterinarian.

- Antibiotic growth stimulants
  - These are antimicrobial substances used to suppress microorganisms which cause disease or which may interfere with the uptake of nutrients in the gastro-intestinal tract.
  - The product must be chosen based on the animal species to be treated. For example:
    - tetracyclines are used for feedlot cattle, ionophores are used for pigs and poultry, and flavophospholipol is used for cattle on winter veld to improve fibre digestion.
- Repartitioning agent (beta agonist)
  - The substance clenbuterol is used in feedlot cattle to promote muscle growth rather than the deposition of fat.
    - This will provide the leaner carcasses which are demanded by the commercial meat market.
- Hormones and hormone mimics
  - The hormones testosterone and oestrogen cause retention of nitrogen which results in better muscle development. These products can be used in feedlot cattle but not in breeding animals.
    - The hormone BST is used to increase the milk production of dairy cattle.

9 Planning a feed flow programme

A feed flow programme is a plan for the year to ensure continual and acceptable nutritional levels for animals in all stages of growth and production. Feed flow planning requires knowledge about the basic nutritional requirements of the farm animals and whether they need additional nutrients to meet growth and production demands.

The single Pearson Square method for feed formulation

It is a simple and effective method used to calculate the proportions of two different feeds required to achieve a desired nutrient percentage. It can be used to calculate the percentage of any desired ingredient, for example crude protein or fibre content.

How to formulate a ration which contains 12% crude protein (CP)

Two available feeds are combined to provide a source of grain (maize, CP 8%) and protein (soya bean meal, CP 36%).

1 Draw a square and place the desired CP content, in this case 12%, in the centre of the square.

12

2 Write the % CP of the two feeds near the left hand corners of the square.

soya 36%

12

maize 8%

3 Subtract the value inside the square from each value near the corner of the square. Write each answer near the corner which is diagonally opposite in the square. Always subtract the smaller value from the larger one (for soya: 36 – 12 = 24; for maize: 12 – 8 = 4). These answers on the right hand side of the square represent units or measures of the two feeds.

soya 36% 4

12

maize 8% 24

4 So we need to add 24 parts of maize to 4 parts of soya. There are a total of 28 parts of feed. To convert these values to percentages, calculate the proportion which each feed makes up of the whole (28) and multiply the answer by 100.

Maize $(\frac{24}{28}) \times 100 = 14{,}3\%$

Soya $(\frac{4}{28}) \times 100 = 85{,}7\%$

Interpretation of the results (in step 4)
If you want to make 100 kg of mixed feed which contains 12% CP, then you need to add 14,3 kg soya (14,3% of 100 kg) to 85,7 kg of maize (85,7% of 100 kg).

Topic 1

Topic questions

- Answer the questions below. Check your answers afterwards and do corrections.
- Give yourself one hour.
- Marks: 100

1 State the three types of digestive processes that take place in ruminants. (3)

2 Describe the function of saliva in the digestive process. (3)

3 The bovine stomach consists of four compartments.

3.1 Name the compartments. (4)

3.2 Explain the role of each one briefly. (8)

4 All ruminants regurgitate their feed.

4.1 Outline the process of regurgitation in a ruminant. (4)

4.2 Explain the importance of regurgitation in the digestive process of a ruminant. (3)

5 Which components of feed can animals use for energy? (3)

6 Give ONE word/term/phrase for each of the following descriptions:

6.1 Roughage with a high moisture content which is mostly used as a feed source for dairy cattle

6.2 A nutrient supplement that is placed in a pasture field to provide the grazing animals with additional nutrients (2)

7 Name five main categories of nutrients in feed. (5)

8 The _____ is responsible for the grinding of food by means of small stones found in it.

8.1 crop

8.2 ventriculus

8.3 proventriculus

8.4 caecum (2)

9 Trace elements are important for the production of healthy red blood cells.

9.1 Name these trace elements. (2)

9.2 What condition results from a deficiency in these elements? (1)

Topic 1

Topic questions

10 What nutrient deficiency causes each condition below?

10.1 parakeratosis;

10.2 curled toe paralysis;

10.3 night blindness;

10.4 milk fever;

10.5 white muscle disease (5)

11 Name five essential functions of proteins in the body. (5)

12 Food supplies animals with energy for metabolic processes and to grow and reproduce.

12.1 What kind of energy does food contain? (1)

12.2 What other kinds of energy can it be converted into by animals? (2)

13 Cellulase is an enzyme that is found in the rumen of a _____.

13.1 horse.

13.2 fowl.

13.3 pig.

13.4 goat. (2)

14 Name FOUR methods of processing that can be used to improve the digestibility of feed. (4)

15 Name three main characteristics of concentrates. (3)

16 Give four examples of feed concentrates. (4)

17 Non-protein nitrogen sources can be used to supplement protein in the ruminant diet.

17.1 Briefly explain why. (2)

17.2 Briefly explain how this is achieved. (3)

Topic 1

Topic questions

18 What is the single Pearson Square method? (1)

19 Explain the difference between a maintenance and production ration. (4)

20 Examine the table below and answer the questions that follow.

Feed	Crude protein (%)	Crude fibre (%)	Metabolisable energy (MJ/kg)
Lucerne pasture	22,5	25,8	9,4
Wheat pasture	12,3	15,5	10,5
Veld grass (summer)	7,0	36,0	8,0
Lucerne hay	14,1	30,1	7,5
Groundnut hay	9,2	24,1	8,7
Maize stover	5,8	27,1	6,8
Oat hay	8,2	28,1	7,1
Soybean meal	45,8	5,8	11,6
Milk powder (skim)	33,5	0,0	12,0
Maize meal	8,9	2,0	12,0
Blood meal	82,2	0,0	9,1
Fishmeal	60,9	0,0	10,6
Ground nut oilcake	45,3	12,6	11,4
Sorghum grain	11,0	1,7	12,2

20.1 Name the four feeds with the highest crude protein content. (4)

20.2 Which feeds identified above are examples of protein-rich animal concentrates? (2)

20.3 Which of the feeds named above are examples of legumes? (2)

20.4 Which feed has the highest crude fibre content? (1)

20.5 Is the feed you named above usually eaten by non-ruminants? Why or why not? (3)

20.6 Which four feeds have the highest ME content? (5)

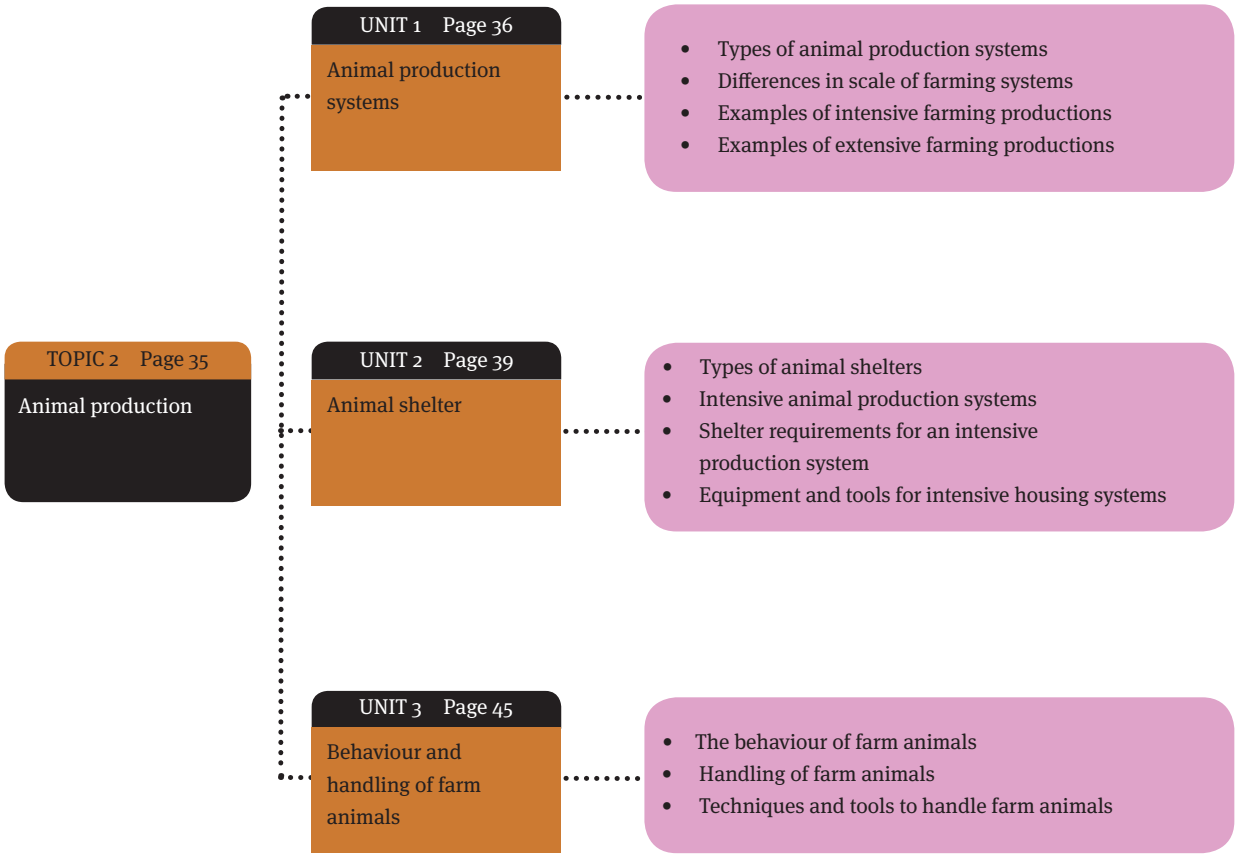
20.7 Classify the feeds you identified above as roughage or concentrates. (3)

20.8 For each feed that you identified above, name the feed component that gives it a high metabolisable energy. (4)

Topic 2

Animal production

Overview



Unit 1

Animal production systems

1 Types of animal production systems

The different ways to raise farm animals are called production systems. The two main production systems are intensive and extensive production systems. They are used in the two main types of farming systems: large-scale (commercial) farming and small-scale (or subsistence) farming.

Differences between intensive and extensive production systems		
	Intensive systems	**Extensive systems**
Surface area used	small area	large area
Number of animals	large number of animals	small/large but spread over large area
Nutrition	food provided	animals forage for themselves but food can be provided
Housing	specialised, usually closed housing needed	simple shelters or open housing
Marketing	supplies markets	can be for markets or own use

Differences between small-scale and large-scale farming systems		
Factors	**Small-scale or subsistence farms**	**Large-scale or commercial farms**
Size of farm	small	large
Number of animals	small	large
Purpose of farming	own use	commercial markets

2 Examples of intensive farming production

Three common types of intensive farming production are:

- **feedlots:** young sheep and cattle are kept in small camps and fed rations which will fatten or grow the animals to market readiness
- **commercial dairies:** large numbers of lactating cows are fed and milked
- **broiler production:** large numbers of birds are raised in well-designed poultry houses.

Factors to increase animal production under intensive farming

Raising animals in intensive systems allows an increase in production. Various factors must be addressed to achieve this. We look at broiler production as an example.

- Nutrition and feeding
  - Commercial broilers are hybrid birds that are selected for their ability to grow rapidly when fed a nutrient-rich diet. This ensures that the broiler is ready for the market at roughly 30 days of age.

- Environment
  - Broilers are generally raised in well-designed houses:
    - where they are fed good quality food so they do not have to use energy looking for food
    - that protects the animal from the excesses of the weather which can cause disease and death, and which can reduce their food intake
    - that have artificial lighting in winter which increases their food intake and therefore their growth.

Broiler farming is economical as large numbers of birds are grown rapidly at a high level of nutrition. It is more expensive to raise meat-producing breeds in extensive systems because they grow more slowly and fewer can be kept.

- Reproduction and breeding
  - Broilers in commercial production systems are hybrids or cross breeds such as the Cobb 500.
    - They grow rapidly under intensive conditions.
- General enterprise management
  - Intensive broiler production systems are very economical, but they must be managed properly to avoid deaths and loss of production.
    - **Hygiene:** Overcrowding amongst birds can cause hygiene problems. This includes the build-up of ammonia from the faeces.
    - **Housing design:**
      → **Poor ventilation:** Houses must be well ventilated because poor ventilation can cause respiratory problems in the birds.
      → **Feeders and watering points:** There must be enough feeders and watering points evenly spaced throughout the house so that the birds to have easy access and prevent weight loss.
      → **Disease management:** Broiler farms have an intensive vaccination and medication programme to limit the effects of disease. The broiler house is managed as an all-in-all-out system. This means that all the birds are removed and slaughtered at the same time. The house is then cleaned and disinfected before new birds are brought in.

3 Examples of extensive farming production

Examples of extensive farming production: Stud, beef, mutton, wool and mohair farms.

Factors to increase extensive farming beef production

Factors to address to increase beef cattle production in extensive farming systems.

- Nutrition and feeding
  - Forage is the main source of feed for beef production. So, veld management is important to keep grazing in good condition to provide sufficient feed for the animals. Feed supplements can be used to provide additional nutrients when these levels are low in veld grasses.

- Environment
  - The environment includes climate, vegetation and diseases. Indigenous or cross-breed cattle are better adapted to the local environment than European breeds. So, farmers should use local breeds to increase beef production.
- Reproduction and breeding
  - Fertility is a very important factor since production depends on the number of calves produced. To ensure a high calving percentage, bulls must be checked for their ability to mate as well as their fertility. There must also be enough bulls to serve (mate) the number of cows in the herd. It is also important to choose the correct breed for the desired carcass at slaughter.
- General enterprise management
  - Three general enterprise management areas must be considered:
    - **Animal health management:** An essential part of the management of beef production is a good animal health programme.
    - **Veld management:** Veld management programmes must also be implemented. A camp rotation system will allow the grazing to be rested.
    - **Marketing plan:** The marketing plan should address how the weaners can be sold for maximum profit. The farmer has to decide if the animals should be fed for longer (rounding off) on the farm, or if it would be more profitable to sell them to feedlots.

Unit 2

Animal shelter

1 Types of animal shelters

Farm animals depend on their owners to provide shelter from the environmental conditions. In some cases, such as poultry farming, shelter must also include protection from predators such as cats, genets and jackals.

Importance of animal shelter

Failure to shelter animals is cruel and also impacts on their health and production. So, farm animals must be protected from:

- **Severe cold:**
  - Warm-blooded animals that are exposed to very severe cold may not be able to maintain their normal body temperature. This may result in:
    - death from hypothermia
    - lung infection which can cause poor growth or death.
- **Extreme heat:**
  - Death due to hyperthermia can be caused by extreme heat.
  - Hyperthermia can also cause loss of appetite as animals use energy to keep cool (by sweating and panting).
    - So, milk production decreases dramatically in dairy animals in hot conditions.
- **Wetting:**
  - Wetting by rain causes chilling of the animal because it lowers the body temperature and uses up valuable energy.
  - It can cause damage to the wool of sheep. For example:
    - sheep can suffer from fleece rot or a skin infection called lumpy wool.
- **Strong sun:**
  - Pigs with light skins can suffer from sunburn and so they need protection from sunlight.

Certain species, such as pigs and poultry, are sensitive to extreme heat and cold.

Shelters in extensive and intensive animal production

The type of farming enterprise or system (e.g. extensive animal production or intensive animal production) determines the type of shelter used.

- Simple shelters and screens
  - All animals need protection from various weather elements.
    - Extreme heat: Under veld conditions, protection from heat is usually provided by trees. Water troughs should be placed here to keep drinking water cool. In semi-desert areas where there are no naturally occurring trees, you can plant trees or provide metal or shade cloth shelters.

- Wind: Strong prevailing winds which can cause chilling. In extensive systems, you can either create a windbreak in fields by planting a line of trees in the path of the prevailing wind or you can build a small, three-sided shelter and ensure that the opening faces away from the wind direction. Ventilation must be checked in closed houses. It should allow adequate air flow without causing cold draughts through the house.
- Rain, snow and extreme cold: All farm animals in areas with heavy rainfall or severe snowfalls in winter animals need shelter from rain and snow. Sheds can provide this under extensive conditions. They should have some type of insulation, such as straw bedding, which will keep animals warm.

- Open housing
  - Open animal houses provide shelter from the weather but also allow animals to exercise, sunbathe and explore their natural environment.
  - It is used in free range pig and poultry systems as well as for calves on dairy farms. This form of shelter is used in backyard, free range and semi-intensive farming systems.
  - Open animal houses:
    - are usually placed in fields, camps or yards
    - are often mobile so they can be moved and cleaned elsewhere hygienic reasons
    - can be brick buildings, moulded plastic huts or corrugated iron barrels.
- Closed housing
  - Closed houses are used mainly in highly intensive farming systems (e.g. mainly for pigs and poultry because these two species are very susceptible to environmental extremes).
  - This form of shelter completely protects animals from the environment.
- Sheds
  - These are buildings which are used to accommodate animals temporarily, such as when shearing sheep or milking cows.
    - They are designed to provide shelter for animals and operators.
- Holding pens and crushes
  - Holding pens are fenced areas in which animals are held before they are handled.
  - Crushes are narrow passages that are fenced on either side. They are used to lead animals to dip tanks or milking parlours. Crushes can also be used to restrain animals when you need to vaccinate or apply tick remedies.

Ruminants are sometimes housed indoors on farms in the northern hemisphere during winter due to extreme cold. This is rarely necessary in South Africa because our climate is not as severe.

2 Intensive animal production systems

Intensive production systems involve industrial production of livestock in confinement (i.e. kept in some kind of housing or shelter) at high stocking density. Intensive systems include small-scale systems, semi-intensive systems or free range systems.

Backyard farming

Farm animals are sometimes raised in backyards in buildings such as garages. These systems are not usually suitable because they have poor ventilation, rough unhygienic floors and they do not receive sunlight. Intensive farms in backyard buildings often experience health problems and are in violation of some municipal and health by-laws.

Intensive/semi-intensive systems

Intensive and semi-intensive systems include closed animal houses, open houses with pens, holding pens for handling animals, shearing sheds or milking parlours, and feed stores. The system will be chosen based on the type of animal being raised.

Free range systems

Free range systems are in between intensive and backyard enterprises. Animals are provided with housing but they also have access to enclosed camps in which they forage for food.

- Free range poultry production system
  - In this system, layers are given a house where they can lay eggs and roost, and a run in which they can exercise, sunbathe and investigate their surroundings. They are able to scratch around for food but they are also given enough food to meet with their production needs.
  - This kind of housing allows for a more stimulating environment than intensive systems. Animals are therefore less likely to be bored, stressed or develop behavioural abnormalities.
- Free range pig production system
  - This system provides a shelter and open pens, and sometimes a mud wallow or a sprinkler system to keep pigs cool.
  - The shelter is in the form of permanent open-sided houses or mobile houses like corrugated barrels. The pigs use the pens to move around in, rootle in soil and to defecate.
  - The pens can be rotated around the house or the house can be moved to keep the pen area hygienic.
  - Crops can be planted where the pigs have fertilised the soil. Pigs can forage for some of their food but they can also be provided with feed. The amount of feed given will depend on the level of production.

- Free range dairy production system
  - Most small dairies in South Africa are free range systems as the cows are grazed in a series of open camps. They usually graze on forage or they are fed fodder such as silage.
  - These camps must provide shade and some solid shelter from rain.
  - The cows are brought into a holding pen and from here they move into the milking parlour. (Calf houses are sometimes used to separate individuals and limit the spread of infection.)
    - Separate milking stalls, divided by rails, usually contain feed troughs to encourage and train the cows to enter the stalls.
    - Milking is done by hand or with milking units, and the milk is stored and chilled in a milk room next to the milking parlour.

3 Shelter requirements for an intensive production system

All shelters must protect the animals and also ensure maximum production.

- Basic requirements of open houses
  - built from material that can be cleaned easily
  - sufficient floor space for all the animals to be accommodated under the roof
  - bedding such as straw to keep the shelter dry and warm
  - easy access to water and feed
  - open side of the house must face away from the prevailing wind.

Poultry houses should also have roosts for sleeping and nests for laying eggs.

- Basic requirements of closed houses
  - no poisonous building material or metal sheets which can wound animals; strong gates and partitions to prevent damage by animals
  - non-slip cement floors which allow easy cleaning and enough floor space for the species and size of animals
  - bedding on the floor for comfort
  - feeders and water troughs or nozzles
  - allow air movement without causing cold draughts
  - insulated and built with long sides facing north and south (allow it to be warm in winter and cool in summer)
  - sloped roof to allow runoff of rain.

Some special cases have their own requirements:

- Poultry houses need wire mesh sides to allow air flow and canvas curtains to close sides in cold weather conditions.
- Houses for day old chicks or young piglets may need heating or cooling systems.
- Piggeries need separate facilities for sows and weaners, and passages for manure removal.

- Basic requirements of milking parlours
  - roofed shelter with separate milking stalls created by wooden poles, or shed enclosed by concrete walls
  - concrete floor should be non-slip and slope downward to a drain for easy washing
  - cement or metal feed trough in each stall for daily allowance of concentrate (given according to milk production of each cow)
  - an adjacent milk room
  - holding pen which leads to milking parlour; dry and clean to prevent dirtying the parlour
  - footbath at entrance to clean animals' hooves (reduces contamination).
- Basic requirements of holding pens and holding sheds
  - must be constructed with suitable materials that will not injure the animals:
    - well-built with strong metal, cement or wooden poles to support cross poles or wire netting
    - no barbed wire, corrugated iron, sharp edges or protruding poles or nails which could injure animals
    - gates that allow flow of animals to their destination.

If animals are to be held in the pen or shed for some time, water must be provided at various points and sun protection should be given.

- Basic requirements of crushes
  - built with strong metal, cement or wooden poles placed vertically, and enclosed with horizontal poles
  - head clamps can be placed at the end of the crush to restrain individual animals
  - for cattle, the crush width must fit a single adult animal.
- Basic requirements for feeding sheds
  - constructed of suitable materials that will not injure the animals
  - have overhead shelter that prevents feed from being wetted by rain
  - provide shelter from sun, if they are open
  - have enough feeders to prevent dominant animals from keeping other animals away
  - have a good water supply that is in the shade to prevent evaporation and concentration of mineral salts
  - be regularly cleaned to prevent rodent problems

4 Equipment and tools for intensive housing systems

- Feeders
  - Feed is the most expensive item in any farming setup. It is therefore important to prevent unnecessary wastage and spoilage. Feeders must be spaced to ensure that all animals receive sufficient food for their needs.

- Types of feeders used in intensive systems depend on the species of farm animal.
  - Poultry farms use either hand-filled feeders or mechanised feeders. The hanging feeder is placed on the ground initially and then raised as the birds get older. It is filled by hand and is designed to prevent the birds from climbing into the container. Mechanised feeders are connected to feed hoppers which deliver the feed into the troughs such as the mechanical trough or pan feeders.
  - Various types of feed troughs are used in piggeries and dairies. Animals with their own stalls usually have a cement trough with the correct amount of feed. Dairy calves are supplied with buckets for feeding milk, concentrate and hay. Feeders that can accommodate more than one animal at a time are used to feed groups of animals. It is important to provide sufficient feeders so that each animal gets enough feed every day.
- Water supply
  - Clean, fresh drinking water is an essential requirement for animals kept in intensive systems. Water containers and piping must be made of material that can be easily cleaned and disinfected.
    - Automatic drinkers are used in intensive poultry farms. They are connected to a pipe system which delivers water into the container or tube. This also allows the farmer to deliver vaccine and medication in the water. Examples of commonly used drinkers are the Bell type, troughs and nipple drinkers.
      → Most farms favour the nipple system because they are less wasteful and labour intensive, and more hygienic because they prevent litter wetting.
      → Nipple drinkers deliver a drop of water from the end of a tube when the bird pecks at it. Intensive piggeries also use this system because of the advantages discussed for poultry. Semi-intensive systems either use nipple drinkers or troughs which are filled automatically or manually.
- Bedding or litter
  - Used in intensive and semi-intensive systems to keep animals warm and dry.
    - For poultry, wood shavings are preferred in deep litter systems such as in broiler houses. Other options include sunflower seed shells, chopped wheat straw and crushed peanut shells. Hay and maize stalks must be avoided because they carry a large amount of fungal spores. Sawdust is not generally used because it is too fine and creates dust.
    - Straw can be used as bedding for dairy stalls, calf housing, sows units, free range houses for pigs and to line the nest of hens.
- Lighting
  - Artificial lighting is used mainly in intensive poultry production to increase the number of daylight hours. This increases the feed intake and growth rate of broilers, and ensures continuous egg production throughout the year by layers. The layers moult and decrease their egg production during autumn under natural conditions due to a shortening of daylight hours. But artificial lighting increases the farm's power usage.

Unit 3

Behaviour and handling of farm animals

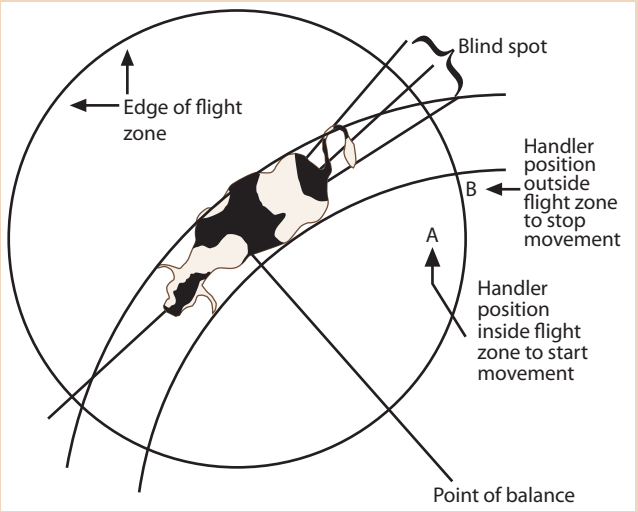
1 The behaviour of farm animals

Farm animal behaviour is genetically determined and helps the animal to survive and reproduce. Observation of farm animal behaviour will help you learn their body language so that you can:

- detect problems with the health of the animal or the conditions under which they are being kept
- handle animals correctly to avoid injury to yourself and the animals
- predict how they will react in different circumstances.

The flight zone

Each animal species has its own flight zone or distance at which it decides to run away from predators and human handlers. Tame animals have small flight zones. When you enter an animal's flight zone in front of their point of balance (roughly in front of the shoulder), it will move away from you. If you want the animal to move forward, then you need to move into the flight zone to position A. If you want it to stop, then you should move to position B. You can use these rules to move the animal in the required direction. This technique is used mainly to herd cattle and sheep.



Common behaviours of large ruminants

Cattle spend their days grazing, resting, ruminating, self-grooming and grooming each other.

- General behaviour of large ruminants
  - Domestic cattle are social animals that gather in herds. The herd has a hierarchical structure, which means that some animals dominate others by showing an aggressive display.
  - The hierarchy of dominance becomes important when food is limited as the animals will then compete with each other and the most dominant animal will get the most feed.
  - This behaviour is used to communicate dominance without injuring the subordinate animals.
    - Aggression is shown when by lowering of the head, bellowing and pawing the ground.

Cattle have panoramic vision except for a small blind spot directly behind them. They have poor depth perception so they often refuse to enter dark places like spray races or to cross over cattle gates.

- Breeding behaviour of large ruminants
  - The breeding behaviour of cattle follows a pattern.
    - A cow on heat becomes excitable, mounts or butts head with other cows and seeks out the bull.
    - The bull responds to the smell of the cow's urine. When the cow is ready, she will stand still for the bull and allow him to mount her and mate.
- Maternal behaviour of large ruminants
  - Cows about to calve show specific maternal behaviour.
    - They will look for an isolated shelter with a soft, dry surface to lie on.
    - The cow licks the calf and eats the afterbirth immediately after calving.
    - A strong, specific maternal bond forms if the calf is allowed to stay with her.
- Abnormal behaviour of large ruminants
    - Various types of abnormal behaviour are seen in cattle. This behaviour is most commonly seen when they are ill.

Common behaviours of small ruminants

- General behaviour of small ruminants
  - Sheep form strong social groups and bonds within a flock and they stay close together while grazing or being herded. This is called mobbing behaviour.
    - If you handle sheep routinely they become tame and will readily learn to enter camps or chutes.
    - Unlike cattle, sheep have a poorly defined hierarchy and they seldom show aggression, except among rams during the breeding season.
- Breeding behaviour of small ruminants
  - Ewes on heat will seek out the rams and stay close beside them. The smell of the ewe in oestrus will stimulate the ram. The ram will smell the ewe's urine and he will extend his neck and curl his lip (flehmen) in response.
  - A ewe on heat will stand for mating.
- Maternal behaviour of small ruminants
  - Many ewes look for an isolated spot in which to lamb.
  - They will lick the lamb and eat the foetal membranes after the lamb is born.
  - The lamb finds the ewe's teats and begins to suckle within an hour or two of birth.
- Abnormal behaviour of small ruminants
  - Sheep show abnormal behaviour under certain conditions, especially when they are ill. (See Topic 4.)

Common behaviours of intensive non-ruminants (pigs)

- General behaviour of intensive non-ruminants
  - Domestic boars are usually kept apart from the sows except when they mate.
  - Pigs have a well-developed sense of smell and hearing. But they have poor eyesight so they use their snouts to examine and explore their surroundings.
  - Pigs are heat sensitive because they can only sweat from their snouts. They wallow in mud bathes or lie in puddles of water to cool down.
  - Young piglets are sensitive to cold and will huddle with their littermates during cold weather.
- Breeding behaviour of intensive non-ruminants
  - Sows on heat become interested in boars and respond to their smell. Sows may nibble the boar's ears and will allow the boar to sniff and nose them. The boar mates with the sow when she stands.
- Maternal behaviour of intensive non-ruminants
  - The sow builds a nest six hours before giving birth. She hollows out a depression and lines it with straw, grass and sticks. Sows in intensive units will show the same behaviour, although they may be unable to build nest. Piglets compete for the sow's teats after birth.
- Abnormal behaviour of intensive non-ruminants
  - Abnormal behaviour is seen in pigs under certain circumstances, especially when they are ill. (See Topic 4.)

Common behaviour of poultry

- General behaviour of poultry
  - Newly hatched chicks are precocial (able to look for their own food and water).
    - They are born with a strong pecking instinct which drives them to investigate all objects on the ground as possible food.
  - Birds show dominant-submissive behaviour a few weeks after hatching
    - Dominant birds will peck less aggressive birds, especially at food troughs. This means that birds at the bottom of the pecking order get less feed.
- Breeding behaviour of poultry
  - Breeding is initiated by the male who does a courtship display. He spreads his wings and uses calls and postures.
    - Unwilling hens run away or ignore this courtship display.
    - Hens ready to breed crouch down and allow the male to mount and mate with her.
- Maternal behaviour of poultry
  - Broodiness has been bred out of commercial laying strains of poultry since their eggs are infertile and are collected for use soon after they are laid. In breeding systems a broody hen incubates her eggs for 21 days after which the chicks hatch.
- Abnormal behaviour of poultry
  - Poultry usually behave abnormally when they are ill. (See Topic 4.)

2 Handling of farm animals

Reasons for handling farm animals

Farmers and farm workers are required to handle animals at some time during the production cycle. They must know how to handle animals so that the animals are not harmed or killed, and the handler is not hurt by large or aggressive animals.

Harm and effect of handling farm animals incorrectly

- Harm caused by incorrect handling:
  - **Bruising:** This is the most common injury. It can be caused by rough handling and poor facilities such as gates that are too narrow or protrusions on structures like crushes or holding pens. At slaughter the bruised meat has to be trimmed off the carcass with the result that the farmer gets less for the animal.
  - **Broken legs:** Rough handling can scare animals. They may try to jump out of pens and break their legs, fall in crushes or be trampled by other animals.
  - **Drowning:** Young calves often drown in dip tanks when adult animals jump on top of them.
  - **Broken necks:** Animals may run into fences or barriers and break their necks if handlers chase them wildly.
- Effects of incorrect handling:
  - The long-term effect of poor handling is that animals become fearful, aggressive and even more difficult to handle.

Basic guidelines for handling farm animals

There are broad guidelines for handling each farm animal species in order to prevent injuries and long-term negative effects. Always handle animals slowly and calmly, and do not shout, bang equipment, hit the animals or use electric prodders and whips.

- Basic guidelines for handling large ruminants (cattle)
  - **Herding cattle:** Learn to judge the flight zone of cattle. It varies depending on how often the cattle are handled, so handle them regularly so that they develop a predictable flight zone.
    - When herding cattle, you need to find the point at which the animal keeps moving forward. Move slowly but confidently while you talk or whistle to cattle.
    - You reduce and increase your distance from the animal to move it forward.
      → If you move inside the flight zone, the animal will run away.
      → If you move out of the flight zone, the animal will stand still. .
  - **Handling bulls and cows with calves:** Never enter a pasture or camp in which bulls are kept unless you know the animal well.
    - Aggressive bulls are usually fed and watered from outside their camps.
    - Cows with calves may become aggressive and charge their handlers.

- **Handling individual animals:** If you need to handle a single animal, bring it with a group into a small camp and then drive the group into a crush where the animal can be restrained.
  - You may be able to get close enough to slip on a halter or place a rope around the neck of a tame animal.
  - An assistant can grip the flank fold to keep an animal still while you examine or treat it.
  - You can use nose tongs or a neck clamp if you need better restraint.

- Basic guidelines for handling small ruminants (sheep)
  Like cattle, sheep have a flight zone which varies in size according to how frequently they are handled. The distance of their flight zone will decrease if they are handled often. Sheep have a tendency to follow leaders so tame animals or goats can be used to lead them.
  - **Herding sheep:** Apply the same flight zone principles described for cattle.
    - You may need more than one handler to drive sheep in from the veld in the right direction.
    - Trained sheepdogs can be used to round up sheep.
  - **Handling individuals:** You can drive individual sheep into a small camp to handle them.
    - Use your arms or a barrier gate to drive them into a corner where they cannot escape.
    - Grasp the flank fold and raise the head upwards to catch the animal.
    - Never grab sheep or goats by the wool or hair because this is painful and can bruise them.
- Basic guidelines for handling intensive non-ruminants (pigs)
  Pigs should be moved in small groups rather than as individuals. Coax the animals along slowly and allow them to investigate their environment because they have poor eyesight. Use a passage made with moveable gates or boards to guide pigs. Do not use electric prodders on pigs.
  - **Handling small pigs (under 10 kg):** Grasp the hind legs, lift the piglet and support it under the chest.
    - Then place the piglet gently back on the ground.
    - Never lift piglets by their ears.
  - **Handling larger pigs (over 10 kg):** Make a passageway with two boards and move the pig slowly to where you want it to go.
    - Clear the way ahead and urge the pig forward by applying gentle pressure with the boards to its side.

A piglet being held by its hind legs and supported under its chest

- If you need to restrain the pig for some treatment or examination, then lead it into a small crate or passage where it cannot move.
- If the animal struggles, keep the head still with a snare or rope which is looped around the top half of the snout.

- Basic guidelines for handling poultry
  - The method used to handle poultry will depend on the tameness and age of the bird. Regular handling will make them tame and prevent injuries.
    - **Handling baby chicks:** Chicks are very fragile so they must be handled gently. Place your hand over them and scoop them off the ground with the other. Do not squeeze or drop them because this will cause injury or death.
    - **Handling adult birds:** Move slowly towards the bird and drive it into a narrow space such as the corner of the run. Place your hand on the back of the fowl you want to catch, grasp its legs and place your fingers between the feet. Never grab the feathers, wings or tail as this will injure the bird.


A chicken being handled by a farm worker

3 Techniques and tools to handle farm animals

Correct use of techniques, tools and aids will help produce healthy, productive animals.

- Ropes
  - Ropes can be used to handle and restrain large farm animals in various ways.
    - You can restrain cattle by looping a rope around the neck or horns.
    - It can also be used to lift the feet of cattle to examine their hooves.
    - Dairy cows can be hobbled with ropes while they are being milked so that they cannot kick their handler.
    - You can restrain large pigs with a snare or loop of rope.
- Halters
  - Halters are made of leather, nylon or rope and they fit around the head of the animal.
    - A length of rope is attached to the halter and it is used to lead the animal.
    - They are useful to lead tame cattle, and even large bulls can become halter tame.
    - Halters can also be used to keep the head of a cow still when a neck clamp is not available.


A show heifer being led with a halter

- Nose tongs
  - Nose tongs can also be used to restrain cattle when no neck clamp is available or it can be used in addition to the neck clamp.
    - It is useful to attach a rope to the end of the nose tongs and this prevents injury to handlers if the nose tongs come loose.
    - Place the pincers of the tongs around the nostrils and close the tongs.
    - Cattle will not struggle as their noses are sensitive.
- Boards
  - Boards are used to move larger pigs from one place to another.
- Neck clamps
  - The neck clamp is a piece of metal equipment which can be opened so that the animal can place its head through and then the clamp is closed around the neck.
    - Animals are usually driven through a crush and towards the clamp which is mounted at the end of the crush.
    - The neck clamp allows very firm restraint of the head for procedures such as dehorning or examining the mouth. Neck clamps must be used very carefully to prevent injury.

Using boards to lead a pig

A cow in a neck clamp at the end of a crush

Basic principles when you transport farm animals

- Use trained drivers as sudden braking, excessive speed and sharp turning can cause injuries.
- Do not transport pregnant, diseased or injured animals if possible.
- Do not transport different species together unless they can be separated.
- Do not mix animals of different ages unless they can be separated from each other as young animals may be crushed.
- Keep animals in a quiet shady area for a few hours before they are transported.
- Do not load animals more than an hour before transporting.
- Ensure there is sufficient ventilation and light in the crates on the truck.
- Ensure that there are no sharp projections in the crates which can injure animals.
- Ensure that the floor of the crates is not slippery.
- Use a vehicle with solid sides to load animals so that they cannot fall off.
- Clean the vehicle before and after loading.
- Hose down cattle and pigs in hot weather to cool them down.
- Do not overcrowd the animals.
- Do not shout, kick, prod or whip animals when offloading.

Sheep being loaded onto a truck

Topic 2

Topic questions

- Answer the questions below. Check your answers afterwards and do corrections.
- Give yourself one hour.
- Marks: 100

1 List the FOUR main factors that can be addressed to increase the production of any farming system. (4)

2 Explain why free range pig and poultry systems are considered to be more humane than intensive farming systems. (4)

3 State FOUR environmental problems that can occur in closed houses. (4)

4 Mention THREE practical methods that can be used to provide shade for farm animals. (3)

5 Identify TWO harmful effects of the cold on farm animals. (4)

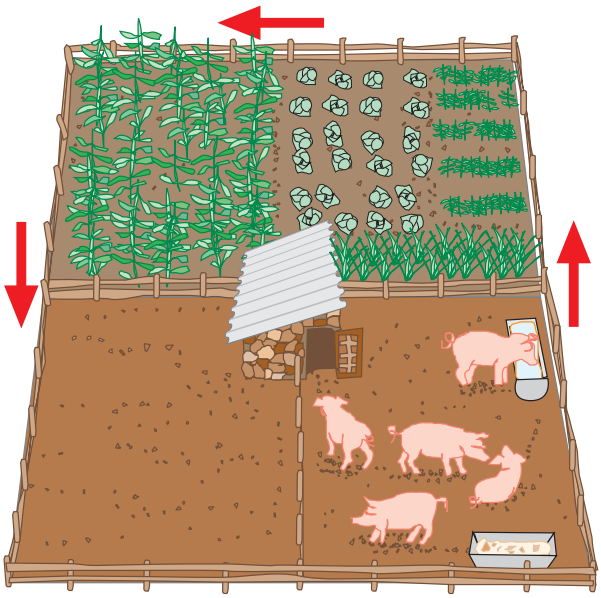
6 Which farm animals are most susceptible to the cold? (2)

7 Describe methods could you use to prevent pigs from overheating and getting sunburned in free range systems. (3)

8 Name THREE energy efficient ways to control the temperature in closed animal houses. (3)

9 Discuss the importance of well-designed feeders in closed animal houses. (4)

10 Identify the production system in the diagram and explain how it functions. (8)



11 Discuss why artificial lighting is used in commercial layer houses. (5)

Topic questions

12 Identify the basic requirements of a free range dairy. (10)

13 Explain the significance of following types of animal behaviour:

- **13.1** dominance/submission
- **13.2** courtship
- **13.3** pecking order
- **13.4** grooming. (8)

14 Which ONE of the following is INCORRECT with respect to the precautions that need to be considered when livestock is transported to an abattoir?

- **14.1** Different types of animals should NOT be transported together.
- **14.2** Pregnant and injured animals should NOT be transported.
- **14.3** Animals of different ages and sexes should NOT be transported together.
- **14.4** Air and light should NOT be allowed to enter the part of the truck where animals are kept. (2)

15 Name four signs of aggression in bulls and cows with calves. (4)

16 Name three golden rules which sum up how we should work with farm animals. (3)

17 List FOUR uses of rope in farm animal handling. (8)

18 You need to examine the tongues of cattle for a foot and mouth inspection campaign. Name the tools/aids that you could use to immobilise their heads. (6)

19 Give ONE word/term/phrase for each of the following descriptions. Write only the word/term/phrase next to the question number.

- **19.1** A place in the handling facility where cattle are kept during the handling process to avoid injuries. (2)
- **19.2** A relatively small area where a large number of animals are kept and fed for optimal production purposes. (2)

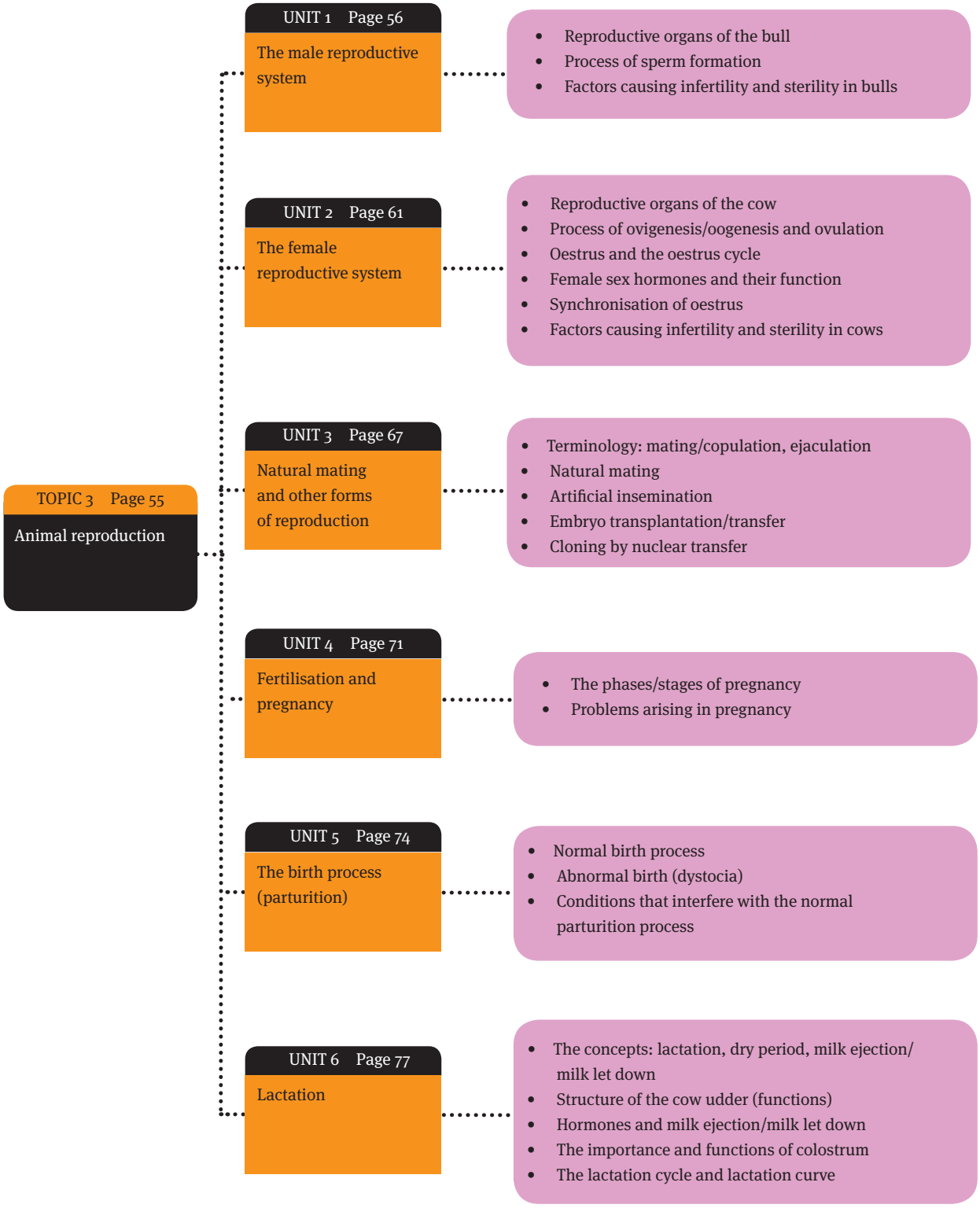
20 List five basic requirements of a vehicle used to transport farm animals. (5)

21 Chicks in intensive broiler houses often die purely from management problems. List at least six causes of chick deaths which can be caused by management factors. (6)

Topic 3

Animal reproduction

Overview



Unit 1

The male reproductive system

1 Reproductive organs of the bull

The reproductive organs of the bull can be divided into the:

- primary reproductive organs (mainly involved in reproduction) and
- the secondary reproductive organs (accessory or additional organs that assist with the production and delivery of semen).

Structure of primary male reproductive organs

Each primary male reproductive organ has a unique structure.

Structure of primary male reproductive organs

Organ	Structure
Scrotum	Composed of skin on the outside and connective tissue and muscle on the inside. It holds the two testes in place outside the body. The scrotum hangs down between the hind legs of the bull.
Testes	A bull has two testes which are contained in a bag of skin or scrotum. When the bull calf is born the testes are held inside the body cavity, but soon after birth the testes descend through the inguinal canal into the scrotum. The testes then hang inside the scrotum between the hind legs of the animal, suspended by a spermatic cord which consists of connective tissue and blood vessels. The testes are composed mostly of long, winding seminiferous tubules which are about 1 km in length. The seminiferous tubules are surrounded by interstitial or supporting tissue.
Epididymis	An organ which lies next to the testes. It contains a long, convoluted tube called the ductus epididymis. The head of the epididymis lies against the upper part of the testes, the body lies over the surface of the testes and the tail on the lower edge of the testes.
Vas deferens	The tail of the epididymis passes into a tube called the vas deferens. The last 10 cm of the vas deferens is thicker than the start of the tube and it is known as the ampulla. The vas deferens connects the epididymis to the urethra.
Penis	The male organ which lies outside the body and allows mating (copulation) to take place. Consists mainly of spongy tissue which becomes firm or erect when the blood vessels become filled. The root of the penis is attached internally to the pelvis. The body of the non-erect penis lies in an S-shaped curve which is referred to as a sigmoid flexure. The tip is known as the glans penis. The penis at rest lies within a sheath of skin called the prepuce. The penis is extruded through the preputial opening in the sheath when bulls mate or urinate.
Urethra	A muscular tube extending from the bladder. It passes through the inside of the penis and opens at the glans penis. The vas deferens and the ducts of the accessory sex glands also open into the urethra.

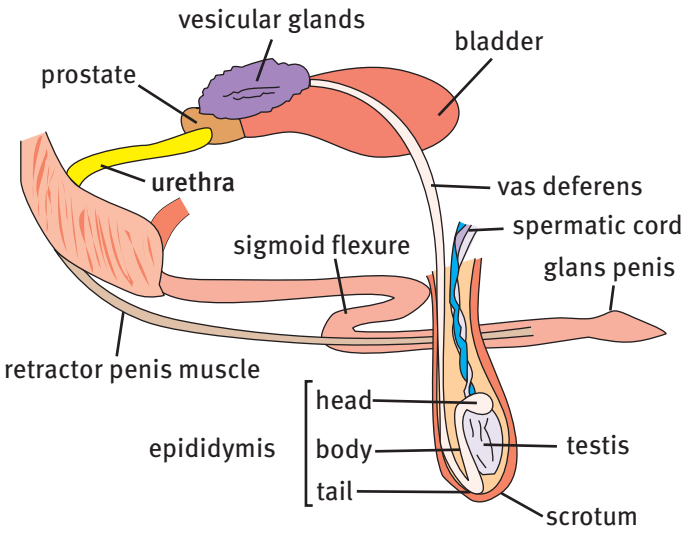


FIGURE 1 Section through the primary and secondary reproductive organs of the bull showing their position in the live animal

Structure of secondary male reproductive organs

The secondary or accessory sex glands of the bull are a group of glands behind the bladder in the pelvic cavity.

- They are in close contact with the ampulla of the vas deferens and the urethra.
  - Vesicular glands (seminal vesicles) are
    - the largest accessory glands
    - they are paired
    - consist of two vesicles or parts which are roughly 10 cm long
    - have a knobbly surface.
    - They lie above the bladder and the two vesicles form a V-shape around the ampulla of the vas deferens.
  - Prostate gland surrounds the urethra where it leaves the bladder in the form of a ring.
  - Cowper's or bulbo-urethral glands are
    - paired glands just behind the prostate
    - on either side of the pelvic urethra.

Functions of the male reproductive organs

Functions of primary male reproductive organs	
Organ	**Structure**
Scrotum	Main function is to protect the testes and regulate their temperature. The testes must be a few degrees cooler than body temperature to produce healthy sperm. This is why the testes are outside the body cavity. The scrotum helps to regulate the temperature in two ways: • The cremaster muscle of the scrotum holds the testes against the body when the ambient temperature is cold and lowers the scrotum during warm weather. • The scrotum also has a thin skin to allow heat radiation which keeps the testes cooler than the rest of the body.
Testes	Function is to produce sperm or spermatozoa in the seminiferous tubules. The testes also produce the male sex hormone, testosterone.
Epididymis	Function is to concentrate, store and allow the maturation of the spermatozoa that originate from the testes.
Vas deferens	Function is to conduct sperm from the epididymis to the urethra during the process of ejaculation.
Penis	The male organ used for mating or copulation. It must become erect before the bull can mate. It becomes erect in response to the presence of a cow on heat, which causes the spongy tissue of the penis to fill with blood (called an erection). The penis lengthens and the sigmoid flexure straightens out. When the bull loses his erection the retractor muscle contracts and the penis returns to its original curved shape.
Urethra	Dual function: • It is the tube which excretes urine from the bladder during urination. • It is the tube through which semen is transported during mating.

Function of accessory sex glands

The accessory glands produce secretions or fluids which help spermatozoa to survive and travel from the testis to the urethra of the penis during ejaculation. When the spermatozoa are suspended in the secretions of the accessory glands, the fluid is referred to as semen.

- **Vesicular glands**
  - secrete a sticky, yellowish fluid which makes up 50% of the volume of semen in the bull
  - secretion is needed to feed the spermatozoa, and correct the pH and osmotic pressure of the seminal fluid.
- **Prostate gland**
  - secretes a watery, alkaline fluid that keeps the pH constant for the spermatozoa.
  - lubricates and cleans the urethra which assists the movement of sperm during ejaculation.
- **Cowper's or bulbo-urethral glands**
  - produce an alkaline fluid which has the same function as the prostate gland.

2 Process of sperm formation

The male cell of reproduction is the spermatozoan or sperm cell. It is a microscopically small body that appears to have a head, neck and tail. The process of spermatozoa formation is called spermatogenesis. There are four stages in the process:

- Division of the spermatogonia (mitosis)
  - Spermatogonia are cells in the wall of the seminiferous tubules of the testes.
    - These cells divide by mitotic division and produce primary spermatocytes.
- Division of the primary spermatocytes (first meiosis)
  - A primary spermatocyte undergoes meiosis to produce two secondary haploid spermatocytes.
- Division of the secondary spermatocytes (second meiosis)
  - Each secondary spermatocyte produces two spermatids.
- Development of sperm cells
  - The spermatids now develop into sperm cells (spermatozoa)
    - consists of a head, neck and tail
    - DNA is contained in the head of the spermatozoa.

3 Factors causing infertility and sterility in bulls

In some cases infertility may be permanent, in which case the bull is called sterile.

- Lack of libido as a cause of infertility: Healthy adult bulls may show lack of libido or sexual urge due to the following reasons.
  - Immaturity:
    - Young bulls that have not reached full puberty may have low or no libido. Onset of puberty varies with breed but is usually at 12–15 months of age.
  - Inexperience:
    - Young and inexperienced bulls may have poor erections. They will require some time to practice mating.
  - Overwork:
    - Bulls that have to walk far to search for females over a wide area can often be exhausted from walking and lack of food or water. They will recover if rested and cared for properly.
  - Disease:
    - Various diseases which cause pain or loss of condition will reduce the bull's libido.
  - Temperament:
    - Poor handling and change of environment may stress the bull and reduce his libido.
  - Breed differences:
    - European breeds mount animals frequently while Zebu animals will only mount females in oestrus.

- Old age:
  - When bulls become too old they may show a lack of libido as a result of reduced testosterone secretion.
- Incorrect feeding
  - Bulls may have poor libido due to nutritional problems. Underfeeding will cause a lack of energy while overfeeding will cause the bull to become fat and lazy. Specific deficiencies like vitamin A or protein deficiencies may cause poor libido.

- Inability to mate as a cause of infertility: Bulls may produce semen of good quality but be unable to mount the cow or mate successfully. Reasons include:
  - Conformation:
    - Poorly developed hind legs or back muscles will affect the ability of the bull to mount the cow.
  - Conditions of limbs:
    - Foot or joint diseases can cause problems with mating because they prevent the bull from mounting.
  - Injuries:
    - An injury to the bull's penis may prevent the bull from mating. This can be caused by thorns or barbed wire.
  - Congenital abnormalities:
    - A small number of bulls may be born with abnormalities of the genitalia which prevent them mating successfully.
- Inability to fertilise as a cause of sterility: This happens when a bull shows good libido and is able to mate normally but fails to fertilise cows. Reasons include:
  - Climate:
    - Bulls that are not adapted to a hot climate may have a low sperm count.
  - Diseases:
    - Various diseases (e.g. vibrio or campylobacteriosis and trichomoniasis) transmitted during mating may cause the failure of conception.
    - Diseases that cause a high fever (e.g. heartwater and redwater) may temporarily affect the sperm production of the bull. Lumpy skin disease (a viral infection) can cause permanent damage to the scrotum and testes. Some infections can cause orchitis (inflammation of the tissues of the testes).
  - Malnutrition and exhaustion:
    - These factors will cause a temporary reduction in sperm count which can be reversed if the bull is rested and fed correctly.
  - Congenital defects:
    - Inborn defects of the testes can make the bull sterile. e.g. producing abnormal sperm, scrotal hernia (testes become damaged) and cryptorchidism (testes fail to descend).

Unit 2

The female reproductive system

1 Reproductive organs of the cow

The reproductive organs of the cow are involved in the processes of ovulation, mating, fertilisation, pregnancy and calving. They are mostly located inside the abdominal cavity. They can be divided into two categories:

- the primary reproductive organs and
- the secondary reproductive organs.

Structure of female primary reproductive organ

Primary reproductive organ of the cow

The ovary is the primary reproductive organ of the cow. There are two ovaries, one on either side of the abdomen.

- They are attached by the fallopian tubes to the point of the horn of the uterus.
- They contain the ova or eggs of the cow.

When the heifer is born her ovary contains 30–400 000 unripe haploid ova or primary oocytes. When the cow reaches puberty a few ova will ripen every 21 days.

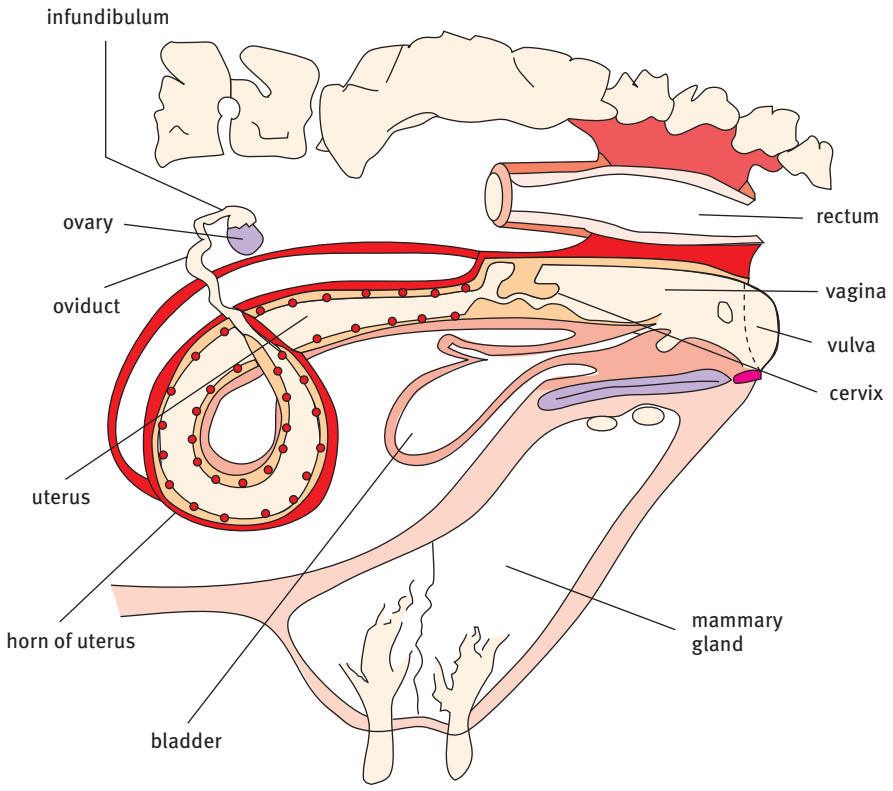


Figure 3 The reproductive organs of the cow

Structure of female secondary reproductive organs

Structure of secondary female reproductive organs	
Organ	**Structure**
Fallopian tubes	These tubes are also called the oviducts and they are two winding tubes which pass from the horns of the uterus to the ovaries. Each tube forms a funnel shaped body at the ovary called the infundibulum.
Uterus	A muscular tube which can be divided into various parts: the thick neck or cervix, the body and the horns. The uterus is lined on the inside with a layer called the endometrium.
Vagina	A muscular tube. It is adjacent to the cervix of the uterus on one end and it opens to the outside through the vulva or lips of the vagina on the other end. The hymen is the membrane at the entrance of the vagina.
Udder	Also known as the mammary gland, it is situated outside the body cavity of the cow.

Functions of the female reproductive organs

Function of female reproductive organs	
Organ	**Structure**
Ovaries	Produce the female sex cells called the ova or eggs which are then released into the funnel of the fallopian tubes during the process of ovulation. The ova develop inside a fluid-filled follicle (Graafian follicle). Oocytes develop every 21 days in response to the hormone FSH.
Fallopian tubes	They pick up the ovum which is released from the ovary during ovulation. Fine hairs or cilia help to move the ovum down the tube to the waiting sperm.
Uterus	Is usually tightly closed but during oestrus the wall relaxes and the cervix opens. The lining or endometrium contains glands which nourish the embryo before it implants. When the embryo implants, the blood supply of the endometrium nourishes it by being in close contact through the cotyledons that form on the foetal membrane. This forms the placenta in cattle.
Vagina	Has a number of functions. It receives the penis of the bull during mating and the semen released during mating. The semen travels up the vagina and through the cervix and the uterus. It then enters the fallopian tubes to effect fertilisation. The vagina is also the birth canal through which the foetus passes into the outside world.
Udder	Produces milk to feed the newborn animal.

2 Process of ovigenesis/oogenesis and ovulation

The process of development of the egg (female sex cells or ova) in a cow is called ovigenesis or oogenesis.

- At birth, a heifer's ovary contains thousands of primary oocytes or follicles.
- When she reaches puberty, under the influence of a number of hormones, a few primary follicles begin to develop. They contain a primary oocyte or egg cell which is surrounded by a layer of cells.
  - These cells multiply and form a fluid-filled cavity in which the oocyte is suspended (Graafian follicle).
  - When the oocyte becomes a mature ovum, the follicle ruptures and the ripe ovum is released into the fallopian tube which is called ovulation.

3 Oestrus and the oestrus cycle

Oestrus is the term used to describe the readiness of the cow for mating. It occurs at the stage in the 21-day oestrus cycle at which the cow ovulates (in heat) and is therefore ready to be fertilised by the bull.

Oestrus cycle

The oestrus cycle is a 21-day period during which a follicle (or follicles) develops into a mature ovum which is then released during the process of ovulation. The cycle is controlled by various hormones. A number of different processes take place during the oestrus cycle, which is divided into four phases.

- Phase 1: Oestrus
  - Days 0–1:
    - The cow is in oestrus (on heat) for about 18 hours. The mature follicle usually ruptures 12 hours later.
- Phase 2: Metoestrus
  - Days 1–2:
    - The cells of the ruptured follicle develop into a corpus luteum (CL).
  - Days 2–5:
    - The CL grows rapidly and developing follicles regress.
- Phase 3: Dioestrus
  - Days 5–16:
    - The CL develops to its maximum size and function and produces the hormone progesterone. This hormone suppresses the formation of other follicles.
- Phase 4: Proestrus
  - Days 16–18:
    - If fertilisation has not yet taken place, the uterus secretes the substance prostaglandin which signals the CL to regress rapidly.
  - Days 18–20:
    - Primary follicles begin to grow again and release oestrogen.
  - Day 21:
    - The oestrogen level rises and causes the onset of heat. The progesterone level decreases, the mature follicle ruptures and ovulation occurs.

However, if fertilisation occurs then the CL continues to produce progesterone:

- no follicles mature
- no ovulation takes place
- the cow will not return to heat again.

The progesterone produced then prepares the uterus for the implantation of the foetus.

External signs of oestrus

Cows show certain external signs and changes in behaviour under the influence of the hormone oestrogen, which show that she is ready for mating.

- Behavioural changes
  - The cow becomes excitable and begins to sniff, ride or mount other cows. A cow that has been ridden will show soiling with dung or mud around the hip bones. Cows in oestrus often stop eating and their milk production drops. They show an interest in the bull and will stand to be mounted when ready to be mated. This is called standing heat.
- Anatomical changes
  - The vulva becomes moist, red and slightly swollen.
  - The cow may also secrete a bullstring – a clear mucous secretion that dangles from the vagina.

Aids for oestrus detection

- A chalk is applied to the chin and the tail heads and will indicate when the cow is being ridden by other cows or is riding other cows.
- Pressure detection devices like the Kamar device – a white adhesive strip which is placed between the tailhead and the hip bone. The strip changes colour from white to red when the cow has been ridden.

4 Female sex hormones and their function

Sex hormones secreted by endocrine glands control the oestrus cycle of the female.

- Follicle-stimulating hormone (FSH)
  - The pituitary gland found at the base of the brain secretes FSH which stimulates the follicles to develop. These follicles secrete oestrogen as they develop.
  - When oestrogen reaches a certain level, FSH secretion is inhibited and the pituitary gland secretes luteinising hormone (LH).
- Luteinising hormone (LH)
  - This hormone is secreted by the pituitary gland in response to the maturation of the Graafian follicle. This causes the follicle to rupture and develop a CL.
- Oestrogen
  - Oestrogen is produced mainly by the developing egg or Graafian follicle.
    - The hormone is responsible for the development of the secondary sexual organs at puberty and the oestrus cycle after puberty.
    - The hormone causes the external signs of oestrus and the behavioural changes in the cow which cause her to seek out and accept the bull.
- Progesterone
  - Progesterone is produced by the developing CL and prepares the uterus lining for the fertilised ovum (embryo).
  - If fertilisation occurs, the CL will remain on the ovary and continue to produce progesterone throughout the development of the foetus (pregnancy).

5 Synchronisation of oestrus

Synchronisation of oestrus is when all the cows are on heat (oestrus) at the same time.

Techniques of synchronisation of oestrus (heat)

There are various techniques, involving the administration of different hormones or substances which affect the oestrus cycle, to synchronise oestrus.

- Prostaglandin injections
  - Injection of this hormone in a herd of cows causes a regression of the CL. Stimulates the cow's own FSH which begins the maturation of the follicles on the ovary. Ensures that all of the cows in the herd will come into heat at more or less the same time.
- Gonadotropin releasing hormone (GnRH) injections
  - Causes new follicles to develop. Results in the appearance of oestrus in the group. Can be injected into cows at various stages of the oestrus cycle.
- Progestin or progestogen administration
  - Synthetic forms of progesterone are used as vaginal implants or they are given in feed. The release of progesterone into the cow's system at a constant rate prolongs the luteal phase. When the implant is removed or the feeding is stopped, the CL regresses and oestrus begins 36–60 hours later.

Advantages and disadvantages of synchronisation of oestrus

Table 1 The advantages and disadvantages of synchronisation of oestrus

Advantages of synchronisation of oestrus	Disadvantages of synchronisation of oestrus
• It easier to manage beef cows as they can be mated or inseminated in a short period of time. • It allows the farmer to make maximal use of a good bull or good semen. • It makes the management of calving easier because the cows all calve at more or less at the same time. This allows for proper supervision of the birth process and prevention of problems that can arise, either in the mother or with the young animals.	• Some of the drugs required to synchronise oestrus are very expensive. • The results of some methods are variable, which means the outcome of the synchronisation of oestrus process is not always consistent. • Prostaglandins cause abortions in pregnant animals. • Progesterone administration is a lengthy process.

6 Factors causing infertility and sterility in cows

- Congenital or inborn factors include:
  - underdevelopment of the reproductive organs, defects of the reproductive organs, freemartinism, prolapse or dropping out of the vagina, and persistence of the hymen which prevents sperm from entering the reproductive tract.
- Injuries to the reproductive tract during mating, birth or the passing of the placenta can cause adhesions or blockages in the reproductive tract.
  - This may prevent fertilisation.

- Ovarian problems may cause a number of reproductive difficulties.
  - These problems include failure to come on heat (anoestrus) and failure to ovulate. Some of the causes of ovarian problems are disease, poor nutrition and very hot temperatures.
- Diseases can cause infertility in cows.
  - These include specific diseases of the reproductive tract like brucellosis, trichomoniasis and vibriosis (campylobacteriosis), general diseases which affect the overall health of the animal and non-specific infections such as those that result from tissue damage during difficult calving.
- Malnutrition can affect the fertility of the cow. For example:
  - underfeeding will cause a delay in puberty, while overweight cows will also show fertility problems.
- Management must be handled correctly. For example:
  - cows that are mated at the wrong time, subjected to unhygienic conditions and poorly adapted to their environment may develop fertility problems.

Factors causing infertility in cows

Cows are infertile when they are neither normally fertile nor completely sterile. So, infertility is thus not necessarily permanent, and can be caused by factors such as injuries to the reproductive tract, ovarian problems, diseases, malnutrition and poor livestock management.

Factors causing sterility in cows

Cows are deemed sterile when they have the physiological inability to effect sexual reproduction. In other words, sterility is a total loss of fertility. Sterility is thus caused when the factors that result in infertility persist. These can be:

- diseases of the genital organs (e.g. retained placenta)
- infections (e.g. trichomoniasis)
- physiological (e.g. repeat breeding)
- anatomical (e.g. freemartinism).

Unit 3

Natural mating and other forms of reproduction

1 Mating or copulation and ejaculation

Mating or copulation is when the male inseminates the female by penetrating the female genital tract and ejaculating sperm from the epididymis of the testis.

Natural mating

The normal method and most important form of insemination in farm animals is natural mating. This is when the bull identifies a cow on heat and mates with her.

- The bull is stimulated to mate by the presence of the oestrus cow.
- The drive to mate is regulated by his libido, which is under hormonal control.

The five main stages of mating or copulation

- Sexual display/courtship behaviour/pattern
  - The bull is attracted to a cow on heat by her behaviour and shows an interest in her. He may sniff her hindquarters and curl his lip in a flehmen reaction. He may also rest his head on her rump.
- Erection
  - The penis of the bull becomes erect when he identifies a cow on heat. The erection occurs due to the dilation of blood vessels in the spongy tissue. Then the accessory glands begin to discharge their secretions into the urethra to lubricate and protect the sperm during ejaculation.
- Mounting
  - The cow will stand still if she is ready to be mated and allow the bull to jump, raise his forequarters and straddle her back. He is able to place the penis near to the vulva in this position.
- Penetration
  - The bull drives his erect penis into the vagina of the cow when he is in the correct position.
- Ejaculation
  - The sperm is now discharged from the epididymis. It travels down the vas deferens, enters the urethra and is discharged through the tip of the penis into the vagina. The bull dismounts from the cow once he has ejaculated.

Artificial insemination (AI)

Artificial insemination (AI) in cattle was originally developed to prevent the infection of cows with venereal diseases such as vibriosis.

- Later scientists realised that this method was a very quick way to improve the quality of herds by using semen from bulls that had superior genetic characteristics
  - One good bull can be used to inseminate many more cows than it is able to serve
    - Today AI is used for genetic improvement in dairy and beef herds.

In AI semen is collected from the male animal under controlled conditions and then it is artificially inserted (inseminating) into the reproductive tract of the female.

Basic requirements for successul AI

- Proper collection and storage of semen:
  - Semen is collected by leading a bull to a 'cow' (a dummy) or another bull (the teaser bull).
    - When the bull mounts the 'cow' or dummy, an artificial vagina (AV) is placed over the bull's penis to collect the ejaculate.
    - Some operators use electrical stimulation or an electro-ejaculator to cause ejaculation.
- Good quality semen:
  - Good quality semen contains a large number of spermatozoa that move around rapidly and a low percentage of abnormalities such as loose tails or double heads.
- Good technique (insemination):
  - The plastic straw is taken out of the liquid nitrogen and the thawed semen is inserted into a special pipette.
  - The operator then places an arm in the cow's rectum, grasps the cervix and pushes it downwards gently. The operator uses the other hand to insert the pipette through the vulva and then through the cervix
    - Half of the semen is deposited (as above) and the rest is deposited into the uterine horn.
    - The pipette is then withdrawn and the cervix is then massaged
      → This causes the secretion of oxytocin, which causes the uterus to contract. This action forces the sperm forward in the reproductive tract.
- Accurate timing (detecting oestrus in cow): Beef cows need to be inseminated as soon as they show signs of heat, whereas dairy cows should be inseminated 12 hours after the detection of heat.

Types of semen diluent and their function

Semen collected from the animal must be suspended in a liquid diluent. This diluent has various components and serves a number of functions. Semen diluent is usually made up with equal parts of a buffer and a protectant.

One of the main functions of diluents is to extend the semen so that it can be used to inseminate more animals. Diluents also have buffering functions (stabilises the pH) and protect the spermatozoa from being damaged by the freezing process which occurs when the semen is stored in liquid nitrogen.

The advantages and disadvantages of AI

Comparing the advantages and disadvantages of AI	
Advantages of AI	**Disadvantages of AI**
Rapid genetic improvement of a herd is possible	Rapid spread of disease if semen is infected
Venereal diseases can be controlled	Need very good hygienic practice and management
Cheaper than buying and keeping expensive stud bulls (± one bull per 30–60 cows)	Rapid spread of undesirable genetic material
Breeding programme has greater flexibility because of wide choice of bull semen	Narrowing of genetic base (reduced genetic diversity)
Oestrus synchronisation and AI make it possible to manage breeding better	
Individual good bulls can supply semen to large number of farms even after his death	

Embryo transplantation/transfer (ET)

Embryo transplantation/transfer (ET) is the transfer of a large number of fertilised embryos from a good quality donor cow into the uterus of many recipient or surrogate cows. The aim is to allow a very good cow to produce a large number of offspring.

- The first stage of ET is to administer FSH and cause superovulation in a chosen cow.
  - The cow is then inseminated with good quality semen.
- When the semen is fertilised, the embryos are harvested or removed from the donor cow by embryo flushing.
  - This is done by inserting a tube into the uterus, adding sterile liquid and then sucking or washing (flushing) the embryos from the uterus.
- The embryos are examined to ensure that they are healthy.
  - Suitable embryos are then either frozen or implanted into recipient cows.
- Finally the embryos grow in the recipients who give birth to the calves.

Advantages and disadvantages of ET

Advantages and disadvantages of ET	
Advantages of ET	**Disadvantages of ET**
• Allows top quality female livestock to have a great influence on the genetic advancement of a herd or flock • Provides the opportunity to introduce desired genetic material into populations of livestock • Greatly reduces the risk of transmission of infectious diseases • Can be used very effectively on commercial farms with good management	• Involves sterile procedures to harvest and transfer the embryos; therefore requires a highly skilled operator • It is an expensive process • Pregnancy rates in ET are highly variable, averaging only about a 50% success rate

Cloning by nuclear transfer

Cloning in biotechnology refers to processes used to create copies of DNA fragments (molecular cloning), cells (cell cloning) or organisms. Cloning by nuclear transfer involves producing an exact copy of an existing animal. It is done by injecting the nucleus of a somatic cell from the animal to be cloned into an unfertilised ovum or egg cell. The ovum's own DNA is removed. This results in a new cell that will divide normally, forming an embryo that is identical to the donor animal. The embryo is placed in the uterus of a surrogate mother where it grows to term.

- Types and aims of cloning:
  - Reproductive cloning
    - Farm animals are cloned to reproduce individuals with valuable genetic material (e.g. farmers may want to reproduce animals that have a particular advantage such as disease resistance or exceptional production characteristics).
  - Therapeutic cloning
    - The main aim is to use embryonic stem cells, which have the unique ability to generate virtually all types of cells in an organism, to grow tissues in the laboratory that can be used to grow healthy tissue to replace injured or diseased tissues.
    - It may also be possible to learn more about the molecular causes of disease by studying embryonic stem cell lines from cloned embryos derived from the cells of animals or humans with different diseases.

Types of cloning processes	
Reproductive cloning	**Therapeutic cloning**
• Done by taking a somatic cell (e.g. a muscle cell) from a donor animal with a biopsy needle. • These cells are then grown in the laboratory by tissue culture until there are a large number of cells. • The nucleus of the somatic cells is transplanted into an ovum from which the nucleus has been removed. • This step is performed under a microscope. • It creates a cloned embryo which is then implanted into the uterus of a surrogate cow, where it grows until the calf is born.	• Used to generate embryos to provide stem cells (undifferentiated cells) which can be used to cure diseases or regenerate organs. • It does not have an application in farm animals yet.

Advantages and disadvantages of cloning

Table 2 Advantages and disadvantages of cloning	
Advantages of cloning	**Disadvantages of cloning**
• Allows many clones to be produced from one donor animal and transplanted into a large number surrogates • Cloned animals will be exactly the same as the animals from which they were cloned, allowing for 'breeding' of desired traits • There will be an endless supply of animals to clone, and we will never run out of food from animals	• Reproductive cloning of farm animals is in the experimental phase and it is not used widely on farms • There are still many technical problems and some cloned animals do not live very long • The technique is also very expensive because the cells need to grow in a laboratory during the early stages of the cloning process

Unit 4

Fertilisation and pregnancy

1 Reproduction terminology

- Fertilisation:
  - In animals, this involves the fusion of an ovum with a sperm, which eventually leads to the development of an embryo. It starts with copulation.
    - After a male ejaculates, a large number of sperm cells move to the upper vagina (via contractions from the vagina) through the cervix and across the length of the uterus to meet the ovum.
    - In cases where fertilisation occurs, the female usually ovulates during a period that extends from hours before copulation to a few days after.
- Pregnancy:
  - In animals, this is the period of reproduction during which a female carries one or more live offspring in the uterus through gestation.
    - It begins when a fertilised zygote implants in the female's uterus and ends once it leaves the uterus.
- Placenta:
  - This is a flattened circular organ in the uterus of pregnant mammals.
    - It consists of vascular tissue in which oxygen and nutrients can pass from the mother's blood into that of the foetus, and waste products can pass in the reverse direction.
    - The placenta is expelled from the uterus at the birth of the foetus.
- Freemartin:
  - An imperfect sterile female calf that is the twin of a male calf whose hormones affected its development.
    - Freemartinism occurs occasionally in twins which are male and female.
    - It results from the fusion of placentas of the two foetuses.
    - This causes the female foetus to be exposed to testosterone, resulting in a masculinised and infertile animal.

2 Fertilisation process

After mating or AI, millions of spermatozoa use the lashing movements of their tails to swim very rapidly up the reproductive tract to the fallopian tube.

- They are assisted by the contractions of the uterus.
- They wait for the ovum to arrive when they reach the fallopian tube.
  - Once the ovum is released from the ovary, it is picked up by the fallopian tube and moved down the fallopian tube where the spermatozoa are waiting.
  - At this stage many of the spermatozoa that reached the fallopian tube will have died off.

- These sperm release an enzyme called hyaluronidase which breaks down the outer layer of the ovum in a process called capacitation.
  →It allows a single sperm to finally enter the ovum and join its DNA with that of the ovum which is called fertilisation.
  → The fertilised cell is called a zygote. It starts to divide and it is has different names at various stages of division (morula, blastocyst and finally embryo).

Multiple births, twinning and freemartins

- Formation of multiple births (twins)
  - If more than one ovum is shed during ovulation, then more than one zygote can be formed. For example, pigs normally have 6–14 piglets and sheep can give birth to twins or triplets. Multiple births are less common in cows but does occur. The formation of the twins is dizygotic if two ova are fertilised and monozygotic when the embryo splits into two during development.
- Formation of freemartins
  - Dizygotic twins of different sexes occasionally develop an interconnected blood supply. If this happens, the heifer receives testosterone which causes the underdevelopment of the female sex organs and the formation of tiny ovaries. This results in a sterile freemartin. These heifers can be identified by external signs such as excess hair on the vulva and an underdeveloped udder and teats.

3 Phases or stages of pregnancy

The embryo remains in the fallopian tube for 4–5 days. It then moves down into the uterus where it lies loose in the uterus for the first month.

- The embryo then differentiates into three different layers, namely the endoderm, mesoderm and ectoderm which give rise to the various tissues and organs.
- Between the first and fourth months of pregnancy, the foetus attaches to the uterus and is enclosed in a number of membranes or layers.
- The amnion membrane surrounds the foetus directly and contains amniotic fluid
- The chorion, which is attached to the umbilicus of the foetus like the amnion, lies against the uterus wall and is filled with fluid.
- A small sac (allantois) gradually enlarges and becomes attached to the chorion.
- The embryo excretes urinary waste through the umbilicus into the allantoic sac.
- The fused chorio-allantois forms round areas of attachment to the uterine wall called cotyledons.
- In cows, cotyledons represent the placenta, or the area in which the blood supply of the foetus and the mother are closely in contact. This allows the embryo to receive oxygen and nutrients by diffusion and osmosis.

The phase/stage of the foetus

The stage of the foetus begins 45 days after fertilisation. The foetus is clearly recognisable since all of its tissues are fully differentiated. During this stage the foetus grows in size, its organs develop further, tiny bones begin to calcify and hair begins to grow.

4 Problems arising in pregnancy

- Resorption
  - Occurs when a young embryo dies off before it implants and is partially or completely re-absorbed. Resorption is the most common cause of failed pregnancies. No external signs will be seen with resorption because the small and soft tissues are absorbed by the cow's body.
  - The reasons for resorption
    - genetic problems which cause faulty development
    - infections of the reproductive tract
    - the breakdown of the corpus luteum which results in decreased progesterone levels and a deterioration of the uterine lining.
- Abortions
  - This is when the foetus dies and is passed out through the vagina. External signs of an abortion include if the foetus is found or the placental membranes are seen hanging from the vulva of the cow. The foetus may also remain in the uterus after infection (in the form of macerated, decomposed or mummified material). The soft tissues will disappear and leave a dry, hard foetus.
  - The reasons for abortions
    - Infections: Most common cause of an abortion. An infection often damages the organs or causes them to be malformed which results in death of the foetus. In some cases it causes placentitis or inflammation of the cotyledons or placenta which disrupts the mother's blood supply.
    - Genetic factors: A genetic defect to a vital organ may cause the foetus to die off and be aborted.
    - Environmental factors: Malnutrition or rough handling will injure a pregnant cow and may cause the foetus to be aborted.
    - Toxins: Various toxins, such as those found in poisonous plants, may cause the cow to abort.
    - Hormonal disturbances: A breakdown of the corpus luteum during pregnancy will lead to a decrease in the progesterone levels and cause the cow to abort.

Unit 5

The birth process (parturition)

1 Parturition (birth)

Physical signs show that the cow is approaching parturition:

- abdomen: becomes enlarged during the foetal stages and appears to drop due to the relaxation of the ligaments of the pelvic canal
- udder: begins to develop in the last few weeks of pregnancy and shows signs of producing milk a few days before calving
- vulva: begins to swell and discharge a thick mucous
- behaviour: on the day of calving the cow stops eating, isolates herself, searches for a place to give birth, shows restlessness and discomfort, and attempts to urinate often.

Functions of the membranes covering the foetus

Foetal membranes/layers and their functions	
Foetal membrane/layer	**Function**
amnion (inner membrane)	Encloses amniotic fluid which serves as shock absorber around foetus and provides lubrication for birth of calf
chorion	Fuses with allantois
allantois (outer membrane)	Encloses the allantoic fluid which collects the excretory products from the foetus
chorio-allantois	Attaches to uterus wall and forms the cotyledons of the placenta which allows exchange of nutrients between the foetus and mother

Stages/phases of parturition

- Stage 1: Preparatory
  - The uterus begins to contract involuntarily at intervals during the preparatory stage. The cervix opens as a result of hormone secretion and is pushed open further by the fluid-filled foetal membranes that press against the uterine end of the cervix. The allantois or outer membrane ruptures and releases allantoic fluid which lubricates the birth canal.
- Stage 2: Expulsion of the foetus
  - The cow usually lies down in this stage. In addition to involuntary uterine contractions, the cow begins to strain using her abdominal muscles to expel the foetus from the birth canal. These combined contractions propel the foetus through the dilated cervix. The amnion (inner membrane) ruptures which releases fluid to help lubricate the passage of the foetus. The foetus is expelled and the umbilicus pulls loose from the uterine wall. The calf's breathing reflex is stimulated because it no longer receives oxygen through the umbilicus or navel.
- Stage 3: Expulsion of the afterbirth
  - A period of rest follows the expulsion of the foetus from the uterus. The uterine muscles then contract again and expel the so-called afterbirth, which is composed of the placenta, umbilical cord and foetal membranes.

2 Conditions that interfere with normal parturition

Dystocia

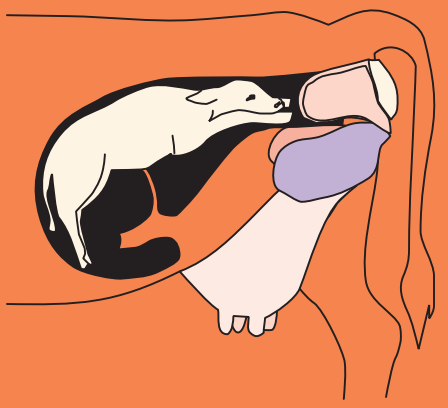
Signs of dystocia (birth problems) include the bursting of the allantois, straining by the cow or the appearance of the feet or head followed by no further activity.

Causes of dystocia

The causes of dystocia can be maternal (due to the cow) or of foetal origin.

Correct birth positions of a calf in the uterus

There are two normal birth positions. In the anterior presentation, the head and feet come out first. Posterior presentation is when the hind legs come out first, followed by the rest of the body.



Causes of dystocia	
Foetal causes	**Maternal causes**
Abnormal presentation Twin pregnancy Over large calves Dead calves Deformed calves	Uterine torsion Metabolic diseases Over fat cows Anatomical defects of pelvis Injuries

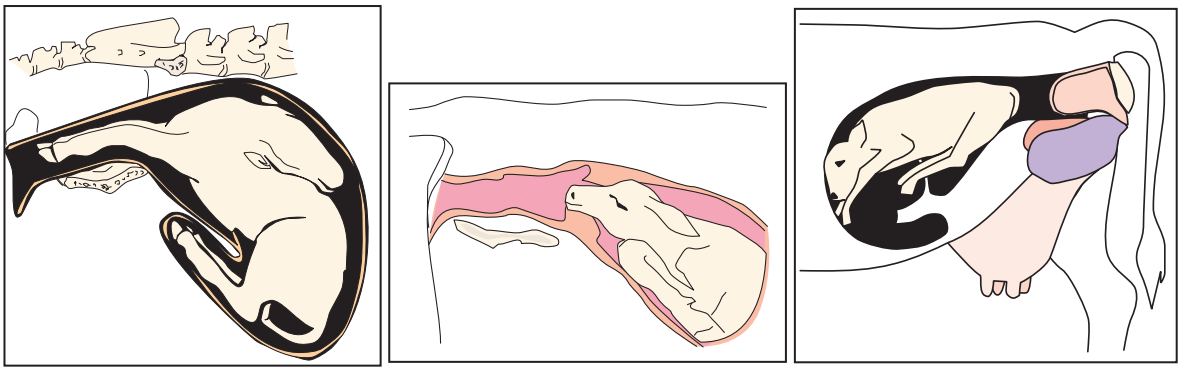


FIGURE 2 From left: Retention of the head; retention of a limb; posterior foetal presentation

Other conditions that can interfere with normal parturition

- Vaginal or vulval tears
  - Vaginal or vulval tears usually result from the use of force to remove a calf. The most common causes are not using lubrication, allowing the hooves of the calf to penetrate the vagina or the use of extreme force.
- Prolapsed uterus

- The uterus may come out of the vagina after the birth process under certain conditions, for example when the cow has to strain very hard during labour.

- Calving paralysis
  - If a calf is pressed against the cow's pelvic cavity, a nerve will be pinched between the pelvic cavity and the bulk of the calf. This nerve damage can result in paralysis. The cow will be able to stand but will not be able to use the hind leg on one side.

3 Principal factors causing retention of the placenta in cows

The expulsion of the placenta usually takes place naturally when the uterus contracts some hours after the birth process. However, some direct and indirect factors can cause the placenta to remain inside the uterus where it may rot and cause health problems.

Table 3 Direct and indirect factors causing the retention of the placenta in cows

Direct factors	Indirect factors
• Abnormal deliveries (e.g. twins, caesareans, dystocia, abortions or premature calving • Failure of the uterus to contract, (e.g. cows with milk fever) • Rapid closure of the cervix may trap released placenta membranes, especially with exceptionally large foetus	• Intensive stress and nutritional deficiencies or imbalances (management problems) • Cows infected with infectious organisms (brucellosis, infectious bovine rhinotracheitis, etc.) • Shortened or prolonged pregnancies

Unit 6

Lactation

1 Structure and functions of the cow udder

The udder or mammary gland is the organ in which milk is produced. The udder of the cow consists of four parts or quarters which are completely separate from each other.

- The udder is covered with skin and is attached to the body by a number of ligaments. Each quarter of the udder is made up of a mass of secretory tissues or alveoli which are arranged in groups or lobules.
- The alveoli produce the components of milk. The milk produced in the alveoli moves into the small milk cavities and then moves down a series of ducts or tubes.
- The small milk ducts lead into the large milk ducts, and from there the milk travels downwards and pools in the gland cavity just above the teat canal. The entrance to the teat is held closed by a ring of muscle.
- The teat itself has a cavity and an opening which is called the teat orifice. The teat opening is held closed by a sphincter muscle which helps to prevent the entry of bacteria up the teat canal. Bacterial invasion of the udder causes an infection called mastitis which decreases milk production.

Lactation, dry period, milk ejection

Lactation is the production of milk in order to nourish the newborn animal. Weaning occurs when the young animal is used to food other than its mother's milk. In dairies, the calf is removed but the mother cow is milked daily. This keeps up her milk production until she is dried off by the farmer. The **dry period** in dairy cows is the period after this drying off has occurred. The dry period usually occurs when the calf is weaned. In dairies the calf is removed so the farmer needs to imitate this by gradually reducing milking until lactation stops.

The **milk ejection** (milk let down) is the release of milk from the udder into the teats, which allows the calf to drink or the cow to be milked.

Composition of milk

Milk is a highly nutritious liquid which is specially designed for the growth and protection of young mammals. Each species produces milk with a slightly different composition. The milk from most species contains roughly 2–11% fat, 3–7% protein, 5% milk sugar, and vitamins and minerals. It is a very rich source of calcium which promotes bone growth in young animals.

Some of the milk components are obtained from the blood supply and these include water, minerals, blood proteins such as antibodies, vitamins and enzymes. Other components such as lactose (milk sugar), casein (milk protein) and fat (butterfat) are formed in the udder tissue itself. Milk production by the mammary gland tissue is controlled by the hormone somatotropin which is secreted late in pregnancy.

2 Hormones and milk ejection/milk let down

Two processes are important for the removal of milk from the udder: passive withdrawal and milk ejection or let down through the milk ejection reflex.

Passive withdrawal

Passive withdrawal of milk is the emptying of the larger ducts and cavities of the udder by neural stimulation of the skin and teats of the udder. This phase begins 5 to 10 seconds after stimulation of the udder. Between 40 and 50% of the milk can be removed passively from the udder.

Hormones involved in milk ejection/milk let down

For the remaining 50 to 60% milk to be removed, successful milk ejection has to take place. This happens due to the milk ejection reflex, which is a neuro-hormonal reflex.

- Milking or suckling stimulates nerve endings in the teats, bringing about the release of the hormone oxytocin from the pituitary gland 20 to 40 seconds later.
  - Oxytocin causes the expulsion of milk from the alveoli by stimulating the epithelial cells of the ducts to push the milk down into the gland cavities and then into the teats.
    - Oxytocin is present in the bloodstream for 6 to 7 minutes after stimulation, which therefore is the time available for milking a cow if the maximum yield is to be obtained from her.
    - An excited or scared cow will secrete the hormone adrenalin. This hormone will inhibit milk ejection, which will prevent the cow from being milked properly.

Importance and functions of colostrum

The milk which is secreted just after the birth of the calf is called colostrum or first milk. It is very thick and provides nutrient rich food for the newborn as well as antibodies that are concentrated from the mother's blood. The intestine of the calf is able to absorb the antibodies for the first 48 days of its life. The colostral antibodies are absorbed into the calf's bloodstream instead of being broken down. They protect the calf against infectious diseases until the young animal develops its own. It is therefore very important that a newborn animal receives enough colostrum as soon as possible after birth and always within the first 48 hours.

3 The lactation cycle and lactation curve

The lactation cycle (period)

The dairy cow has been bred to supply a large quantity of milk for as long as possible. To achieve this, the cow must give birth to one calf a year.

- The lactation period begins after calving and three months later she should come on heat and be mated or inseminated.
  - The cow is dried off in the last two months before she is due to calve again. This is known as the drying period.
  - This means that her milk production is halted by reducing the milking of the udder.
  - Drying off allows the udder two months to rest and recover before the cow calves again.
    - The cow is therefore in lactation for roughly 300 days or 10 months.
    - This 12 month cycle is called the lactation cycle. Farmers need to monitor the lactation cycle of their herd in order to manage them effectively. It is important to get cows pregnant as early as possible within the 12 month period.
    - Dairy cows usually have 5–6 lactation cycles during their lifetime.

The lactation curve

The cow secretes colostrum for a few days just after calving and then she begins to produce normal milk.

- A good dairy cow produces roughly 40 litres per day at this early stage of lactation
- Milk production reaches a peak roughly 1–2 months after lactation begins.
- Thereafter the daily production gradually decreases until she is dried off two months before her next calf is due to be born.
  - This fluctuation in the amount of milk produced is shown by a lactation curve.
    - Dairy farmers record the lactation curve of the herd to monitor their production.
    - This allows farmers to assess whether the cow's milk production has reached its genetic potential.
    - The amount of milk produced during the lactation cycle depends on genetics and the feeding of the animal.

Topic 3

Topic questions

- Answer the questions below. Check your answers afterwards and do corrections.
- Give yourself one hour.
- Marks: 100

1 Name the reproductive organ in which the following processes take place:

1.1 ovulation

1.2 fertilisation

1.3 spermatogenesis

1.4 implantation

1.5 lactation

1.6 parturition. (6)

2 Hormones are release during the oestrus cycle. Name a function of the following hormones in the oestrus cycle:

2.1 Progesterone

2.2 Oestrogen (2)

3 Outline the main difference between infertility and sterility. (2)

4 List FIVE important factors to consider in the collection, examination and storage of semen to ensure that the product is of good quality. (5)

5 It is important for a farmer to be able to detect oestrus in a cow.

5.1 Explain why it is important. (1)

5.2 Describe TWO signs of oestrus/heat in a cow. (4)

5.3 What is standing heat? (2)

5.4 When is the best time to mate/inseminate a cow? Distinguish between beef cattle and dairy cows. (2)

5.5 Is the oestrus cycle in cows seasonal? (1)

6 Describe the process of fertilisation. Explain where and how it takes place. (5)

7 Can a monozygotic twin be a freemartin? Explain your answer. (3)

Topic 3

Topic questions

8 Describe the difference between resorption and abortion. (5)

9 Outline the sequence of events when a cow gives birth. List and briefly describe all of the important processes. (10)

10 Incorrect foetal presentation is one of the main causes of dystocia in cows because it prevents the calf from moving through the birth canal.

10.1 What are the main incorrect foetal positions that cause problems? (3)

10.2 How are the positions referred to in (10.1) usually corrected? (1)

11 Milk production is under hormonal control.

11.1 Which hormone is involved in the control of lactation? (1)

11.2 Name FOUR common causes of a drop in milk production. (5)

11.3 What normal physiological process can cause a drop in milk production three months after calving? (1)

12 Name the main categories of causes for a lack of libido in bulls.

12.1 List four and provide a brief description of each one. (8)

13 Discuss the role of disease in the reproductive failure of cows. (6)

14 Cloning is the process of producing an exact replica of an animal.

14.1 Would you use this technique as a replacement for natural mating? (2)

14.2 Give reasons for your answer. (3)

15 Discuss the importance of correct feeding during the reproductive process. Provide and elaborate on at least two factors. (6)

16 Which THREE of these foetal presentations can cause dystocia?

16.1 Anterior presentation

16.2 Posterior presentation

16.3 Breech presentation

16.4 Anterior presentation with head retained

16.5 Posterior presentation with limb retained (3)

17 Name THREE conditions of the calf that can cause dystocia. (3)

Topic questions

18 Name FOUR signs that indicate that a cow is about to calve. (4)

19 Define milk let down. (1)

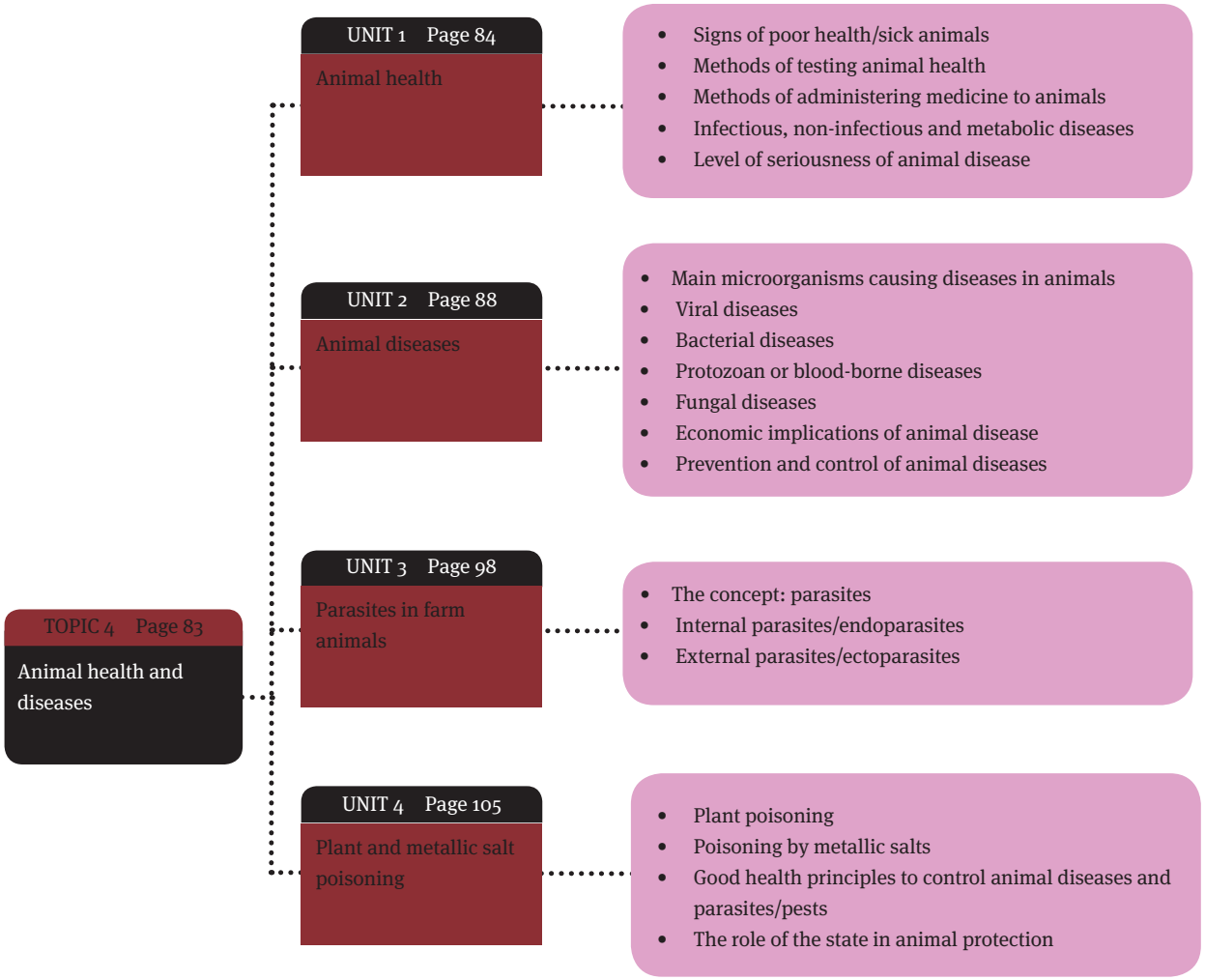
20 Use the information below to draw a lactation curve. (5)

A good dairy cow produces roughly 40 litres per day at this early stage of lactation. Milk production reaches a peak roughly 1–2 months after lactation begins. Thereafter the daily production gradually decreases until she is dried off two months before her next calf is due to be born.

Topic 4

Animal health and diseases

Overview



Unit 1

Animal health

1 Signs of poor health/sick animals

- We can tell if animals are in poor health or sick by
  - comparing their normal behaviour and functions with their behaviour and functions when they do not seem well.

A clinical examination is when you examine animals for signs of disease. One of the ways of examining a sick animal is to use a rectal thermometer which is used to take the temperature of mammals.

Signs of poor health/sickness in ruminants (cattle, sheep and goats)

Function or body system	Healthy animal	Sick animal
Appetite	Eats, drinks and ruminates	Not interested in food, does not ruminate
Behaviour	Alert, ears erect, interested in surroundings, stands up when approached by humans	Depressed, walks slowly or lies down and will not get up, ears hanging
Body temperature	Cattle: 37,8–39,8 °C Sheep: 38,9–40 °C Goats: 38,6–40,2 °C	Fever (›1 °C above normal), sign of an infection
Excretion	Passes normal faeces	Hard, runny or blood-stained faeces
Mucous membranes	Pink and moist	Yellow, dark red, white, brownish or bluish
Paralumbar fossa	Strong rumen contractions can be felt	Weak or no rumen contractions
Urination	A strong stream of light yellow urine	Intermittent urination in bulls/rams, red urine

Signs of poor health/sickness in pigs

Function or body part	Healthy animal	Sick animal
Appetite	Interested in food, drinks water	No or little interest in food/water
Behaviour	Alert with erect ears, interested in surroundings	Depressed with hanging ears
Excretion	Faeces of normal consistency	Hard faeces or runny possibly with blood clots
Eyes	Clear and moist	Dull and runny
Mucous membranes	Pale pink	Dark red, pale or bluish
Skin	Unpigmented pigs should be light pink (depends on breed)	Red raised spots, bluish discolouration on unpigmented areas
Temperature	37,8–39,9 °C	Fever (›1 °C above normal)

Signs of poor health/sickness in poultry		
Function or body part	**Healthy animal**	**Sick animal**
Appetite	Actively looks for food, eats well, drinks water	Refuses to eat/drink
Behaviour	Alert, interested in surroundings	Depressed, feathers fluffed up, eyes closed, doesn't move away when approached
Breathing	Regular close-mouthed breathing, may pant on hot days	Noisy wet sounds, difficult breathing with open mouth
Egg production (layers)	Normal production	Reduced production
Excretion	Normal faeces	Very wet faeces
Eyes	Clear and open	Eyelids swollen closed
Feathers	Smooth and clean, may lose some feathers at certain times of year (moulting)	Brittle, broken and falling out
Legs and feet	Smooth	Scaly, birds pecking at scales
Wattles and combs	Usually red and smooth	May be pale/blue in colour, show lumps or swellings

2 Methods of testing animal health

Methods to investigate, test or diagnose suspected ill health in an animal or herd.

- Clinical examination
  - A clinical examination of an animal is done to help determine the cause of a disease or make a diagnosis. This involves the examination of various body parts and functions. This is important because similar symptoms can be seen in diseases or conditions that have different causes.
- Laboratory tests
  - Various laboratory tests can be done on live animals to help make a diagnosis.
    - Blood smears: These can be made to diagnose diseases like anthrax or various blood-borne diseases in which parasites can be seen in blood cells.
    - Serology: Blood samples can be tested for antibodies to infectious agents.
    - Cultures: You can do a culture for an infectious agent. This involves the growth of the culturing material in a laboratory from an abscess or a milk sample in order to identify the bacteria that caused it.
    - Faecal examination: Faecal samples can be tested for signs of roundworm and fluke eggs will indicate the severity of the infestation.
- Postmortem
  - A postmortem (or PM) is the procedure when you cut open the carcass of a dead animal to determine the cause of death.
  - The cause may be obvious such as when a large number of internal parasites are found. But if no macroscopic signs are found, then
    - samples must be taken for microscopic examination of tissue samples to determine a specific diagnosis → This is called histology.

3 Methods of administering medicine to animals

- Injections (can be intravenous, intramuscular or subcutaneous)
  - Sick animals suffering from bacterial infections can be treated with injections of antibiotics. Some worm remedies are either injected as a once-off treatment or given on a sustained basis as part of a worm control programme.
- Dosing
  - Dosing is when remedies are given by mouth. These treatments include worming remedies, diarrhoea medications and antibiotics. Worm remedies can be used as a once-off treatment or on a sustained basis as part of a programme. Dosing must be done correctly to ensure that the animal is not harmed.
- Vaccinations
  - Vaccinations are used to prevent various diseases. Most vaccines are injected subcutaneously or intramuscularly. In poultry some vaccines are applied as eye drops or a spray which is inhaled by the birds.
- In-feeds
  - Some medications are given in the animal feed. This method is used for some growth promotants or antibiotics given to prevent infections in animals. It is often done on a sustained basis in intensive animal production systems.
- Dipping
  - Animals can either be dipped or the dip can be applied by spray or pour-on methods. This is used mainly to treat or control external parasites.
- Footbaths
  - Can be used to control ticks found on the feet of animals. It can also be used to treat and prevent diseases such as foot rot in sheep or cattle.

Sustainable use of medication

Sustainable medication (SM) in agriculture combines the advantages of modern, traditional and complementary treatment systems, to provide better healthcare services for livestock.
Its basic characteristic is to form a preventive and affordable system from a combination of the best of modern and traditional medicine, integrating the latest technology to access and utilise the benefits of Indigenous Knowledge Systems related to the care and treatment of livestock. A further characteristic of SM is the fact that the main therapeutic materials can be regenerated, replaced or replenished after each harvesting with minimal damage to the environment. The underlying aim of SM is to use a holistic approach in animal healthcare in order to attain results in treatment that will eventually minimise or rule out further occurrences of diseases.

4 Infectious, non-infectious and metabolic diseases

- Infectious diseases
  - Caused by various infectious agents such as bacteria, fungi, protozoa and viruses, resulting in a fever reaction, which is the body's defensive reaction to try and kill the infectious organism.
  - Infectious diseases are contracted by coming into contact with infected animals or objects that have been contaminated with the infectious organism, while others can be transmitted by insects and ticks.

The insects, etc. that transmit infectious diseases are called vectors.

- Non-infectious diseases
  - Are not caused by infectious agents and they cannot be transmitted between animals. There are various causes and risk factors:
    - Environmental causes – Non-infectious diseases can be caused by the interaction between the animal and its environment. Environmental causes include injury (cuts or broken bones), sun damage (cancer), drowning, lightning strike, heat stroke, burns and exposure to the cold.
    - Parasites – Parasites are a serious threat to farm animals in South Africa. External and internal parasites cause a loss of production and deaths.
    - Poisons – Animals that ingest poisonous substances may die or suffer severe organ damage which can affect their productivity. These substances include chemicals and poisonous plants.
    - Genetic or congenital problems – These are conditions which the animal is born with. These are not always life threatening but some of them can be fatal.
- Metabolic diseases
  - Occur in farm animals due to an increased need for a nutrient. For example, a calcium deficiency in highly productive dairy cows causes milk fever. The animals show nervous symptoms and they may die if they are untreated.

Level of severity of animal disease

Level of seriousness of diseases, the speed with which they develop and their duration or course helps in making a diagnosis.

- Per-acute disease: develops very rapidly, is very severe and possibly fatal.
- Acute disease: it is severe and develops rapidly.
- Chronic disease: it develops slowly over a period of time and may be fatal if it remains untreated.
- Subclinical: this is when a disease-causing organism is present but the animal is asymptomatic. Clinical or visible signs may have passed or they may be seen later in the animal's life.

Unit 2

Animal diseases

1 Main micro-organisms causing diseases in animals

Infectious diseases are caused by infectious agents or microorganisms, including viruses, bacteria, protozoa and fungi, resulting in the four main types of diseases: viral, bacterial, protozoan and fungal.

Viral diseases

Viruses cause viral diseases. A virus is an infective agent that typically consists of a nucleic acid molecule in a protein coat, is too small to be seen by light microscopy, and is able to multiply only within the living cells of a host. There are six important viral diseases that occur in South Africa. They can spread very quickly, and are not treatable.

- Foot-and-mouth disease (FMD): It is the most important threat to food security in a country because it affects the production of animals and it limits the export of agricultural products to developed countries. It is a state controlled disease.
  - Host
    - FMD is a viral disease of cloven-hoofed animals such as cattle, sheep, goats, pigs and some antelope species.
  - Transmission
    - The FMD virus is very infectious. It can spread rapidly by direct transmission from animal to animal and by infected objects.
    - It can also be spread by indirect transmission from one farm to another by infected animals or by trucks, clothes and instruments.
    - Some animals become sub-clinical carriers of the disease when they recover.
  - Symptoms
    - Cattle develop blisters on their tongue and the mucous membranes of their mouth and feet. These can rupture and cause painful sores.
    - They salivate and are unable to eat.
    - Dairy cows develop blisters on their teats which allow mastitis-causing bacteria to enter and severely affects milk production.
    - Sheep and goats develop less severe symptoms, and lesions are often unnoticed by the stock owner.
    - Pigs in commercial systems are severely affected and they lose a lot of weight.
  - Treatment and control
    - There is no treatment for the disease. The state veterinary department controls FMD by fencing the South African borders and the Kruger National Park , where the buffalo are carriers of FMD.
    - They also control animal movement during outbreaks by imposing quarantines and testing and slaughtering infected animals.

- Rabies: This is an important animal disease because it can spread to humans and it is almost always fatal. It is a controlled disease.
  - Host
    - Rabies is a viral disease that can occur in all warm-blooded animals, including humans.
  - Transmission
    - It is transmitted through bites although sometimes it can be transmitted by saliva alone. The source of the virus varies in different parts of South Africa.
    - Cattle are the most commonly affected livestock species.
    - They become infected when bitten by infected mongooses or jackals.
    - The virus has become established in domestic dogs in KwaZulu-Natal and the Eastern Cape which poses a danger to humans and other dogs.
  - Symptoms
    - The virus moves to the nearest nerve and then travels up to the brain.
    - It can take up to a month for the first symptoms to develop.
    - The same symptoms are evident in all animal species, namely a change of behaviour which usually leads to sudden bouts of aggression.
  - Treatment and control
    - There is no treatment for rabies in domestic animals.
    - Cattle in areas affected by rabies can be vaccinated against the disease.
    - All cats and dogs should be vaccinated regularly against rabies to prevent the exposure of humans to the disease.
- Rift Valley fever (RVF): Outbreaks occur periodically as epidemics because the occurrence of RVF is affected by summer rainfall.
  - Host
    - Affects domestic ruminants but humans can become infected when they handle infected animal tissue.
  - Transmission
    - It is transmitted by mosquito species which prefer to bite livestock.
    - Outbreaks usually occur in late summer and autumn.
    - It is particularly common after heavy spring rains because this allows large numbers of mosquitoes to breed.
  - Symptoms
    - When an animal is infected by a mosquito bite, the virus is transmitted through the blood to the liver which becomes infected.
    - The liver of an unborn foetus will be destroyed and it will die and be aborted
    - During RVF outbreaks, 80–100% of pregnant animals abort if they have not been vaccinated. Large numbers of newborn and young lambs (most commonly affected), kids and calves die.
  - Treatment and control
    - There is no treatment. The control of the mosquito vectors is impractical in livestock. Annual vaccination with a live RVF vaccine before the late summer will protect animals from infections.

- Avian/bird flu: This disease has become important worldwide because of its ability to mutate. This enables it to cause epidemics in humans. It is a controlled disease.
  - Host
    - Avian flu is caused by an influenza virus which is adapted to birds. But it can spread to other species, including humans, under certain conditions.
  - Transmission
    - Wild birds and ostriches can serve as asymptomatic carriers of the virus and they can spread the disease to commercial poultry farms.
    - The virus is transmitted by direct contact with infected birds or indirect contact with contaminated objects.
  - Symptoms
    - In poultry the virus causes a wide range of symptoms including depression, breathing problems, a fall in egg production and sudden deaths.
  - Treatment and control
    - There is no treatment for avian flu.
    - Infected birds like ostriches are slaughtered to eradicate the virus because of concerns about the potential spread to humans.
    - Vaccines can be used in poultry houses to prevent the rapid spread of the virus.
- African swine fever (ASF): Is a tick-borne viral disease which is confined to the African continent. It should not be confused with swine flu and European swine fever (or hog cholera) which do not occur in domestic or wild pigs in South Africa at present. ASF is a controlled disease.
  - Host
    - The ASF virus occurs asymptomatically in warthogs and bush pigs. It causes disease symptoms in domestic pigs.
  - Transmission
    - The virus is carried by a tampan which occurs in the burrows of warthogs and bush pigs in the northern areas of the country (Limpopo).
    - Domestic pigs will develop ASF if they are bitten by an infected tampan.
  - Symptoms
    - The first signs of ASF infection in domestic pigs are high temperature, loss of appetite, listlessness and unsteadiness.
    - Later on infected pigs can have bluish mucous membranes and exhibit breathing difficulties, vomiting and diarrhoea. They often die within four days after the first symptoms appear.
  - Treatment and control
    - There is no treatment or vaccine for ASF. So it is controlled by the state to prevent the spread of the disease from the limited area in the north of the country (Limpopo Province) where it often occurs. Veterinary services restrict the movement of wild pigs or their meat from Limpopo Province into other areas. Piggeries in this area are built according to certain specifications to avoid contact with wild pig species.

- Newcastle disease (NCD): One of the most important diseases affecting the productivity of commercial and small-scale poultry. It is a controlled disease.
  - Host
    - NCD is an acute viral disease of domestic poultry. It also affects some other bird species such as waterfowl, pigeons and imported parrots.
  - Transmission
    - Transmitted when infected birds shed the virus through droplets that are spread when they cough, as well as through their faeces and eggs.
    - Birds can be infected when they breathe in the virus or take it in by mouth
    - The virus can be carried into poultry houses or onto properties when people handle sick birds or visit infected farms.
    - The virus can be carried on people's hands, clothes and shoes or on equipment.
  - Symptoms
    - Signs of the disease appear within five days.
    - The virus can affect the respiratory, digestive and nervous systems. These systems can be affected in combination or in sequence.
      → The respiratory signs are gasping, coughing, sneezing and noisy breathing.
      → Nervous system signs include trembling, paralysis of the wings and legs, and twisting of the neck. Watery, greenish diarrhoea indicates that the digestive system has been affected.
      → Other typical symptoms are a severe decrease in egg production and the appearance of abnormal-looking eggs.
  - Treatment and control
    - There is no treatment for NCD. Birds in small-scale systems and commercial houses must be vaccinated because the disease affects egg production and weight gain.
    - Several NCD vaccines are available.
    - The B1 and La Sota strains are used commonly to vaccinate day-old chicks. These vaccines are given in their drinking water or sprayed in bird houses.

Bacterial diseases

- Anthrax: A serious disease caused by the bacterium *Bacillus anthracis*. It is a controlled disease.
  - Host
    - Ruminants, pigs, horses, various wild animal species and humans.
  - Transmission
    - Farm animals become infected by direct contact with sick animals or by exposure to *Bacillus anthracis* bacterial spores in the soil. Spores are on the carcasses of dead animals which have died from the disease and been buried.
    - Outbreaks usually begin when the anthrax spores are exposed by droughts or floods. The disease spreads rapidly when the carcasses are opened by scavengers or cut up by farmers. The infection may then spread to other species.

- Symptoms
  - The disease is usually per-acute in ruminants. The animals commonly show very few symptoms and die rapidly. Anthrax should always be suspected in cases of acute death. Carcasses must not be opened until an animal health technician or veterinarian has made a blood smear. Brick-like anthrax bacteria are seen in the blood in positive cases.
  - They may show a leakage of blood from body openings such as the nose and anus after death.
  - Pigs may have a swollen throat and die more slowly.
- Treatment and control
  - Treat animals with a high temperature with penicillin.
  - The farm must be quarantined if an anthrax outbreak is suspected to control its spread. The quarantine lasts until 14 days after the last confirmed case of the disease.
  - Carcasses must be buried and covered with lime to help break down the bacterium.
  - All farms must vaccinate their animals every year to prevent an anthrax outbreak since it is impossible to eliminate anthrax spores from the soil.

- Mastitis: An infection of the udder that usually occurs during lactation.
  - Host
    - Caused by various species of bacteria that infect cattle, sheep or goats. It is most important in dairy animals as it causes a loss of production.
  - Transmission
    - The bacteria are usually transmitted by contact with infected animals, either by milkers on the hands or milking machines.
    - Infected cows serve as carriers of certain bacteria for healthy cows.
    - The udders of cows can be infected by some environmental or soil bacteria, especially under muddy conditions.
  - Symptoms
    - There are different severities of mastitis and they range from per-acute to chronic cases. Chronic mastitis is usually only detected by somatic cell counts or cow-side tests like the California Mastitis Test.
    - In very severe cases the udder can become swollen and inflamed. It eventually turns blue and gangrenous and animals may die because of toxin production by the bacteria.
    - Acute and sub-acute cases show clots in the milk and painful swelling of the infected quart.
  - Treatment and control
    - Mastitis can be treated with antibiotics which are injected into the udder (intra-mammary preparations).
    - Cows with badly damaged udders must be culled. There are many management practices to prevent mastitis in dairies and these include hygiene and the proper use of milking machines.

- Tuberculosis: Bovine tuberculosis (or BTB) is a chronic disease of cattle and it causes a severe drop in milk production in cows. It is a controlled disease.
  - Host
    - Cattle are the main hosts of BTB although it can also infect humans.
  - Transmission
    - *Mycobacterium bovis* is the bacterium which causes BTB. It is transmitted directly by infected cows or indirectly on grazing or by equipment.
  - Symptoms
    - BTB is a chronic disease that develops very slowly. The first symptoms only become visible a few years after infection by which time the animal is sick.
    - The bacteria cause the formation of small nodules in the lungs and other organs. Once the infection is widespread, the animal shows severe weight loss, swollen lymph nodes and it may develop a cough if the lungs are affected. Milk production of infected cows drops dramatically. Infected animals will die eventually.
  - Treatment and control
    - Antibiotic treatment of BTB is not economical.
    - BTB cases must be reported to the state veterinary authorities who brand the animal with a T and supervise the slaughter in a special abattoir.
    - All other cattle in the herd must be tested to identify infected animals. Cattle farmers must test animals for BTB before they buy them.

Protozoan or blood-borne diseases

- Redwater: Caused by *Babesia bovis* and *Babesia bigemina*.
  - Host
    - The redwater parasite causes this disease in cattle.
  - Transmission
    - The protozoal organisms are transmitted by certain tick species which occur mainly in the northern and eastern parts of South Africa.
  - Symptoms
    - The two *Babesia* species cause similar symptoms initially. The *Babesia* parasites travel to the liver when cattle are bitten by infected ticks.
    - The parasites spread to the red blood cells where they attach and multiply, and cause a fever.
    - They eventually break down the red blood cells which causes anaemia and red discolouration of the urine (redwater).
    - Animals become weak, stop eating and die within a short time unless they are treated.
    - Nervous symptoms develop later with *Babesia bovis*. A cerebral or brain infection can give rise to increased excitability, convulsions and paralysis.
  - Treatment and control
    - Can be treated with babesicides. Calves can be vaccinated to control the disease. Exposure to infected ticks will also stimulate their immunity.

- Anaplasmosis or gallsickness *(Anaplasma marginale)*: Affects the red blood cells very chronically.
  - Host
    - It occurs in cattle.
  - Transmission
    - It is caused by the organism *Anaplasma marginale*. It is transmitted by ticks and attacks the red blood cells.
  - Symptoms
    - Animals develop a fever for a short time after being bitten by an infected tick
    - Thereafter they gradually lose their appetite and their condition deteriorates
    - They develop jaundice as their red blood cells begin to break down
    - Eventually the rumen stops functioning due to lack of food and the animals become very weak.
  - Treatment and control
    - Can be treated with a dose of tetracyclines.
    - Farmers may have to treat animals in chronic cases to get the rumen functional again.
    - Calves can be vaccinated against anaplasmosis to prevent infection and their continual exposure to infected ticks will stimulate their immunity.
- Heartwater: A very important tick-borne disease because it is fatal if untreated.
  - Host
    - This is a disease of cattle and small ruminants caused by *Erlichia (Cowdria) ruminantium*, which is a rickettsia or type of bacterial disease.
  - Transmission
    - Transmitted by the bont tick (*Amblyomma hebraeum*) which occurs in the eastern and northern areas of South Africa.
  - Symptoms
    - Animals that have been bitten by an infected tick develop a very high temperature, lose their appetite and later begin to show various symptoms as a result of damage to blood vessels.
    - Fluid can build up in the brain which causes nervous symptoms such as high stepping, walking in circles and then lying down and paddling of the legs
    - Fluid collects in the lungs and makes it difficult to breathe.
    - Froth may be seen from the nose and the animals will die at this stage if they are not treated.
  - Treatment and control
    - Treatment with tetracyclines can save sick animals.
    - Calves can be vaccinated against heartwater and this will protect them until adulthood.
    - Adult cattle will be immunised by their continual exposure to infected ticks
    - Sheep and goats must be dipped to prevent heartwater.

- Coccidiosis: A protozoan disease that occurs in young ruminants and poultry. It occurs especially when animals are kept in crowded conditions. There are a large number of species of the coccidian parasite, such as *Isospora* and *Eimeria*.
  - Host
    - The condition occurs in young calves, sheep and goats up to the age of 2–3 months, and in poultry in intensive systems. Older animals become immune to the disease but they remain carriers.
  - Transmission
    - Coccidia infect the intestinal wall of their hosts. They multiply and produce oocytes which are shed in the faeces. These oocytes land on pastures or floors of poultry houses where they are picked up by susceptible animals.
  - Symptoms
    - The most typical symptom of coccidiosis in ruminants is diarrhoea. It can be mild or very severe and sometimes even bloody. Symptoms in birds are poor growth, depression and diarrhoea. A large number of deaths can occur.
  - Treatment and control
    - Anti-coccidials are given in the water or by injection to treat coccidiosis.
    - Drugs called coccidiostats are used to reduce the number of organisms in the herd/flock.
    - Vaccines are also available to control coccidiosis on intensive poultry farms
    - Various management factors (e.g. improved hygiene, reducing crowding and stress factors) can be used to control the disease.

Fungal diseases

- Lumpy wool: Caused by a fungus-like bacterium or actinomycete called *Dermatophilus congolensis*.
  - Host
    - This condition is seen in sheep as a result of continual wetting of the fleece.
  - Transmission
    - The spores of the organism are spread from one sheep to another. This occurs when the fleece remains wet from heavy rain or when sheep are dipped during cool weather.
  - Symptoms
    - The organism infects the skin and causes matting of the fleece or so-called lumpy wool. This damages and reduces the value of the fleece. It causes loss of condition in non-woolled sheep like dorpers.
  - Treatment and control
    - Antibiotics can be used to treat badly infected animals. Farmers should also prevent prolonged wetting of fleece and the contact of these sheep with unaffected ones.

- Ringworm: An infection caused by a skin fungus. It is commonly caused by the fungus *Trichophyton* spp.
  - Host
    - It is seen in various domestic animal species but it is most common in young calves and Karakul sheep.
  - Transmission
    - Commonly found in young animals that are kept in unhygienic housing or poor conditions.
    - The fungus is easily transmitted because it forms resistant spores which can be transmitted to other animals by direct contact or by indirect contact with infected pens or kraals.
  - Symptoms
    - The fungus infects the hair follicle and causes the hair to break off.
    - Circular, hairless patches are usually seen and they are not itchy
    - These patches usually appear on the head and neck but they can extend over the whole body.
    - The condition is unsightly and reflects the poor condition of an animal.
  - Treatment and control
    - Apply iodine or sulphur preparations once a week to treat cases of ringworm.

2 Economic implications of animal disease

Death or mortalities

A high mortality rate can cause the farmer huge economic losses. Anthrax is an example of a disease that causes a large number of mortalities.

Economic loss

Diseases that do not cause a high percentage of mortalities may cause economic loss because of a decrease in production. In these cases animals lose weight, show a drop in milk or egg production, fail to reproduce or suffer abortions.

Trade restrictions (export)

Some diseases cause huge economic losses because exports to countries that are free of those specific diseases are stopped.

Impact of animal diseases on the environment

Impact comes mainly from the methods used to prevent and control the diseases:

- Chemical substances, such as pesticides, can have direct effects on the environment by affecting unintended target organisms and animals, thus disturbing the functioning of ecosystems.
- Reduction of livestock morbidity and mortality promotes an increase in human and animal populations. Consequently pressure on the environment is increased, which puts resources at risk.

3 Prevention and control of animal diseases

It is very important to prevent and control animal diseases in South Africa because:

- viral diseases cannot be treated economically
- some bacterial infections cannot be treated, e.g. bovine tuberculosis (BTB)
- diseased animals suffer a loss of production
- treatment is often too late for some acute diseases
- some animal diseases are transmissible to humans (this is called zoonosis).

There are various methods to prevent and control diseases.

- Vaccination
  - This is one of the most important means of disease control. It is a simple intervention which is harmless to the animal and it can be used to prevent disease. This means that there is no production loss and the cost is very low when compared to the value of the animal.
- Testing
  - Some diseases are controlled by testing animals before they are purchased. The intra-dermal or skin test is a convenient method to identify TB infected herds.
- Maintaining closed herds
  - To prevent diseases such as tuberculosis, a closed herd is maintained. Only clean animals are kept and all new animals are tested before they are introduced to the herd. Fences must be maintained so that the herd is not exposed to infected animals.
- Fencing, buffering and inspection
  - This method can be illustrated by the example of a foot-and-mouth disease outbreak in the Kruger National Park. Animals are vaccinated in a buffer zone around the park. Disease transmission is monitored by maintaining fencing and frequently inspecting animals to monitor the possible spread of disease.
- Quarantine
  - It is very important to quarantine or isolate new animals before they are mixed with the other animals on a farm.

Unit 3

Parasites in farm animals

1 Parasites

Parasites of domestic animals are macroscopic creatures which spend part or all of their life cycle in or on the animal. They are important because they cause damage, transmit disease and sometimes even cause the death of the animal.

2 Internal parasites/endoparasites

These parasites that we refer to as worms. Most of these are found in the digestive system. Some internal parasites (e.g. tapeworms) have a temporary or intermediate host and a main host.

- Roundworms
  - Life cycle
    - Large numbers of roundworms can occur in the intestines of domestic animals. They either absorb the food that is digested by the animal or suck blood from the intestine wall.
    - After mating the female sheds eggs in the faeces of the host animal. The eggs land on grass pastures and they hatch under the right conditions. The larvae are picked up by passing animals.
  - Animal hosts
    - All farm animals have specific roundworm species which can infest them. Some of them cause severe loss of condition and production and even cause death in their hosts.
  - Symptoms
    - The symptoms of a roundworm infestation depend on the type of worm and these are shown in the table on pagepage 101. Infestation with certain roundworm species can severely affect the health and production of animals.
  - Treatment
    - Roundworm infestations can be diagnosed based on the observed symptoms. This can be confirmed by the presence of worm eggs in the faeces. Worm infestations can be treated with worm remedies.
- Tapeworms
  - Life cycle
    - Adult tapeworms are long, flattened worms which occur in the intestine of their main hosts. They produce eggs when they mate and these are shed in the faeces. These eggs are ingested by the intermediate host and they form immature larvae or cysts.
    - These resting forms of tapeworms remain in the tissues until they are eaten by the main host. The cyst then hatches in the intestine of the main host and the adult worm develops inside its intestine.

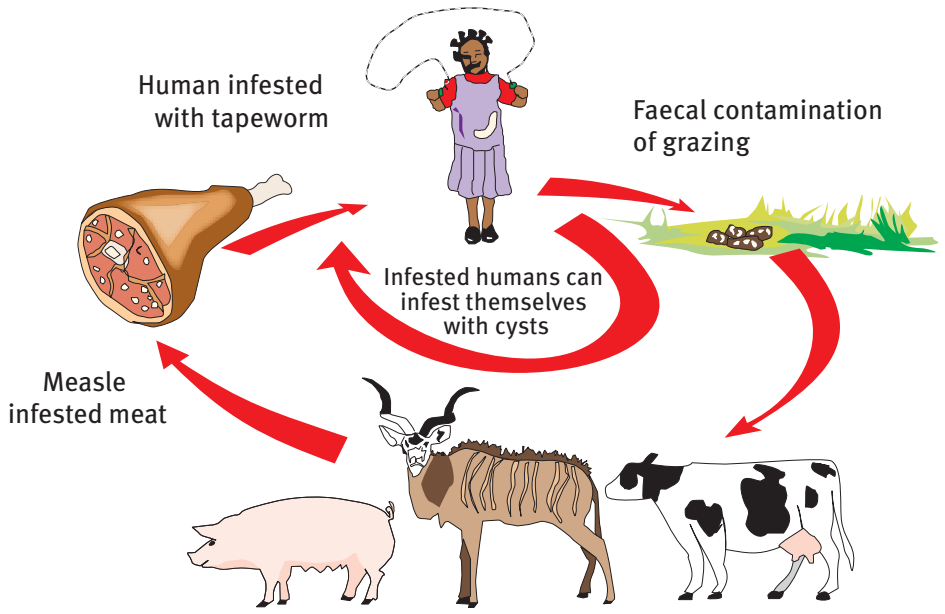


FIGURE 1 Life cycle of a human tapeworm

- Animal hosts
  - All farm animals have tapeworm species which can infest them.
  - Some of these species can cause health problems while others are more important for human health.
- Symptoms
  - The milk tapeworm (*Moniezia*) can grow to a massive size and it causes a loss of condition in calves and lambs.
  - The animals become stunted and pot-bellied and they may even die due to poor condition.
  - Two other important tapeworms that affect animal health are the beef *(Taenia saginata*) and pork (*Taenia solium*) tapeworms.
  - Their main host is the human being.
  - When infected humans defecate on pastures, the tapeworm eggs are eaten by cattle or pigs and cysts develop in the muscles of these animals.
  - Humans become infested with the tapeworm when they eat this meat.
- Treatment
  - Young animals can be dosed with tapeworm remedies as soon as they begin grazing. (See also the table on page 101.)

- Liver flukes (trematodes)
  - Life cycle
    - Farm animals may become infested when they graze in vleis or around dams where small water snails are found. These snails are the intermediate fluke hosts. The snails shed the small, immature form of the fluke (cercariae) onto the pasture and these are eaten by animals. Once in the intestine of the host, the cercariae develop into young flukes which then travel to the liver. They grow into adults in the liver where they suck blood and cause tissue damage. The females lay eggs which are passed out into the faeces and these eggs hatch into miracidia which infest the water snails.
  - Animal hosts
    - Cattle, sheep, goats and horses may become infested with liver flukes.
  - Symptoms
    - Liver flukes are bloodsuckers which cause severe anaemia and liver damage. Sheep can develop bloody diarrhoea.
  - Treatment
    - There are a number of remedies which can be used to treat liver fluke infestation. (See next page.)

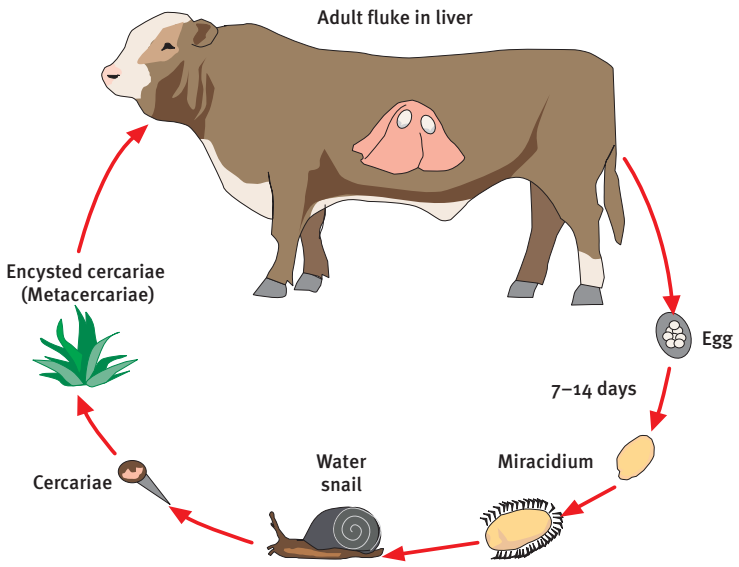


FIGURE 2 Life cycle of a liver fluke

Financial implications of internal parasites

Roundworms, tapeworms and flukes can all cause loss of condition, poor production and even death in farm animals. The beef and pork tapeworm cause cysts in the meat which are referred to as measles. They cause losses for the farmer because this meat is condemned at the abattoir.

Some important internal parasites of domestic animals			
Worm	**Main host(s)**	**Intermediate host**	**Effect on animal**
Wireworm (*Haemonchus* spp)	cattle and sheep	none	anaemia, bottlejaw, weakness, death
Stomach worms (*Ostertagia* spp)	cattle and sheep	none	diarrhoea, weight loss, death
Pig roundworm (*Ascaris suum*)	pigs	none	reduced growth, lung problems
Milk tapeworm (*Moniezia*)	lambs and calves	grass mite	weight loss, death
Beef (*Taenia saginata*) and pork (*Taenia solium*) tapeworms	humans	cattle and pigs	condemnation of measly meat
Liver fluke (*Fasciola hepatica*)	cattle and sheep	water snails	anaemia, severe diarrhoea, death

Preventative/control measures for internal parasites

Roundworm control programmes should be used to prevent heavy infestations. Select the correct remedy for the specific roundworm that needs to be controlled. Human tapeworm infestation of meat can be controlled if toilets are provided to prevent faecal contamination of pastures. Liver fluke infestations can be controlled with remedies called flukicides, like closantel, clorsulon, rafoxanide and triclabendazole.

3 External parasites/ectoparasites

These include insects and arachnids. The insects have six legs and they include flies and lice. Arachnids have eight legs and this group includes ticks and mites. Most of these parasites feed on the blood, secretions or tissues of the host animal.

- Flies: This category of external parasites includes two species of flies which cause problems in small stock.

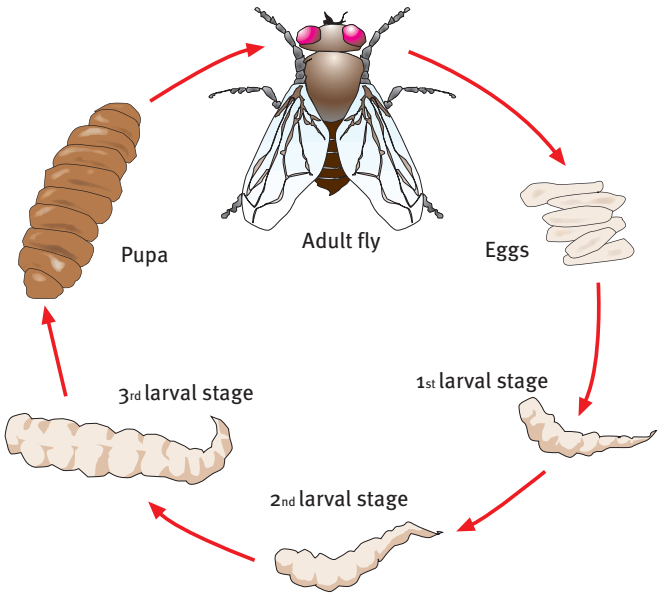


Figure 3 Life cycle of a typical fly

- Blowflies
  - Large, metallic green or blue flies which lay their eggs on animal carcasses. Some blowflies lay their larvae on live animals. A number of blowfly species (*Lucilia cuprina*, *Chrysomya* spp) lay their eggs on woolled sheep (merinos) in areas where the fleece becomes wet or soiled by urine or faeces.
  - When the larvae hatch, they begin to feed on the softened skin and cause large wounds.
- Nasal flies
  - Nasal flies (*Oestrus ovis*) are seldom seen by farmers because they fly very fast. They lay live larvae in the form of a maggot around the nostrils of sheep and goats. These larvae crawl into the nose and up into the nasal sinuses. They feed in the sinus area and they are sneezed out when they are mature. They then pupate in the soil and develop into adult flies.
  - Nasal flies cause severe irritation to the infested animal which may lose weight or even stop eating.

- Lice: Wingless insects that are related to flies.
  - They spend most of their life cycle on other animals.
  - Usually each domestic animal species is infested by a particular louse species.
    - Red or biting lice irritate and damage the fleece or hair of woolled sheep and Angora goats.
    - The infested animals then rub themselves against objects and pluck at their fleece. Blue lice suck blood and cause anaemia.
- Ticks: Eight-legged insects that suck blood from animals.
  - There are three stages of their life cycle, namely larvae that hatch from eggs laid by females, nymphae and adults.
  - Ticks feed on the blood of animals at all of these stages.
  - There are three different types of ticks.
    - Single host ticks: These ticks feed on the same animal at every stage throughout their lifecycle. The blue tick (*Boophilus spp*) is an example of a single host tick.
    - Two host ticks: The larvae and nymphae of these ticks feed on small mammals. The adult ticks feed on domestic animals. The paralysis tick (*Ixodes rubicundis*) is an example of a two host tick.
    - Three host ticks: The larvae, nymphae and adults each feed on different animals during their lifecycle. The hosts include wild animals, birds and domestic animals. The bont tick (*Amblyomma hebraeum*) is an example of a three host tick. These ticks are more difficult to control because they feed on different hosts and some of these hosts are wild animals.

Examples of important ticks in farm animals			
Tick species	**Main host(s)**	**Affected areas**	**Effects on animal**
Bont tick (*Amblyomma hebraeum*)	cattle and sheep	northern and eastern areas	transmits heartwater, long mouthparts cause wounds
Blue ticks (*Boophilus* ticks)	cattle	widespread except for dry western areas	transmits redwater and anaplasma, suppresses appetite
Karoo paralysis tick (*Ixodes rubicundus*)	sheep, goats and calves	highveld areas of Free State and Gauteng	paralysis
Brown ticks (*Rhipecephalus* spp)	sheep and goats	Eastern Cape	paralysis and lameness
***Hyalomma* ticks**			sweating sickness, tissue damage, transmits anaplasma

- Mites
  - Closely related to ticks but they are much smaller, so most mites can only be seen with a microscope.
    - Each domestic animal species is infested by a particular mite species which lives permanently on its body.
    - Like ticks, mites have larvae, nymphae and adult stages to their life cycle. Mites burrow into the skin at all three of these stages and they feed on the serum which oozes from the wound.
    - *Psorgates ovis* is one of the most important mites that affect farming and it causes a condition called sheep scab.

Financial implications of external parasites

External parasites cause damage to animals in various ways which can cause financial losses for farmers.

- Damage to fleece in woolled sheep
  - Blowfly strike in sheep causes losses in woolled sheep because it reduces the amount of fleece available to be sheared.
  - Some parasites irritate the skin.
    - Red louse infestation and sheep scab causes fleece to be plucked out, soiled or damaged when sheep bite themselves or scrape against objects like fences.
- Loss of weight
  - Certain ticks release substances which cause a loss of appetite in cattle. The cattle lose weight which leads to financial loss. External parasites which cause irritation of the animal like sheep scab, sheep louse infestation and nasal worm all cause loss of condition in the host animals because of this discomfort.
- Weakness due to anaemia
  - Heavy infestations with external parasites like ticks and lice that suck blood can cause anaemia, especially in young animals. The anaemia causes weakness and sometimes can even result in the death of animals.

- Disease and death
  - Some ticks carry the blood parasites that cause heartwater, redwater and anaplasmosis. These diseases cause serious symptoms which have to be treated and they require the farmer to spend money on medicines. If the animals are treated too late, the disease may result in the deaths of large numbers of animals.

Treatment and control of external parasites

There are various remedies which can be used to treat external parasite infestation. Some of these can be used to prevent parasite infestations.

- Flies
  - Blowflies
    - Wounds infested by blowfly maggots must be treated with products that contain insecticides. You can prevent blowfly infestations in woolled sheep if you spray them with remedies registered to control fly strike. It can also be prevented if you shear sheep around their hindquarters to prevent soiling with faeces.
  - Nasal flies
    - Sheep and goats with nasal worm infestation can be treated with an injection of macrocyclic lactones. They can also be dosed with other remedies registered for nasal worm control.
- Lice
  - Registered chemicals can be used to treat louse infestations.
    - Clean herds can be maintained if you treat introduced animals before they have contact with the rest of the flock/herd.
- Ticks
  - Apply registered tick remedies to control ticks. They can be applied by dipping, spraying, pour-ons or tick grease. There are two main forms of control.
    - Total or intensive control requires that all ticks are killed, such as in the case of dairy animals.
    - Low level control allows a small number of ticks to survive so they can immunise animals against the tick-borne diseases that occur in the area.
- Mites
  - Mites cause a controlled disease called sheep scab.
    - All flocks must be treated once a year with registered products as a preventative measure.
    - The law states that all animals must be dipped or injected with registered remedies if an outbreak occurs.
    - There are various remedies which are registered to control sheep scab, such as macrocyclic lactone injections and dips that contain amitraz or organophosphates.

Unit 4

Plant and metallic salt poisoning

1 Plant poisoning

The most important poisonous plants

- Lantana (*Lantana camara*)
  - Has spread over large areas of the country
  - Is a declared weed in South Africa.
  - Landowners must eradicate it, as it is an important cause of poisoning in cattle. Lantana causes irreversible liver damage.
- Gifblaar (*Dichaepetalum cymosum*)
  - A small herb that occurs in Limpopo and Gauteng and emerges in spring before other plants.
  - Cattle may be tempted to eat gifblaar if there is nothing else to graze on.
  - It causes heart failure which is untreatable.
  - Gifblaar veld must be avoided in the spring.
- Poison bulb (tulip poisoning); includes the bulbs *Homeria* and *Morea* spp.
  - The plants are found in the central and western areas of the country, and the Eastern Cape.
  - Is one of the few plant poisonings that can be treated effectively with activated charcoal. Farmers should keep new animals away from heavily infested pastures to control poisoning
  - Affects hungry animals and those that have been newly introduced to the plants
    - Animals can die suddenly of a heart attack or they can become apathetic
    - This apathy is shown by lowered heads, groaning and grinding of teeth. .
- Maize fungus (*Stenocarpella (Diplodea) maydis*)
  - Grows on maize cobs in winter in the maize areas of the north western Free State, Mpumalanga and KwaZulu-Natal, especially during cool and wet weather.
  - This poisoning causes 2% of all the plant poisonings in cattle.
    - It causes nervous symptoms, mainly high stepping and paralysis.
    - Poisoning can cause stillbirths and neonatal deaths in calves.
    - There is no treatment for maize fungus but animals can recover if they are removed from the source of poisoning.
- Thorn apple (*Datura stramonium*)
  - These large annual weeds are found mostly on disturbed land.
  - They produce spiny or thorny seed capsules which release large numbers of small black seeds. The leaves of the plant are used for medicinal purposes but they are seldom eaten by livestock because of their unpleasant taste. The seeds are also poisonous. Sometimes they are harvested along with maize or hay and this can poison ruminants and horses.
  - The alkaloid in the seeds can suppress the heart rate, cause nervous symptoms and even death. The effect depends on the dose.

Prevention and treatment of plant poisoning

Most plant poisonings in animals cannot be treated. They usually cause irreversible damage to the body's organs. Stock owners can prevent plant poisoning if they:

- learn about the plants in the area
- fence plants off during danger periods
- herd animals away from dangerous plants
- avoid overgrazing and overstocking.

2 Poisoning by metallic salts

Farm animals are exposed to chemical poisoning from various sources.

- Metal salt poisoning
  - There are two examples that can affect farm animals.
    - Pesticides and herbicides are used on farms for weed and pest control and they can poison livestock. Organophosphates are often involved and this is sometimes due to their incorrect application on animals.
    - Farmers occasionally also dose animals with copper sulphate if they suspect a deficiency in this salt. Sheep are very prone to poisoning if they receive a copper sulphate overdose.
  - Symptoms
    - Most agricultural chemicals cause nervous symptoms (e.g. muscle tremors and excitement, ending in death of the animal. Sheep poisoned with copper sulphate may die rapidly and show severe and jaundice.
  - Treatment
    - There is no treatment for most pesticide, herbicide or copper sulphate poisoning.
- Urea poisoning
  - Urea is commonly used as a non-protein nitrogen supplement in ruminants and it is usually given in the form of a block.
    - It can lead to urea poisoning under certain circumstances.
  - Symptoms
    - Excess urea intake converts the urea to ammonia which causes alkalosis. Poisoned animals show bloating, nervous symptoms, and can die if not treated.
  - Treatment
    - Administer vinegar into the rumen or by mouth to treat alkalosis. This treatment will restore the pH to normal levels.

Prevention and control of poisoning by metallic salts and inorganic substances

All herbicides and pesticides that are used on farms must be locked away safely. They must also be handled carefully according to the manufacturer's instructions. Urea poisoning can be prevented if you feed the urea to ruminants gradually and without breaks in between. The recommended amount (1% of the total feed) should not be exceeded and the urea blocks should not be allowed to dissolve in water.

3 Principles to control animal diseases and parasites

- Implement regular vaccination programmes to control preventable diseases that occur in your area.
- Implement regular parasite control programmes for internal and external parasites that occur in your area.
- Request proof of freedom from important diseases such as brucellosis and TB for which testing can be done.
- Quarantine new animals and treat them for parasite infestations during this period.

4 The role of the state in animal protection

The state uses various means to safeguard the national herd in order to maintain food security.

- Legislation
  - Certain laws which can be implemented to stop the spread of animal diseases. These laws stem from the Animal Diseases Act 35 of 1984.
  - It gives the state certain powers during disease outbreaks. For example:
    - the state in South Africa controls certain exotic diseases as well as FMD, African swine fever, Newcastle disease, anthrax, rabies, BTB and sheep scab. These are called controlled diseases.
  - Some diseases must be reported to state authorities and these are called notifiable diseases. Examples include:
    - lumpy skin disease, Rift Valley fever and blue tongue.
  - Another important law is the Stock Remedies Act 36 of 1947.
    - It ensures that medication sold for animal use has been tested to ensure that is both safe and effective. The stock remedy can then be given a registration number (or G number).
- Import controls
  - The state controls the import of animals into the country to prevent the importation of exotic diseases. Certain tests have to be performed on animals before they are imported into the country to show that they are free of certain diseases.
- Laboratory services
  - State-funded laboratories assist South African farmers with the diagnosis of diseases.
- Vaccine production
  - Onderstepoort Biological Products produces vaccines for South African diseases such as blue tongue, horse sickness and heartwater. These vaccines are only available in South Africa.

Topic 4

Topic questions

- Answer the questions below. Check your answers afterwards and do corrections.
- Give yourself one hour.
- Marks: 100

1 Choose ONE answer below to complete this sentence: Various laboratory tests can be done on live animals to help make a diagnosis. For example, a faecal examination can be done to _____

1.1 to look for parasites in blood cells

1.2 check for antibodies

1.3 test for signs of roundworm

1.4 grow a culture for an infectious agent (2)

2 Angora goats can suffer from anaemia. (4)

2.1 List FOUR possible causes.

2.2 How would you eliminate each cause to make a diagnosis? (4)

3 There is an infectious disease that causes deaths in newborn animals.

3.1 Name this disease. (1)

3.2 How can these young animals be protected? (1)

4 FMD causes few mortalities in farm animals. Discuss why it is important to control this disease. (5)

5 Animal health is important in livestock production.

5.1 Study and complete the table below. Write down the question number, the letter and your answer next to each letter. (3)

Scientific name	Internal/external	Type of parasite	Effect on host animal
Psorogates ovis	external	sheep scab mite	A
Lucilia cuprina	B	blowfly	wounds in woolled sheep
Fasciola hepatica	internal	C	anaemia

Topic questions

5.2 There are TWO examples of metallic salt poisoning that can affect farm animals. Identify them. (2)

5.3 What are they symptoms and treatment of urea poisoning? (3)

6 Name FOUR infectious diseases in this topic that are zoonoses or transmissible to humans. (4)

7 Describe the general behavioural changes shown by a sick farm animal. (4)

8 Give TWO examples of a chronic infectious disease. (2)

9 It is important for farmers to control viral diseases.

9.1 Can antibiotics be used to treat viral diseases? (1)

9.2 What is the main method of control for these diseases? (1)

10 List FIVE typical symptoms of heartwater. (5)

11 There are various types of internal parasites.

11.1 Which TWO main types have intermediate hosts? (2 × 1 = 2)

11.2 Give an example for each answer in (11.1). (2)

11.3 Name the intermediate host of each answer in (11.2). (2)

12 Livestock is vulnerable to ticks.

12.1 Outline the negative effects of ticks on farm animals. (4 × 2 = 8)

12.2 List the infectious diseases transmitted by ticks. (3 × 1 = 3)

12.3 Explain how ticks provide immunity against tick-borne diseases. (2)

13 List FOUR important infectious diseases of pigs that have occurred in South Africa. (4)

14 Indicate THREE main types of livestock affected by foot-and-mouth disease. (3)

15 Poisonous plants can affect animal production.

15.1 Name a poisonous plant that can cause liver damage in ruminants. (1)

15.2 Name TWO poisonous plants that cause heart attacks. (2)

15.3 Which plant poisoning causes nervous symptoms? (1)

15.4 How can plant poisonings be prevented in a herd? (1)

Topic questions

15.5 Give an example of a dip which can cause fatal poisoning in animals when the correct dose is exceeded. (1)

16 Why is sheep scab control vital to the wool industry in South Africa? (2)

17 Name FOUR conditions/parasites which can damage the fleece of sheep. (4)

18 An external parasite lays live larvae on its host.

18.1 Name this parasite. Give its scientific and common name. (2)

18.2 What are the symptoms of this condition? (1)

19 Describe the steps one can take to prevent urea poisoning in livestock. (4)

20 Explain the differences between the terms:

20.1 infection and infestation

20.2 macroscopic and microscopic (2 × 2 = 4)

21 Explain the meaning of these terms:

21.1 serology

21.2 histology

21.3 postmortem (3 × 2 = 6)

22 The sale of medication for farm animals is regulated by an Act.

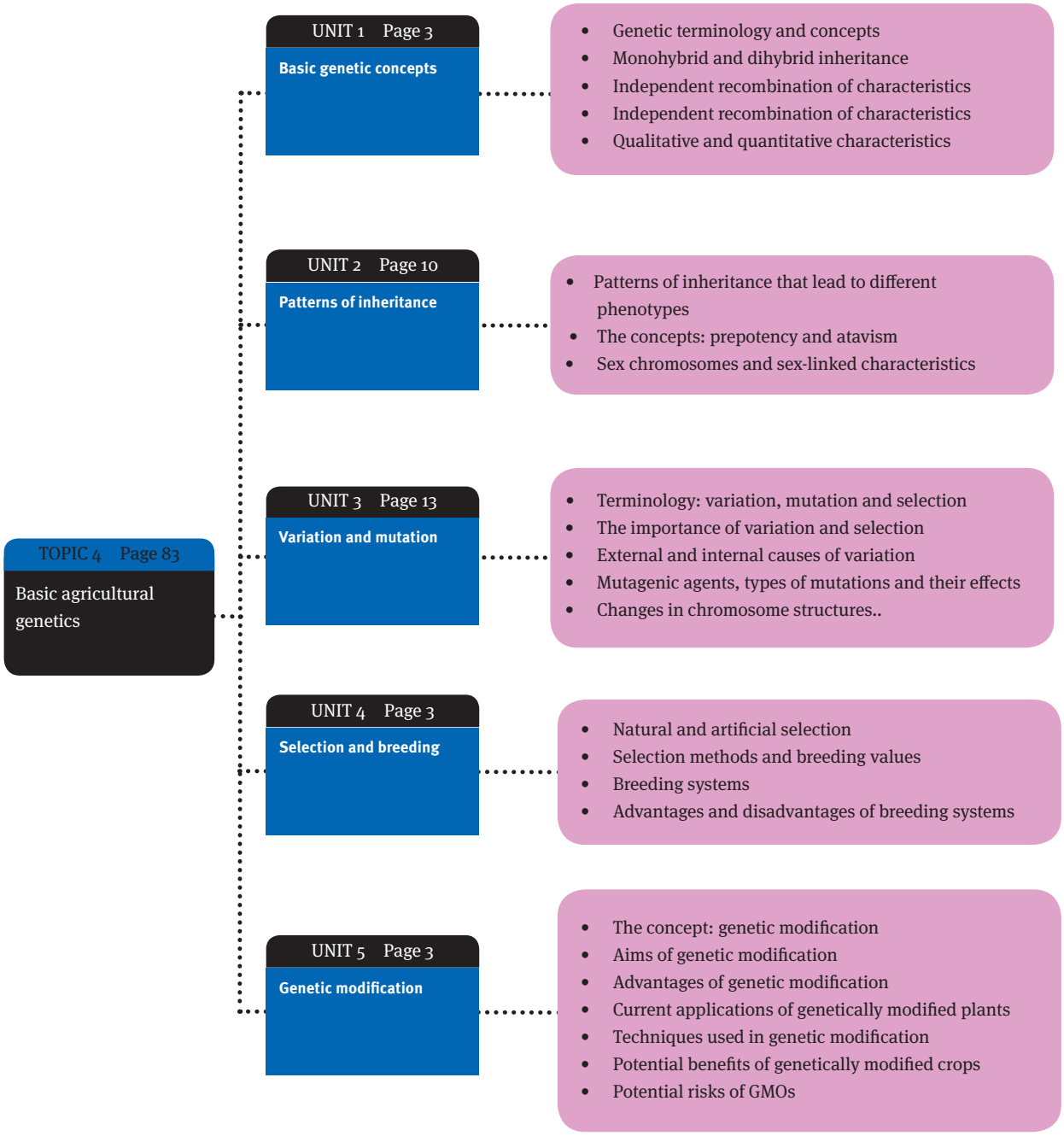
22.1 Name the Act. (1)

22.2 Explain the purpose of the Act. (2)

Topic 5

Basic agricultural genetics

Overview



Unit 1

Basic genetic concepts

1 Genetic terminology and concepts

- Genetics and heredity
  - Genetics is the study of heredity in living organisms. Heredity is the way in which characteristics are inherited. Inherited characteristics are passed down from parents to offspring.
- Genes
  - Genes are short stretches of DNA which code for the production of a specific protein or enzyme. The genes of animals and plants are arranged into groups on structures called chromosomes.
- Chromosomes
  - A chromosome is a threadlike structure or strand of DNA in the nucleus of most living cells. Made up of nucleic acids and protein, chromosomes carry genetic information in the form of genes and are responsible for the transmission of hereditary information. Each species has a particular number of chromosomes (e.g. cattle have 60, humans have 46, peas have 14 and crayfish have 200).
- Alleles
  - The homologous chromosome pair has genes for a particular characteristic. But they are not necessarily identical because each member of the chromosome pair is derived from a different parent. The two equivalent genes derived from each parent are called alleles.
    - Homozygous alleles have the same type of characteristic, for example both genes for height code for tallness.
    - Heterozygous alleles that code for height will have an allele coding for tallness and one for shortness.
- Genotype and phenotype
  - We use different terms to describe the genes for a genetic characteristic and the appearance of the genetically determined characteristic.

The distinction between genotype and phenotype

- Genotype
  - The two alleles of the chromosome pair are referred to as the genotype for a characteristic. The alleles are represented by letters of the alphabet. Therefore the genotype is expressed by two letters to represent the characteristic of each member of the pair, for example TT, Tt or tt. The capital letter denotes a dominant gene and the small letter denotes the recessive or dominated gene.
- Phenotype
  - The phenotype is the physical expression of the genotype of an organism, in other words the appearance of the characteristic. So the phenotypes of TT, Tt and tt are tall, tall and short, respectively.

2 Monohybrid and dihybrid inheritance

In 1856 and 1868 Gregor Mendel, an Austrian monk, was the first person to use experiments to show how the inheritance of characteristics takes place. He did this by cross breeding pea plants with different characteristics. The laws that he discovered, which are named after him, revealed the basic mechanisms of inheritance.

Monohybrid inheritance – Mendel's First Law

Mendel's First Law, the Law of Segregation, was discovered when Mendel performed a monohybrid cross experiment. He selected one characteristic (or phenotype) and studied the result when two variations of this characteristic were crossed.

Details of monohybrid cross experiment

Mendel carried out monohybrid experiments with pea plants.

- In one of these experiments he crossed tall and short pea plants.
- In another experiment, he investigated the characteristic flower colour by studying the result of crossing pea plants with red flowers and white flowers.
  - In this experiment, Mendel cross-pollinated red flowered and white flowered pea plant parents (P).
  - He collected the seeds, planted them and then looked at the colour of the flowers of the progeny (F1).
    - He found that all the F1 progeny had red flowers, which indicated to him that red was a dominant characteristic.
    - But when he crossed the F1 peas with each other, 75% of the F2 generation had red flowers while 25% had white flowers.

Explanation of monohybrid cross experiment

Mendel wondered why the white flowers suddenly reappeared when the red ones had seemed to dominate. To explain the findings, we can represent the genotype of the F1 and F2 generations. We can assign a capital R to indicate the dominant red allele and a small r to indicate the recessive (dominated) allele.

Different combinations of these arise during meiosis when the gametes are formed, namely RR, Rr, rR and rr. So Mendel discovered that some genes have a dominance-recessive relationship.

Statement of Mendel's First Law

Mendel First Law (Law of Segregation) states that the alleles for a specific characteristic (such as flower colour) separate during the process of meiosis. They alleles recombine during fertilisation and result in various genotype combinations.

Dihybrid inheritance – Mendel's Second Law

Mendel's Second Law (Law of Independent Assortment) was discovered when he decided to try a more complicated experiment and used pea plants with two unrelated characteristics. This is called a dihybrid cross experiment.

Details of dihybrid cross experiment

He chose plants with different seed appearances. They were yellow and smooth, or green and wrinkled.

- He cross bred the two varieties and grew pea plants from the progeny.
  - All the F1 progeny had yellow, smooth seeds which indicated that these two characteristics were dominant.
- Then he crossed plants from these seeds with each other (F1 × F1).
  - They produced four different seeds: 9 round yellow seeds, 3 round green seeds, 3 wrinkled yellow seeds and 1 wrinkled green seed.

Explanation of dihybrid cross experiment

This dihybrid cross result is very different from the results obtained with the monohybrid cross because of the larger number of genotypic combinations which are possible. The various allele combinations are shown in the Punnett square diagram on the next page. The experiment showed the appearance of two new phenotypes, namely the round green and wrinkled yellow seeds.

Statement of Mendel's Second Law

Mendel's Second Law (Law of Independent Assortment) states that there is independent reassortment and recombination of characteristics. This means simply that two unrelated characteristics operate separately from each other..

3 Three methods to illustrate genetic crosses

Genetic diagram of genetic crosses

Figure 1 represents the outcome of the genetic cross of two individuals. P stands for parent and the F represents the offspring from filial (daughter). Each successive generation is given a number: first offspring = F1; next offspring = F2 and so on.

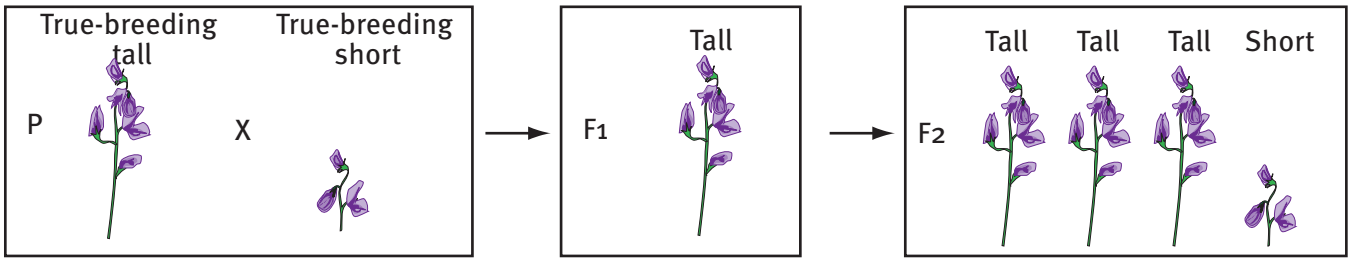


FIGURE 1 Genetic diagram showing Mendel's cross of tall and short pea plants

Schematic representation of genetic crosses

The cross between tall and short pea plants can also be shown by a schematic representation. This method shows the genotypes of the parents. This allows us to predict the genotypes of the offspring by representing the possible combination of alleles which result from the gametes. There are four possible outcomes of this cross.

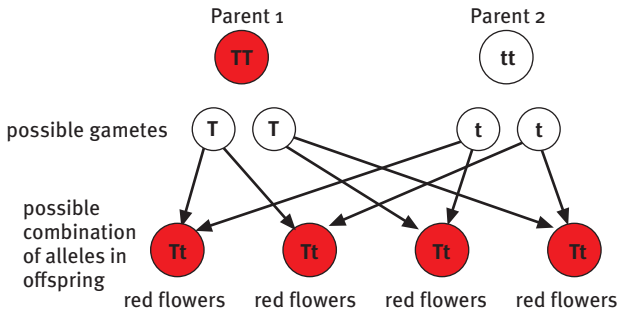


FIGURE 2 Schematic diagram showing Mendel's cross of tall and short pea plants

Punnett Square

The Punnett Square is a grid or box which is used to predict the outcome of a particular genetic cross. It shows all the possible allelic combinations in a cross of parents with known genotypes. This allows the probability of offspring possessing certain sets of alleles to be predicted. The Punnett square is useful for crosses which involve more than one characteristic.

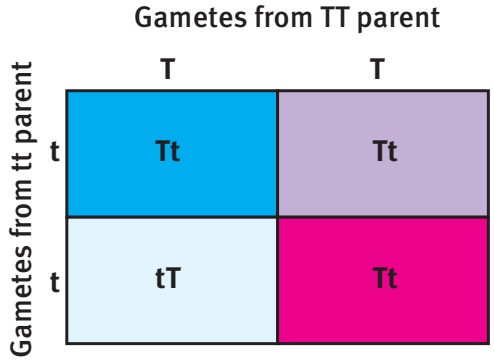


FIGURE 3 Punnett square showing possible allelic combinations of Mendel's cross of tall and short pea plants

4 Independent recombination of characteristics

Mendel's Law of Segregation states that:

- Every individual possesses a pair of alleles (assuming diploidy) for any particular trait.
- Each parent passes a randomly selected copy (allele) of only one of these to its offspring.
  - The offspring then receives its own pair of alleles for that trait.
    - Whichever of the two alleles in the offspring is dominant determines how the offspring expresses that trait (e.g. the colour and height of a plant, or the colour of an animal's fur).

However, due to the fact that each parent passes a randomly selected copy (allele) to its offspring instead of a pre-defined copy, there is an independent recombination of characteristics (traits) arising from the passing on the alleles from parents to offspring.

- Therefore, the offspring can end up with any recombination of paternal or maternal chromosomes.

5 Quantitative and qualitative characteristics

Hereditary genetic characteristics, passed down from parents to their offspring, can be placed in two main categories.

- Qualitative characteristics
  - Characteristics such as eye colour or gender (i.e. whether the organism is male or female). In other words, qualitative characteristics involve a particular quality of the organism.
- Quantitative characteristics
  - Involve a quantity such as height, weight or milk production. The number genes an organism has for a particular trait determine this type of characteristic. This is called polygenic inheritance.
    - In this case, the genes have an additive effect. For example, if a person has a few genes for shortness and a few genes for tallness, then that person will be of medium height.

Unit 2

Patterns of inheritance

1 Patterns of inheritance that lead to different phenotypes

Geneticists later discovered that variations exist on the two patterns of inheritance discovered by Mendel. These lead to different phenotypes that cannot be explained by the simple dominant/recessive relationship shown by Mendel's pea plant experiments.

Types of dominance

Mendel demonstrated simple dominant/recessive inheritance, but there are other types.

- Incomplete dominance
  - Occurs when both alleles of a heterozygous pair influence the phenotype. This means that the phenotype is halfway between the two homozygous phenotypes.
- Co-dominance
  - Is a pattern of inheritance in which both alleles are expressed equally in heterozygous individuals.

Multiple alleles

The example of Mendel's tall and short pea plants involves two types of alleles, namely T and t. Some genetic characteristics involve more than two types of alleles. An example of a characteristic determined by multiple alleles is that of coat colour in rabbits. There are four different alleles that each code for a different amount of pigmentation: C^+ codes for brown/wild type colouration, c for an albino/no pigmentation, C^{ch} for grey/chinchilla, and C^h for Himalayan/white with dark hair on ears, feet and noses. These various alleles have a dominance hierarchy. For example, C^+ will dominate over all the others. Although there are four possible alleles for coat colour, a rabbit can only have two of these.

Polygenic inheritance

Polygenic inheritance occurs when a characteristic is determined by the additive effect of a number of genes. For example, milk production in dairy cattle is determined by the presence of a number of genes that influence the quantity of milk produced. Cows with a large number of genes for low production will be poor producers, while those with a large number of genes for high production will produce more milk.

Epistasis

Epistasis is the phenomenon which occurs when genes interact and hide the action of another. This can be seen in the example of coat colour in horses. As with rabbit coat colour, there are a number of alleles that can influence coat colour in horses. Horses have genes that block the pigmentation coded for by other genes. This results in the appearance of albino (no pigment) or the various other coat colours, namely red, black or brown.

2 Prepotency and atavism

These refer to the frequency at which genes appear in a population of plants or animals.

- Prepotency
  - Is a greater than normal ability of an organism to carry over their genes to their offspring. These can either be external characteristics or production characteristics.
    - Prepotency is seen sometimes in pure bred animals because they have a large number of dominant genes.
- Atavism
  - Occurs when a homozygous recessive gene suddenly appears in a population.
    - This can be shown by the sudden appearance of a red calf in herd of Black Angus cattle or the sudden appearance of a different coloured flower after several generations.

3 Sex chromosomes and sex-linked characteristics

Sex (gender) can be classified as a qualitative genetic characteristic.

- Geneticists have found that female humans and mammals have two X chromosomes while the males have one X chromosome and a small Y chromosome.
  - Maleness or femaleness is therefore a genetic phenotype. Extra or missing X and Y chromosomes can cause various problems.
    - Humans and animals have a 50:50 chance of producing male or female offspring, which is shown by the genetic diagram below.
    - Sex-linked genes are located on the sex chromosomes.

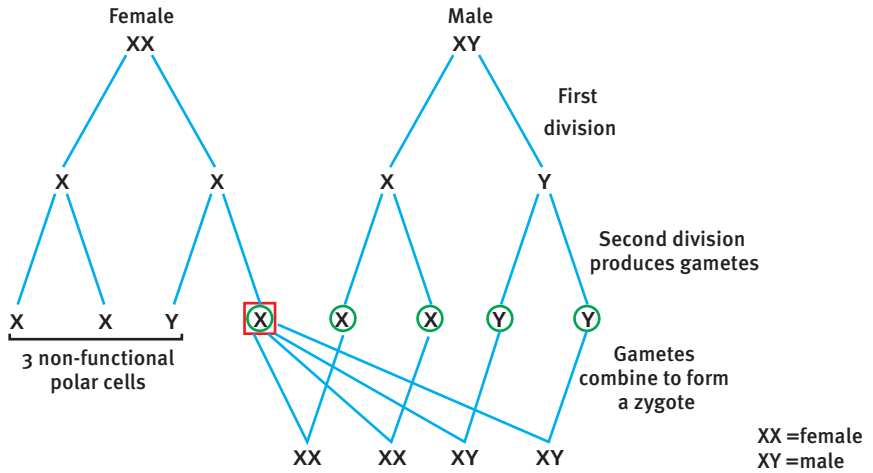


FIGURE 4 Sex determination in offspring

Unit 3

Variation and mutation

1 Variation, mutation and selection

- Variation in populations causes offspring to be slightly different from their parents.
- Mutation is a change which takes place in the original DNA sequence of an organism during the process of replication.
- Selection is the process that breeds organisms for certain genetic characteristics.
  - This is done by nature or by humans.

2 The importance of variation and selection

Changes in the DNA of an organism occur as a result of spontaneous mutations, chromosome defects and sexual reproduction.

- These changes cause variation in individual organisms.
- Through a process of selection, variations can result in new breeds and varieties of plants and animals.

Internal and external causes of variation

- Internal causes of variation
  - These affect the composition of the DNA of an organism and are genetic
  - Can also be caused by chromosomal abnormalities such as translocation, replication and deletion.
    - All these internal causes of variation result in offspring having DNA that differs from that of their parents.
- External causes of variation
  - The environment causes non-genetic or non-hereditary variation of the individual.
  - Genetic potential will only be reached in a suitable environment.
    - External caused of variation are therefore an important consideration that agriculturalists must take into account.

3 Mutagenic agents, types of mutations and their effects

Approximately one DNA replication fault occurs in about every million divisions.

- DNA Mutations that take place during replication in the somatic cells will only change the individual.
- DNA mutations that occur in the gametes during meiosis will be inherited.

Mutations can be induced by certain substances called mutagens/mutagenic agents.

Types of mutagenic agents

A mutagen/mutagenic agent is a substance or process which causes a mutation or change in the structure of DNA. Examples of mutagens include chemicals and various types of radiation, such as x-rays and UV radiation.

- These mutagens increase the frequency of changes in genetic material because they cause mutations in DNA.
- Mutagens are also usually carcinogens because they alter the DNA structure of somatic cells.
- Mutagens have been used to alter organisms for the study of genetics.
- They are also used to produce plant mutants such as colour variations in ornamental flowers or new cereal varieties.
    - Chemicals
        - There are various mutagenic chemicals. They can be classified into three groups.
        - Base analogues are similar in structure to the purine and pyrimidine bases in DNA. This means that they can become incorporated into DNA during replication. The base analogue, 5-bromouracil (5BU), resembles thymine so it substitutes for this base and then pairs with adenine. At the next replication the 5BU is mistaken for cytosine and gets paired with guanine. An AT pair therefore becomes a CG pair.
        - Alkylating agents also induce base substitution. Alkylating agents do this by adding chemical groups to the molecules of the bases. Mustard gas is an example of an alkylating agent. It is sometimes used as a chemical weapon.
        - Intercalating agents are chemical agents that have a flat ring structure which becomes wedged between the bases. This is called intercalation and it tends to distort the helix. The distortion causes insertions or deletions to occur during DNA replication.
    - Radiation
        - Radiation such as X-rays and UV rays can break down DNA strands. A gene or chromosome can be lost during the repair process if both strands are broken. Radiation also produces dimers or unwanted bonds between bases which results in the insertion of two complementary bases instead of one.

Types of mutations

- Single base loss/substitution
    - A mutation that occurs when one base is replaced with another purine or pyrimidine.
    - It is a spontaneous chemical change which occurs during replication. Apurination refers to the loss of a purine base by DNA. A base can also be replaced by the process of deamination which involves the loss of an amino group (NH_2).
    - The loss or substitution of a base causes a point mutation.

- Strand slip-up
  - Occurs when the DNA helix unzips.
  - Both DNA chains are exposed and therefore replicated at the same time
  - Sometimes one of the strands forms a loop which causes the insertion of bases on the one side and the deletion of bases on the other side.

Effects of mutagenic agents

- Effect on DNA structure: Mutagens can affect the structure of DNA in two ways.
  - Point mutation This occurs when one base pair in the DNA sequence is substituted for another. A point mutation usually has little effect on the individual gene where it occurs because it has a minor effect on the protein for which the gene codes.
  - Sequence mutation: This occurs when a whole gene sequence changes. This causes a change in the protein for which the gene encodes. The effect of this mutation depends on the importance of the gene to the survival of the organism.
- Effect on function: A mutagenic agent can result in a loss or gain of function.
  - Loss of function: A mutation can severely affect gene function or even cause a gene to stop functioning. Indels often cause a loss of function.
    - These mutations are usually recessive because the other allele of the pair can produce the protein. But there will not be any function at all when the individual is homozygous for the mutation.
  - Gain of function: A new trait or phenotype is created when a change in gene function produces a new protein. This gain in function can be harmless. But the new protein can be harmful if it interferes with some other function.
- Effect on the organism: Mutagens can affect the organism in three different ways:
  - Neutral effects
    - Neutral mutations change the amino acid produced by the mutated gene but they do not affect the protein function.
  - Harmful effects
    - This type of change in the gene compromises its function which has a harmful effect on the organism and it can be lethal in homozygous form.
  - Beneficial effects
    - Sometimes mutations produce a new allele which makes the organism more successful in its environment, as shown by the example of the English peppered moth (*Biston betularis*).

4 Changes in chromosome structures

Chromosomes can be deleted, duplicated, inverted, translocated or crossed over during meiosis. Translocation defects of chromosomes can cause fertility problems in cattle. Chromosomes often duplicate in plants which results in a condition called polyploidy. This means that they have extra chromosomes which can give the plant new characteristics.

Unit 4

Selection and breeding

1 Natural and artificial selection

Natural selection

Occurs in nature. The combination of climate and the environment selects individuals that are best adapted to the current conditions in a specific habitat. This process occurs because the best adapted organisms survive and are able to breed and produce offspring.

- Natural selection in plants
  - The plants that survive in desert areas have developed special ways to find and store water. For example, desert plants have fleshy leaves which store water, waxy leaves that prevent evaporation and very long roots that can access underground water. Many of these plants have spines on their leaves so that thirsty animals cannot eat the leaves.
- Natural selection in animals
  - Desert animals also have special adaptations to survive extreme heat and dry conditions. For example, desert rats do not sweat and their kidneys can reabsorb water from the urine. Camels store water in the humps on their backs which allows them to go without drinking for long periods. The gemsbok is a desert antelope which has a special blood vessel system in its sinuses. This protects the brain from harm caused by very high temperatures. Natural selection over very long periods of time leads to the evolution of new varieties and even new species.

Artificial selection

This is the selection of plants and animals by humans. It occurs when plants and animals are bred because of certain desirable characteristics. Artificial selection can cause visible changes within a relatively short period of time. In agriculture we select characteristics which will increase disease resistance and yields/production (such as milk production), and also provide a good feed conversion in animals.

- General principles of artificial selection
  - Measurability (biometrics): You must be able to measure the selected trait, for example milk production, weight at weaning age or weight at slaughter age
    - These measurements must be made accurately so that they can be used for the selection process.
    - The science that measures and studies traits used for artificial selection is called biometrics.
  - Heritability: The traits selected by the breeder must be heritable.
    - This means that it must be possible to transfer them to the next generation
    - Some traits are highly heritable while others have poor heritability.

Heritability of some production traits in pigs	
Trait	**Heritability**
Average weaning mass	Low
Litter size at birth	Low
Litter size on weaning	Low
Feed conversion	Moderate
Average daily gain	High
Back fat thickness	High
Percentage lean meat	High

- Economic importance: The selected traits must be of economic importance.
  - This means that they must increase productivity such as milk production, weight gain, egg production, wool yield or disease resistance.
- Difficulties with artificial selection
  - Too many selected characteristics
    - The aim of the selective process will be achieved slowly if too many characteristics are chosen by the breeder.
    - So it is better to select a few important traits.
  - Negative characteristics
    - Negative traits can be selected when you choose production characteristics for artificial selection.

2 Selection methods and breeding values

Breeders can use various selection methods for breeding to obtain the plants and animals with the desired characteristics. Modern selection methods use breeding values (BV).

- Mass selection
  - Also called individual selection. The individuals are selected for breeding based on their performance.
- Pedigree selection
  - Breeding stock is selected based on the performance of their forebears.
- Family selection
  - Similar to pedigree selection but involves comparing siblings. They can either be full siblings that have the same mother and father or half siblings that share only one parent.
- Progeny selection
  - Based on the performance of the offspring of the individual. The individual is selected for breeding if the progeny show the desired characteristics during progeny testing. BVs are used to determine the suitability of the parents.

Estimated breeding value

EBV is a value assigned to the production trait of an individual. The EBV can be calculated in two ways. In the first method, individuals are compared with their contemporaries in the same environment to exclude external effects on variations. In the second method, information from all relatives of the individual is used. The selection must be based on proper records of the performance of individuals, groups or families.

3 Breeding systems

- Inbreeding
  - The mating of plants/animals that are more closely related to each other than the rest of the population. This is usually done by breeding an individual with a close relative, for example a female animal with either a brother or father.
  - The aim is to produce a population of plants or animals with the homogenous traits which characterise the breed or variety. This means that they are genetically similar or pure-bred.
  - Inbreeding is an essential method to maintain pure-bred lines in plants in order to produce hybrid seeds.
    - An example of inbreeding in livestock is the selective breeding which done in cows for larger udders and therefore the ability to produce more milk.
- Line-breeding
  - This is a less intense form of inbreeding. It makes use of individuals that are less closely related but still of the same breed or variety for mating.
  - In animals this means mating a related male ancestor with a pure-bred female.
    - An example of line breeding is when a bull is selected to mate with a distant relative (granddaughters) rather than with a close relative (his daughters).
- Out crossing
  - This method introduces new characteristics to inbred animals. A distantly related relative of the same breed with desirable characteristics is brought in to cross breed with inbred animals.
    - An example of outcrossing is when one improves the vigour of an inbred herd of cattle by using a bull distantly related to the cows in the herd.
- Cross breeding
  - Involves the crossing of two or more different animal breeds or plant varieties. The result is a hybrid animal/plant with enhanced qualities, which is called hybrid vigour or heterosis.
    - Cross breeding in cattle
      → The development of the Bonsmara breed is an example of effective cross breeding in cattle. This involved the crossing of British cattle like the Shorthorn and Hereford breeds, which are good beef producers, with the indigenous Afrikaner breed, which is better adapted to local conditions. This cross breeding led to good carcass quality, disease-resistance and tick-resistance, increased fertility and docility, and early sexual maturation.
    - Cross breeding in crops
      → Used extensively to improve the quality of crops. Hybrids of various cultivars produce plants that are more suited to commercial requirements (e.g. beet plants with higher sugar levels and plants that are more disease-resistant or have a higher oil content in their seeds). F1 hybrids perform best and successive generations do not always have the same uniform characteristics. This means that the farmer needs to buy new seeds each year.

- Upgrading
  - Used to improve a poor quality herd. This is done by mating a good sire with females of inferior quality or using semen of good quality animals to inseminate these females.
  - This has a positive effect for the first few generations but the benefits decrease in later generations.
    - It is therefore an excellent way to produce animals for slaughter rather than for breeding.
- Species-crossing
  - Refers to the crossing of different animal species to produce offspring.
    - Species-crossing in animals
      → The crossing of two different animal species usually produces non-fertile offspring because each species has a unique chromosome number. This means that non-viable gametes form after meiosis. However, agriculture has benefited by the cross of a horse with a donkey to produce a mule.
    - Species-crossing in plants
      → Used to produce unusual ornamental plants and crops with a new characteristic. The cross between a *Brassica* or cabbage species with a *Raphanus* or radish species has produced a cold-resistant plant called radpole which is grown for fodder in some parts of the world. Species crosses in plants can result in new and fertile species. This is because they have a tendency to polyploidy or the production of additional chromosomes. If chromosomes replicate and form a compatible number, then this will result in a viable species cross.

1 Advantages and disadvantages of breeding systems

Advantages and disadvantages of breeding systems

Breeding system	Advantages	Disadvantages
Inbreeding	Produces uniform animals/plants	Recessive defects become apparent; Reduction in vigour
Line-breeding	Produces uniform animals and less defects than inbreeding	Less hybrid vigour than cross breeding
Out crossing	Brings desired characteristics into pure breeds	Less hybrid vigour than cross breeding
Cross breeding	Gives rise to hybrid vigour; Introduces new desirable traits	F_1 hybrids have maximum effect after which hybrid vigour declines
Upgrading	Improves poor quality animals quickly	Effect slows down after a few generations
Species-crossing	Produces new plant/animal species	Animal species crosses are infertile

Unit 5

Genetic modification

1 Genetic modification and its aims

The DNA of organisms can be changed or manipulated in the laboratory. We call this process genetic modification/engineering and the organisms involved are known as genetically modified (GM) organisms or GMOs. They are developed to produce an organism with new characteristics which will benefit agriculture:

- improved adaptation to the environment
- increased resistance to disease or predators
- increased and more consistent yields
- the development of new products which are useful as foods or medicines.

2 Advantages of genetic modification

- You can select characteristics that are not available by natural variation.
- You can use DNA from difference species to confer or give a desired characteristic.
- There are more ways to improve organisms that are used in agriculture.

3 Applications of GMOs

- Pest-resistant plants
  - A gene from a bacterium called *Bacillus thuringiensis* (Bt) has been introduced into crops like maize plants and potatoes to produce pest-resistant plants.
  - The Bt gene codes for the production of a crystal that is toxic to insects.
  - The plant then produces the Bt crystal which is toxic to the insects that attack it.
    - Bt resistant cotton, maize and potato cultivars are examples of pest-resistant plants.
- Herbicide-resistant plants
  - The application of herbicides to fields of crops can be dangerous since the weed killer itself can kill the crops.
  - Herbicide-resistant crops can be treated with herbicides that effectively eradicate the weeds but do not kill the crops.
    - Canola and cotton are examples of herbicide-resistant plants.
- Disease-resistant plants
  - Various vegetables and crops have been engineered to resist diseases caused by viruses, bacteria and fungi. These diseases can affect their productivity and they are difficult to treat.
    - Some examples are virus-resistant tomatoes, bananas, cucumbers and rice, and fungus-resistant peppers and cucumbers.

- Vegetables with longer shelf lives
  - GM varieties of tomatoes have been developed which last longer after they have been picked. This is an advantage because it prevents spoiling before the product gets to the market. It therefore reduces the losses due to softening and rotting tomatoes.
- Healthier tobacco
  - Genetic modification has been used to develop tobacco plants that produce less nicotine or none at all. Cigarettes made with the tobacco still contain harmful carcinogenic chemicals but they are less addictive so people smoke less.
- Bacterial protein production
  - Genetic manipulation is very easy to achieve in bacteria. The *E. coli* species, which has been widely researched, grow fast and can be grown in large tanks on an industrial scale. When genes for the production of various proteins are inserted into *E. coli*, the bacteria produce the proteins in large amounts.
    - GM bacteria are currently being used to produce hormones, for example insulin and bovine somatotropin (BST).
    - BST is responsible for milk production in cattle and it can be produced when the BST gene is inserted into *E. coli* bacteria. The bacteria produce BST which can be harvested and used in cattle to increase their milk production.
- Transgenic salmon
  - A gene for a growth hormone has been inserted into Atlantic salmon.
  - These transgenic salmon are sold under the trade name AquAdvantage® and they grow six times faster than non-transgenic fish.
    - Therefore they are the right size for market in 16–18 months instead of three years.
- Fluorescent fish
  - Scientists transferred a bioluminescence gene from jellyfish into a fish species called the zebra fish.
  - This gene allows the zebra fish to fluoresce or glow when they are in distress, for example when toxic substances are added to water.
  - These GloFish® can be used by scientists to detect water pollution.
- Recombinant vaccines
  - Various vaccines for livestock have been developed using GMOs. These are referred to as recombinant vaccines.
  - The advantage of these vaccines is that they contain very little of the infectious agent. This eliminates the potential to cause the disease which is being vaccinated against.
    - Various recombinant vaccines are currently used in the poultry industry and many are being developed for mammalian livestock.
    - A recombinant rabies vaccine has been used effectively to vaccinate wild animals and dogs and reduce the incidence of the disease.

4 Techniques used in genetic modification

- Identifying the gene
  - The gene with the desirable characteristic must be selected.
  - These characteristics include protein production and herbicide resistance.
- Modifying the gene
  - The selected gene is usually from a different species, for example a bacterium
  - Therefore the required gene must be modified in order to be accepted by the plant.
  - Scientists use promoter and terminator gene sequences to ensure that the foreign proteins can be correctly translated.
    - The gene sequence is usually inserted into a vector.
    - The vector can be a plasmid or a bacterium called *Agrobacterium* which tends to insert itself into plant DNA.
- Inserting the gene
  - The DNA can be inserted into plants with a gene gun or *Agrobacterium*.
    - The gene gun shoots out microscopic particles of gold or other metals propelled by compressed air. The micro-particles are coated in a solution which contains the transgenes and these are shot into the plant tissue. Some of these genes are carried into the nuclei of the plant cells which allow them to replicate.
    - *Agrobacterium* can carry an implanted gene into the DNA of the plant which allows the desired protein or substance to be produced.
- Verifying gene presence, monitoring and testing
  - The GM plants are then checked by molecular analysis in the laboratory to confirm that the plant has taken up the gene (i.e. to verify gene presence).
    - In monitoring, the performance of the modified plant is tested in isolation. This is to ensure that the plant has the required characteristics.
    - The effectiveness of its new gene and the safety of the plant have to be tested under controlled conditions. This must take place before the GM plant can be released on a large scale.

5 Characteristics of GMOs

- They have genetic material from a donor organism inserted into their DNA. This gives them new or changed characteristics. These new or changed characteristics can be either quantitative or qualitative.
- GMOs with quantitative changes have increased abilities such as rate of growth or yield of food component.
- GMOs with qualitative changes have entirely new characteristics, for example being able to resist a herbicide or glow in the dark.
- GMOs – especially plants – often have a marker gene, such as those for antibiotic resistance, to distinguish them from the non-GMO plants.

6 Potential benefits of genetically modified crops

Potential productivity benefits Genetic manipulation in plants can increase their productivity. This can be due to an increase in yield, disease resistance, herbicide resistance or the production of more beneficial nutrients.

Potential environmental benefits GM crops are potentially more environmentally friendly because, for example, they are pest resistant and so no (or less) pesticides are used. This results in a decrease in contamination of air, soil and water. In addition, GM crop production can result in less deforestation needed to feed the world's growing population. A decrease in deforestation decreases carbon dioxide in the atmosphere, which in turn slows global warming.

Potential economic benefits GM crops potentially have economic benefits, such as a decrease in production costs due to the reduced use of pesticides. This has the potential to increase the wealth of farmers while also decreasing food prices due to lower costs and higher yield. This can help to reduce poverty and starvation in developing countries.

Potential health benefits GM crops can be designed to be more nutritious than conventional crops. Potentially, this can lead to a reduction of illnesses, as GM crops provide necessary vitamins and minerals to vast populations who previously had limited access to these nutrients. GM crops may also be used to produce pharmaceuticals and vaccines in the future.

Potential to create 'super food' Scientific knowledge developed from producing GM crops can lead to the creation of super foods. These are types of food that are cheap to produce, grow fast in large quantities and are highly nutritious.

Potential of increased food security Scientific advances in GM crops can lead to the development of new kinds of crops that can be grown in extreme climates such as dry or freezing environments (like deserts). For example, scientists have already developed a type of tomato that grows in salty soil. Such a development would increase food security as people in extreme climates would be able to grow a wider range of cops.

Potential benefits to livestock Livestock are also beneficiaries of the higher nutritious value of GM crops. This has the potential to increase livestock's resistance to disease, their productivity and their hardiness.

7 Potential risks of GMOs

Scientific reasons why GMOs must be researched and produced with various controls.

- Escape of transgenes
  - There has been one incident in which a herbicide-resistant transgene escaped into a non-GM canola plant. Plants that are pollinated by wind often exchange genes and this is difficult to control. The consequences of the canola plant incident were not very serious. But there are concerns about the escape of transgenes if crops are to be used to produce pharmaceuticals which can be toxic to humans.
- Resistance to transgene effects
  - If weeds become resistant to herbicides or insects become resistant to the Bt toxin, then herbicide-resistance and insect-resistance will become useless GM characteristics. Various strategies have been suggested to prevent this outcome.
- Food safety issues
  - There have been fears about the safety of food produced by GMOs. However, no ill effects have been shown by GMOs despite the fact that millions of people have eaten the food produced from these crops.
- Effect on non-target organisms
  - There are concerns that insect-resistant GMOs like Bt maize plants will affect non-target organisms. Beneficial insect species like bees and butterflies are of particular concern.

Topic 5

Topic questions

- Answer the questions below. Check your answers afterwards and do corrections.
- Give yourself one hour.
- Marks: 100

1 Study the diagram. Then choose the best answer for each question. Write down only the question number and the letter that represents the best answer.

		Paternal	
Maternal		B	b
	B	BB	Bb
	b	Bb	bb

1.1 This diagram is called a _____.

A Monohybrid cross

B Mendelian inheritance

C Punnett square

D dihybrid cross (1)

1.2 The capital B in the diagram indicates a _____.

A genotype

B dominant allele

C phenotype

D gamete (1)

1.3 In the diagram, both the maternal and the paternal organism have:

A the phenotype Bb

B the phenotype BB

C the genotype Bb

D the allele Bb (1)

Topic questions

1.4 In the diagram, assuming the maternal organism is a dog with a black coat (B) and the paternal organism is a dog with a white coat (b), _____ of the offspring will be black while _____ will be white.

A 25% ; 75%

B 50% ; 50%

C 75% ; 25%

D None of the above. (2)

2 Fill in the missing words.

2.1 Chromosomes divide during _____ into a pair of _____. (2)

2.2 An homologous chromosome pair _____ during _____ resulting in a _____ cell. (3 × 1 = 3)

3 Cow parsley (*Anthriscus sylvestris*) produces a purple-leafed variant called Ravenswing. The purple colour is produced by the allele R which shows incomplete dominance over the allele for green leaves (r). Heterozygotes (Rr) produce green and purple spotted leaves.

3.1 Show the genotypes that result from a cross between the Ravenswing variant and a green plant. (2)

3.2 What are the resulting phenotypes? (2)

3.3 Show what genotypes and phenotypes result from crossing the progeny of the cross mentioned in (3.1), namely F1 × F1. (3)

4 Tortoise shell cats (red and black colour combination) are always female because the alleles for the red and black colouring are linked to the X chromosome. This means that tom cats can only be red (O) or black (o).

Use a Punnett square to determine how many tortoise shell cats will be produced by crossing red, black and tortoise shell females with red or black males. (Hint: You only need to show the female progeny.) (6)

Topic 5

Topic questions

5 Sex is a qualitative characteristic in humans and most animals.

5.1 Which sex has homologous chromosomes?

5.2 Name a sex-linked characteristic found in animals.

5.3 What is the sex ratio of offspring after sexual reproduction? (3 × 1 = 3)

6 Some genetic characteristics are quantitative.

6.1 Name an example of a quantitative genetic characteristic. (1)

6.2 Quantitative genes have _____ effects. (1)

6.3 What quantitative characteristics would be important in agricultural production? (2)

7 Explain briefly how external factors can cause variation in individuals. (2)

8 Polyploidy in plants is a chromosomal abnormality which results from _____ of chromosomes during replication. (1)

9 Spontaneous mutations arise in the DNA of all living organisms.

9.1 Give four examples of spontaneous DNA mutations. (4)

9.2 Explain how mutations can affect gene function. (5)

9.3 What effects can mutations have on organisms? (3)

10 Explain the difference between inherited and non-inherited mutations. (2)

11 Explain why sexual reproduction is a cause of genetic variation. (4)

12 Name five mutagens that can be used to cause DNA mutations. (5)

13 Selection of the animals that have adapted the best to their environment is called _____. (2)

14 What adaptive characteristics could you expect to find in desert plants? (5)

15 Artificial selection is the process used by humans to improve plants and animals.

15.1 What type of characteristics should be selected for breeding plants and animals? (3)

15.2 What problems could be encountered when performing selective breeding? (2)

15.3 Explain the principle of hybridization and its application in agronomy. (5)

15.4 What are the two main disadvantages of pure bred species? (2)

15.5 Why do most species crosses in animals result in infertility? (1)

15.6 Why are species crosses possible in plants? (1)

Topic 5

Topic questions

16 What is the advantage of genetic engineering or transgenics over selective breeding? (2)

17 Name four aims of genetic engineering in crops. (4)

18 GMOs are used widely in agriculture.

18.1 Identify the main environmental concerns about GMOs. (3)

18.2 How can you identify an escaped GMO? (1)

18.3 Name the bacterium used to transfer genes into GMOs. (1)

18.4 Explain why the bacterium named in (18.3) is used. (4)

19 Various types of breeding systems are used in agriculture.

19.1 Name one example of the result of a species crossing.

19.2 Give an example of cross-bred cattle.

19.3 Give an example of pure-bred cattle.

19.4 What type of plant breeding system can be used to develop a new plant cultivar? (4 × 1 = 4)

20 Name the selection system used for sires in animal science. (1)

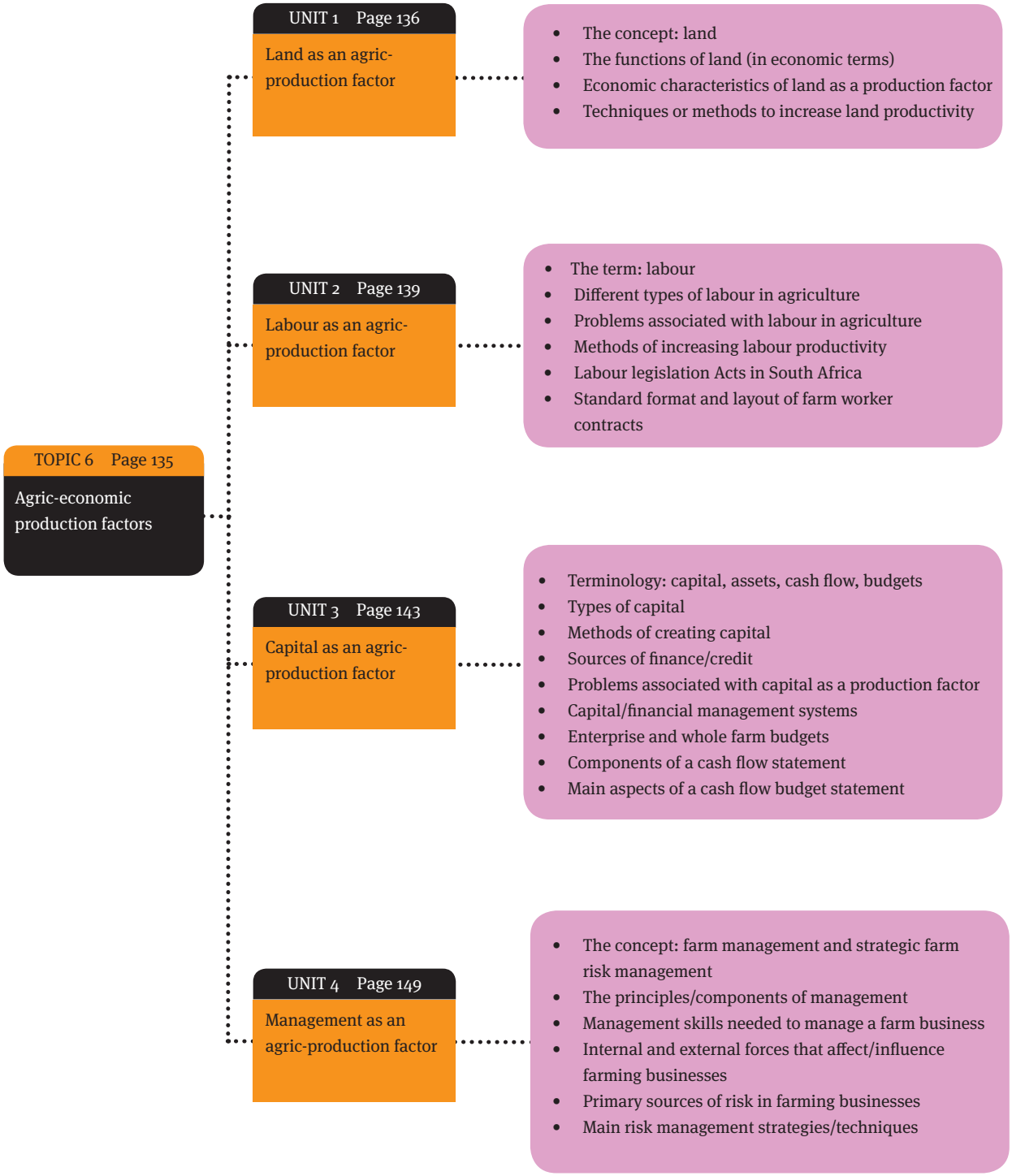
21 What value is used to rate sires with good production characteristics? (1)

22 Mention the role biometrics plays in performance testing. (1)

Topic 6

Agric-economic production factors

Overview



Unit 1

Land as an agric-production factor

1 Land and its functions

Land is the part of the Earth's surface that is not covered by water, as opposed to the sea or the air. In agriculture, the focus is on soil. Soil is the upper layer of Earth in which plants grow, a black or dark brown material typically consisting of a mixture of organic remains, clay, and rock particles.

The functions of land (in economic terms)

- Land provides space for economic activities
  - Land provides a platform for various production processes and economic farming activities to take place. Soil is the medium in which crops grow.
- Land provides food for plants, animals and human beings
  - Crops obtain most of the water, nutrients and air that they need from soil. The soil also provides a suitable temperature and enough air for the supply of food. The chemical reactions that take place in the soil ensure that good quality crops are produced. Livestock also obtain food from the soil in the form of grass. The food that we eat comes from the soil, namely fruits, vegetables and herbs.
- Land provides raw materials
  - Raw materials are resources that are used to produce or manufacture other products. Plants obtain raw materials from the soil such as water, carbon dioxide and nutrients. These are used by the soil to manufacture carbohydrates through photosynthesis. The soil also provides plants, such as trees, that can be used as raw materials to make furniture.
- Land provides minerals
  - Land provides different minerals that serve different purposes. They can be classified into three categories:
    - minerals of monetary value, e.g. gold, silver and diamonds
    - minerals used as raw materials in industries, e.g. coal, copper, iron and platinum
    - minerals used as nutrients by plants and animals, e.g. calcium, phosphorus and zinc.

2 Economic characteristics of land as a production factor

- Land is durable
  - Development processes in the soil ensure that the soil is able to renew itself. This makes it a useful and viable commodity.
- Soils have different production potentials
  - Soils have characteristics such as texture, structural type and the environment in which they are found. This means that soils have different production potentials.

- Availability of agricultural land is limited
  - Only 25% of the Earth is covered by land and only half of this land can be ploughed. Only a small percentage of soil can be used for agricultural production.
- The nature of soil restricts agricultural activities
  - Crops often only grow in certain types of soil. The nature of the soil restricts the agricultural activities, the crops that can be planted and diversification.
- Soil is found in a specific environment
  - Particular soils are located in particular environments and this determines their potential and value.
- Soil is subject to the law of diminishing returns
  - Soil has a maximum yield, where after its yield decreases.
- The physical condition of soil cannot be changed
  - Soil inherits its characteristics from the mother rock from which it is broken down. Therefore soil texture cannot be changed.

Analysis might show that a soil needs a particular fertiliser to achieve maximum crop production. The fertiliser application will increase the production of the crop, but the effect will probably decrease after further additions of the same fertiliser. This is known as the law of diminishing returns.

3 Techniques or methods to increase land productivity

Techniques or methods to increase land productivity must be considered and implemented withing the context of environmental sustainability so that future generations have access to this natural resource.

- Adapt production to scientific methods
  - Scientific methods, such as precision farming, will ensure maximum sustainable production. A scientific approach to irrigation will also be more effective than traditional methods. In this way, using scientific methods will allow for both maximum productivity and environmental sustainability.
- Consolidating uneconomical farm units
  - Consolidation of similar farm units will reduce management and running costs because separate farm units are more expensive to manage than combined, smaller units.
- Use of technology
  - Technology can be used to complete tasks in less time and with lower production costs.
- Water supply through irrigation
  - Crops that are watered by irrigation systems show higher production levels than crops that obtain their water naturally from the water table. The quality of irrigated crops is also better.

- Increase access by building roads
  - Increase accessibility to land will allow machinery, tractors and labourers to be transported to the land as needed. Products can also be more easily transported for processing or to the market.
- Choose a farming type that suits the nature of the soil
  - A poor choice of farming type, one that does not suit soil (or climate) conditions will result in total failure of the farming enterprise.
- Gather enough information on the land to be used
  - Soil analysis should be carried out at least every four years to give an indication of major nutrient levels within the soil. Larger fields should be split into smaller areas for sampling purposes to make sure each sample is as representative as possible.
- Diversify land
  - Different soil types will suit different forms of production. The farm should be divided into units according to the soil type and different forms of farming practised on each one. This is called diversification and it can ensure a continuous source of income for the farmer.
- Modify land
  - Farm land that has proved to be uneconomical could be modified. For example, the land could be excavated and farm infrastructure could be built on it.
- Improve the physical condition and productivity of the soil
  - Problems with soil texture and slope can be solved in several ways.
  - Textural problems can be overcome if you:
    - add organic matter
    - improve drainage
    - avoid over cultivation
    - do not cultivate the soil when too dry or too wet
    - improve the pH value of the soil.
  - A slope on land can be dealt with by the use of:
    - contour ploughing
    - contour banks
    - stone banks
    - terraces.

Unit 2

Labour as an agric-production factor

1 Types of labour in agriculture

Labour is the physical and mental effort performed in return for remuneration, which is in the form of wages. In agriculture, there ate two broad types of labour.

- Permanent/fixed labour
  - Refers to farm workers that are employed on the farm throughout the year. They usually live on the farm and have certain rights and privileges, such as housing and food rations. Most permanent labourers are skilled.
- Part-time/temporary labourers
  - Refers to farm workers that do not stay permanently on the farm and do not work throughout the year. There are two types of part-time labourers:
    - seasonal labourers – they are employed during a particular season or at peak periods to perform a particular task such as harvesting, pruning or weeding
    - casual labourers – they are employed to do a particular task such as fencing or building.

2 Problems associated with labour in agriculture

- Lack of skills
  - Most farm labourers are poorly educated and they lack training. Modern farming methods such as precision farming are sophisticated and require skilled labourers.
- Poor labour management
  - Farmers are not always trained as managers. A lack of management skills, such as supervision, can lead to less productive workers.
- Negative effect of HIV/AIDS
  - This disease and its opportunistic infections reduce the number of days that labourers are able to work. HIV/AIDS also impacts the effort that workers are able to put into their tasks for effective production.
- Scarcity of labour
  - Fewer people are prepared to work as farm labourers due to low salaries, the physically demanding nature of the work and the low status of the job.
- Competition from other sectors
  - Industries usually pay higher wages than farmers. This causes skilled farm workers to look for work in industries to attain better living conditions.
- Exploitation of farm workers
  - Farm workers may be exploited due to ignorance: not knowing their rights, basic conditions of service, or what the minimum wage is. Some farm owners / managers still have racist attitudes (legacy of apartheid) to farm workers.

Methods of increasing labour productivity

- Improved conditions of service
  - Appropriate wages and fair working conditions, stipulated in a contract can improve labour productivity.
- Physical farm (infrastructure) planning
  - The physical aspects of the farm need to be well planned so that farm workers do not waste time moving from production sector to another Living quarters should be separate but easily accessible.
- Supervision
  - Supervision, control and monitoring of performance against production targets help to increase labour productivity. Incentives can be built in for targets achieved.
- Daily planning
  - Daily activities must be planned and tasks should be delegated. This will ensure that workers know what is expected of them.
- Training
  - A skills development programme needs to be planned after a skills audit has been carried out. Skilled workers are more productive than unskilled ones.
- Effective mechanisation
  - Appropriate use of machinery can boost worker productivity by providing them tools to do their jobs effectively and efficiently.
- Economic planning of the farming activity
  - The budget for each aspect of the business must be planned to keep expenses low. Partnership deals between farm owners and workers in terms of targets and profit sharing will encourage workers.
- Planning of the production processes
  - Each step in the production process must be planned, and short-, medium- and long-term goals need to be set, communicated to workers and monitored. This will help to boost productivity.

3 Labour legislation Acts in South Africa

Labour legislation is needed so that farmers and workers are protected as both parties will know what their respective rights and responsibilities are.

- Occupational Health and Safety Act
  - Addresses the safety of workers in the workplace. It enforces training of workers who operate machinery and the wearing of protective gear while at work.
- Labour Relations Act
  - Regulates the relationship between employers and employees. It addresses aspects like the right to strike, labour dispute procedures and how to deal with unfair labour practices.

- Basic Conditions of Employment Act
  - Ensures that workers are treated fairly.
  - It addresses several aspects, e.g.
    - payment method
    - minimum wages
    - working hours
    - overtime
    - leave
    - termination of employment.
- Compensation for Occupational Injuries and Diseases Act
  - States that workers must be compensated if injured or get sick while on duty.
- Skills Development Act
  - This Act is managed by the Department of Labour.
  - Depending on how many employees they have and the size of their turnover, employers contribute to the Skills Development Levy.
  - Contributions are sent to two bodies to facilitate training, namely:
    - the relevant sector's Education and Training Authority
    - Skills Development Fund.
  - The Act aims to develop and improve workforce skills and employers receive a refund if they train their workers.
- Employment Equity Act
  - Ensures that there is no workplace discrimination based on:
    - race
    - religion
    - gender
    - sexual orientation
    - disability, etc.
- Broad Based Black Economic Act
  - This Act is guided by the Broad Based Black Economic Strategy which was implemented by the Department of Trade and Industry.
  - The Agri-BEE charter requires sectors to implement employment equity and to subject their black employees to transformational activities such as:
    - skills development
    - company ownership and management.
  - Sectors that adopt the Agri-BEE charter are awarded codes for good practice and points that position them favourably for doing business with local, provincial and national government.

Standard format and layout of farm worker contracts

A good employment contract protects the interests of the labourer and employer. It should contain these details:

- Particulars of the employer:
  - The name and identity number of the farm owner, the business name and physical address, and the type of business.
- Particulars of the employee:
  - The name of the employee, their residential and postal address, contact phone numbers, next of kin, gender, identity number, academic and professional qualifications, work experience and disabilities (if any).
- Employment details:
  - These details will vary in different sectors but they include the place of work, date of employment, normal working hours, job title and job description, entitlement to holidays and holiday pay.
- Payment details:
  - This section outlines salary or wage rate, calculation of wages, frequency of payment, overtime rate and any other cash payments.
- Leave details
  - This aspect addresses any leave that the workers are entitled to and terms about absences due to sickness and injury.
- Pension arrangement
  - All matters that relate to pension and pension schemes are described.
- Notice or contract period
  - The type of contract will determine the contract period and the notice period required to terminate a contract.
- Disciplinary procedures
  - This section deals with disciplinary procedures to be taken under various conditions. It also deals with breaking the terms of the contract.
- Health and safety obligations
  - This part of the contract outlines the responsibilities and obligations of the employer as contained in the Occupational Health and Safety Act and the Compensation for Occupational Injuries and Disease Act.

Unit 3

Capital as an agric-production factor

Important terms

- Capital
  - The wealth, including goods, which is accumulated by saving. It is used in the production process to generate income.
- Assets
  - Items of financial value that the farmer owns and they often require large amounts of capital input. Assets include land, buildings and machinery and they can be classified as short-, medium- and long-term. On the other hand, liabilities are what the farmer still owes, such as loans and an overdraft. The net worth of a farm equals the assets minus the liabilities.
- Cash flow
  - Refers to the movement of money into or out of a business. It is usually measured during a specified, finite period of time.
- Budgets
  - A document that shows the income, expenditure and profits for a certain period.

1 Types of capital

Capital refers to sums of money or assets put to productive use. There are three types of capital that are relevant in agriculture.

- Fixed capital: involves fixed assets.
  - Examples are land, buildings, fences and boreholes.
- Movable capital: capital goods that can be moved from one place to another.
  - Examples are tractors, machinery, equipment and livestock.
- Working capital: involves goods used in the production process.
  - Examples are seeds, fertilisers, salaries and wages, and fuel.

2 Methods of creating capital

- Individual's own savings
  - Capital can be created through savings and investments.
- Production and local market sales
  - The farmer can increase production to accelerate the accumulation of capital.
- Credit
  - Allows farmers to get goods or services before they pay for them. Farmers can use credit to borrow money from financial institutions but they must pay interest on the borrowed money. They must usually provide collateral for the credit.

3 Sources of finance/credit

Type of credit	Description
Long-term credit	Long-term credit takes a long time to repay, namely 10–35 years. It is used for big capital goods such as land, or for big projects such as the construction of buildings and dams. The source for long-term credit is the Land Bank.
Medium-term credit	Medium-term credit is used to buy movable capital. This usually takes about 2–10 years to repay. The sources of this finance are co-operative societies, NGOs and commercial banks. Umthombo is an NGO that provides loans to sugar cane producers
Short-term credit	Short-term credit is used as working capital to buy goods for the production process such as seeds, pesticides and fertilisers, salaries and wages, and fuel. Types of short-term credit include overdraft, credit cards and advance personal loans. The loans must be repaid within two years. Commercial banks are the source of this credit

4 Problems associated with capital as a production factor

- High-risk factor
  - There are many factors that the farmer cannot control, such as weather patterns and diseases. These risks must be managed to avoid capital losses:
    - Insure all aspects of the farming enterprise
    - Diversify by running different farming enterprises on the same farm
    - Hedging by maintaining pre-determined prices even if conditions change.
- High interest rates
  - Financial institutions charge interest on loans which decreases profit margins. Loans must be carefully managed to avoid high interest charges.
- Scarcity of capital
  - Many financial institutions are reluctant to finance beginner farmers as they doubt their ability to repay the loan. They therefore require security before they grant a loan.
- Overcapitalisation
  - Overcapitalisation occurs when more money is put into the farm than can be earned from it. This means that the business runs at a loss. This occurs when land or equipment is bought or leased for more than it is worth, or when unnecessary assets are accumulated and money is not made out of the investment.
- Undercapitalisation
  - Undercapitalisation means that you invest less capital than is required to run the farm, which hinders productivity and leads to a loss in income. This may occur because of poor financial planning, failure to get an adequate loan or insure against risks, or simply because of unfavourable economic conditions.

5 Capital/financial management systems

- Financial records
  - A financial record shows all monies received and used in a farming enterprise. An income statement can be used to show the income and expenses for a financial year.
- Farm asset records
  - Items of financial value owned by the farmer are listed in an asset registry. Assets should always be worth more than liabilities as they improve the net worth of a farming business. The best document to use for this is a balance sheet.
- Farm budgets
  - A farm is a business which aims to make a profit. In order to make a profit, the farm owner needs a financial plan or budget that lists all planned expenses and revenue for a particular time period, usually a year. A budget helps to:
    - predict expenses and revenues
    - measure the actual financial operation of the farm against the predictions
    - identify cost constraints (i.e. areas where the farmer may have to cut costs to make a profit).

6 Enterprise and whole farm budgets

- An enterprise budget
  - Refers to the budget of a single farming or production unit in the farming business.
    - For example, a farm that has livestock as well as dairy, maize and broiler production units needs a separate budget for each unit or enterprise.

An enterprise budget for a maize production unit

Estimated cost		Estimated returns	
Item	**[Amount (R)]**	**Item**	**[Amount (R)]**
Water	10 500	Mealies	350 000
Fertiliser	30 000	Maize meal	250 000
Labour	27 000	Compost	7 500
Maize seeds	3 000	Maize feeds	250 000
Pesticides	18 756	Haylage	20 000
		Silage	20 000
Total cost	**89 256**	**Total return**	**897 500**

- A whole farm budget
  - Incorporates all of the budgets for the different farming enterprises or units.
    - It is required to determine the financial needs (e.g. all expected variable and fixed costs) and performance (e.g. all anticipated income) of all the production units.

A whole farm budget			
Estimated cost		**Estimated returns**	
Item	**[Amount (R)]**	**Item**	**[Amount (R)]**
Livestock			
Bulls	5 000 400	Old bulls	200 000
Feeds	520 000	Old cows	500 000
Veterinary treatment	100 000	Beef	600 000
Wool shearing	1 800	Mutton	200 000
Transport	12 600	Sheep	500 000
Abattoirs	15 000	Goats	350 800
		Goats milk	5 800
		Manure	20 600
		Hides/skins	11 800
		Wool	95 000
Total cost:	**5 649 800**	**Total return:**	**2 484 000**
Dairy			
Milking parlour maintenance repairs	25 000	Milk	600 000
Milking staff	10 000	Manure	23 000
Feeds	10 000	Sour milk	350 000
Transport	40 000	Yoghurt	380 000
Veterinary treatment	10 000		
Packaging	6 900		
Total cost:	**101 900**	**Total return:**	**1 353 000**
Item	**[Amount (R)]**	**Item**	**[Amount (R)]**
Maize production			
Water (irrigation)	10 200	Mealies	35 500
Fertilizer	33 000	Maize meal	65 000
Maize seeds	5 000	Compost	34 500
Labour	25 000	Haylage	32 200
Pesticides	20 500	Silage	56 700
Agents	15 000		
Transport	19 500		
Total cost:	**128 200**	**Total return:**	**223 900**
Broiler production			
Chicks	2 500	Broilers	90 000
Feeding equipment	10 000	Manure	45 000
Labour	11 500		
Feeds (mash)	12 000		
Water	3 000		
Transport	2 800		
Vaccines	1 800		
Total cost:	**43 600**	**Total return:**	**135 000**
Whole farm total cost:	5 923 500	Whole farm total return:	4 195 900

Differences between an enterprise and whole farm budget

Table 1 Comparison of an enterprise and a whole farm budget

Enterprise budget	Whole farm budget
Concentrates on budget for each enterprise	Incorporates budgets of all enterprises on the farm
Allows farmer to control the income and expenses of each enterprise which spreads the risk	Allows farmer to have overall control of the whole farm business

7 Components of a cash flow statement

Shows the movement of money through a business over time. It is based on a month-to-month record and can be referred to as the monthly budget. There are three components to a cash flow statement:

- the income component
- the expenditure component
- the cash flow summary component.

Income component

The farmer records the expected income for each aspect of production on a monthly basis. He or she specifies the amount of money expected and the month in which it is due. If there is no income to be received, this is indicated with a zero. There are three sources of income:

- cash flow from sales, e.g. money received from the sale of crops and livestock
- capital sales, e.g. from the sale of machinery and breeding stock
- non-farm income, for example wages for the farmer.

Expenditure component

The farmer indicates the expenditure to be incurred for each month to prepare for these expenses. If there are no expenses for a particular month, then this is indicated with a zero. There are two types of expenses:

- operating expenses, for example operating inputs such as seeds and fertilisers
- capital expenditure, for example assets such as tractors and machinery.

Cash flow summary component

A cash flow summary shows the opening balance, total income, total expenditure, profit and closing balance for each month.

Main aspects of a cash flow budget statement

Farmers can use a cash budget to monitor cash flow. It has two main aspects:

- Cash receipts or cash inflows: cash receipts – they record cash received; they indicate the date, the amount received and a description of the transaction.
- Cash disbursements or cash outflows : they record cash paid out; they indicate the date, the amount paid and a description of the transaction.

A typical cash flow statement of a farming business			
	Month 1	**Month 2**	**Month 3**
Beginning cash balance	**- R150 000**	**- R26 600**	**R222 000**
Cash inflows (income)			
Livestock sales	R300 000	R400 000	R0
Insurance received in product loss	R40 000	R50 000	R0
Sale of crops	R150 000	R200 000	R300 000
Other	R20 000	R30 000	R50 000
Total cash	**R510 000**	**R680 000**	**R350 000**
AVAILABLE CASH	**R360 000**	**R653 400**	**R572 000**
Cash out flow (expenses)			
Casual labour	R102 800	R120 000	R200 000
Feed	R71 800	R80 000	R100 000
Seed and plants	R40 000	R50 000	R60 000
Pesticides and herbicides	R20 000	R25 000	R30 000
Transport	R15 000	R20 000	R25 000
Other (fixed costs)	R40 000	R40 000	R40 000
Sub total	**R289 600**	**R335 000**	**R455 000**
Other cash outflows			
Capital purchases	R12 000	R24 000	R12 000
Interest paid	R30 000	R27 000	R28 000
Rent and shared crop paid	R25 000	R25 000	R25 000
Hired management	R10 000	R10 000	R10 000
Owners draw	R20 000	R20 000	R20 000
Sub total	**R97 000**	**R106 000**	**R95 000**
Total cash out	**R386 600**	**R441 000**	**R550 000**
CLOSING CASH BALANCE	**- R26 600**	**R212 400**	**R22 000**

Unit 4

Management as an agric-production factor

1 Farm management and strategic farm risk management

Farm management

Management skills are essential for the success of a business. Farm management involves planning how production will be organised and co-ordinated to achieve the set outcomes in the production process. It should include short- and long-term outcomes. Farms must be managed to coordinate the aspects of land (soil), labour and capital. This will ensure that they are all used optimally and in a sustainable way to achieve maximum production.

Strategic farm risk management

Strategic farm risk management involves developing a vision and mission, and setting goals and objectives. Strategies must also be put in place to overcome unexpected events that might affect production such as droughts and thunderstorms.

2 The principles and components of management

- Planning
  - Planning involves deciding what activities will be done, by whom, when, where and how. Short- and long-term plans must be made. Areas that required planning are finances, marketing of products, and farm activities (including the production chain in each activity). Steps in the planning process include:
    - Estimate when a farming activity will be completed and how much it will cost.
    - State the aims and objectives of the farming activity, specify what the manager wants to achieve and indicate priorities.
    - Draw up the policy to be followed during the production process.
    - Draw up a programme that indicates tasks, the persons responsible and when they should be done.
    - Draw up guidelines that indicate procedures for each task.
    - Draw up rules and guidelines that state how activities are to be carried out.
- Organisation and co-ordination
  - Organisation is the bringing together of all the parts of an activity to maximise production. Co-ordination ensures that all activities are brought together to perform as a functional unit. There are five elements of organisation:
    - identify tasks
    - set objectives
    - delegate specific functions and tasks
    - control
    - review.

- Decision making
  - Decision making is a mental process that involves weighing up alternatives and choosing the best one. There are several important steps in decision making:
    - Describe the issue.
    - Identify and evaluate all possible alternatives relating to the issue.
    - Choose and implement the best alternative.

Decision making involves four important elements

- Decision maker: The farmer is the owner (proprietor) so he is responsible for decisions and any risks taken. The degree of success results in profit or loss. The farmer may delegate decision making to the farm manager.
- Objectives of the decision maker: The decision maker must state the strategic objectives, the mission and the vision of the company in a business plan. The farmer should decide what to produce and how much, the method of production, and where and when to sell produce.
- Conditions/situations for which decisions are taken: Decisions should take into account ideal and abnormal situations. The farmer should insure against drought, disease and disastrous weather phenomena.
- Measuring the effect of a decision: It is important to assess if the decision taken was the best one under the circumstances.

- Control
  - Control ensures that plans are implemented and this means that the results of decisions must be checked and verified. It is important to state deliverables to ensure good monitoring.
- Motivation
  - Extrinsic and intrinsic motivation is important in the farming business. Extrinsic forms of motivation are bonuses, incentives, certificates and tokens of appreciation. Intrinsic motivation is achieved by showing respect, creating a pleasant atmosphere and sharing the goals, mission and vision of the business.

3 Management skills needed to manage a farm business

- Leadership skills
  - Farm managers should show initiative, have vision and be creative. They should be highly motivated, have a positive attitude and be able to oversee all farm activities.
- Decision making skills
  - It is essential to make critical decisions and the manager must take responsibility for these decisions.

- Problem solving skills
  - Steps in problem solving: define the problem, identify the cause, brainstorm different solutions, choose the most appropriate solution, implement the solution and check the results.
- Crisis management skills
  - Skills are needed to manage crises, such as sick animals in the middle of the night or a burst dam. Problem solving skills are important in managing crises; so are expertise, experience and knowing where to get assistance.
- Organisational/conceptual skills
  - Organisational/conceptual skills ensure that production operates smoothly. This also involves consideration of timing and complexity of production tasks. Changes in various situations require flexibility and innovation. Training of workers is necessary if new skills are needed.
- Communication skills
  - Fluent written and oral communication is important. Gestures can also be used to explain how a particular activity should be undertaken.
- Production skills
  - A good farmer knows how farming units operate and how to synchronise them. They should also understand the mentality of farm workers to place workers where they will be most productive.
- Technical skills
  - The correct techniques and technologies should be selected at various stages in the production process to save time and optimise productivity. Over- and under-mechanisation lead to wastefulness and production losses.
- Financial skills
  - Financial expertise is needed to succeed in farming and make a profit. The farm manager should be able to draw up and use all the financial documents.
- Record keeping skills
  - It is important to keep records for each activity to make informed decisions and to ensure that previous mistakes are not repeated. It is useful to keep financial, crop and labour records (depending on the type of enterprise).

4 Forces that affect farming businesses

Internal forces that affect/influence farming businesses

Farmers usually have more control over internal forces (e.g. worker motivation) than external ones (e.g. government policy or the weather).

- Sufficient capital
  - Agriculture requires capital and cashflow to buy machinery, pay labourers and buy farming inputs like seeds. They need to pay for these items before they sell their products. This makes it is difficult for new farmers to compete with established commercial farmers for the market.

- Labour efficiency
  - It is important that labourers are punctual and work efficiently. Supervision will ensure that labourers achieve the set targets.
- Skills
  - Skills enable labourers to perform their duties quickly and efficiently. A skills development programme should be introduced on farms to address the needs of managers and labourers.
- Management
  - Good management is needed to achieve the intended results.
- Resources
  - Agricultural resources are critical for agricultural production. We can divide agricultural resources into two main categories: natural resources and production inputs.

External forces that affect/influence farming businesses

Farmers must predict and plan for external forces. They also include forces over which the farmer has little control.

- Availability of reliable markets
  - Many small farmers and co-operatives cannot get easy access to chain supermarkets and big markets.
  - Without market access, there is a risk that their businesses will fail.
- Consumer purchasing patterns
  - Farmers must keep an eye on consumer trends to ensure they produce products that are in demand.
- Availability of credit/loans
  - Resources are the main financial burden for farmers. These expenses include:
    - farming inputs such as seeds, technology and salaries.
  - It is difficult for small farmers to get credit and many financial institutions require security.
- The number of competitors
  - Competitors in the farming business should be viewed in terms of four aspects:
    - New entrants have a small chance of success because they lack experience and have fewer skills and resources compared to established farmers.
    - Both small and commercial farmers can produce intensively and qualitatively, but the target market is more likely to buy from the commercial farmers.
    - Individual farmers will struggle compared to co-operative societies as they have fewer resources.
    - Customers are more likely to buy an original product unless the substitute product is cheaper or has more appeal.

- The national and global economic situation
  - Inflation: means that there will be a lot of money in circulation. The prices of agricultural products will rise. The rise does not always correspond with the rise of salaries which affects the purchasing (buying) power of consumers.
  - Recession: affects the economy and therefore leads to unemployment. Consumers will only buy basic foodstuffs during a recession and so farmers, as producers, will suffer in the process.
  - Changes in government fiscal policy: impacts how farmers can get loans for production or capital for investments, as it determines interest rates on loans.
- Environmental conditions
  - They must favour the type of farming business so that the business can succeed. Deforestation, degradation, desertification, loss of fertility and biodiversity, and air and water pollution negatively affect the environment. Farmers should conduct an environmental impact assessment before they undertake any activity. They need to specify how they will manage the environmental issues.
- Political and socio-economic conditions
  - Demographic changes and consumer trends affect consumer purchasing patterns.
  - HIV/AIDS influences population growth in South Africa. Infected people cannot always work and they may have less money or purchasing power.
  - Change of government and/or government policy (or legislation) affects the way businesses operate.

5 Primary sources of risk in farming businesses

- Nature risk
  - Nature is a source of risk for farming businesses. Natural disasters such as droughts, floods and storms, and unexpected weather patterns like excessive rainfall in winter pose many challenges to farmers.
- Resource risk
  - The important natural resources in agriculture are soil, water, vegetation, climate and terrain. Each of these resources can contribute to losses in the following ways:
    - Removal of vegetation as plant cover exposes soil to erosion. Soil erosion negatively affects the production potential of the soil.
    - Terrain can increase the rate of soil erosion if the slope is too steep.
    - The overuse of pesticides has a residual poisonous effect on the soil which will lead to soil pollution.
    - Sudden changes in climate will affect the growth of plants and the production of farm animals negatively. Plant succession will also be affected since the nutritional value of grasses will be reduced.
    - Water pollution affects the water quality and therefore its usefulness and the composition of nutrients that it contains.

- Production risk
  - Farmers and farm managers should know the production processes and have technical skills needed for production in each enterprise in order to be successful. If they lack these skills, production will decrease and the farm will not generate enough profit.
- Financial risk
  - Undercapitalisation can lead to low yields and profits.
    - The farm might not generate enough cash flow to meet operating expenses or to pay debtors and expand the business.
    - Unexpected events such natural disasters pose a risk to the entire market.
  - On the other hand, overcapitalisation might lead to a loss if the farmer overestimates his profits and he is unable to repay his debtors.
- Strategic risk
  - This involves managing strategic aspects of the farming business such as goals, vision, mission and business strategy.
    - Strategic risk arises when these are mismanaged, causing operational inefficiency, labour unrest of market confusion.
- Human resource risk
  - Labourers can lead to losses if they:
    - are not skilled to perform their jobs
    - are not motivated
    - are not supervised
    - do not know what is expected of them.
  - The farming business will then collapse.
- Unfavourable legislative and political environment
  - There are several Acts with which businesses need to comply. But there may be risk associated with compliance.
    - Compensation for Occupational Injuries and Diseases Act:
      → could lead to financial risk if a payout is required.
    - Impact Assessment Act:
      → requires businesses to undergo an impact assessment and state their environmental management programme.
    - Consumer Act:
      → protects the exploitation of consumers. This might be risky for the farmers because some of their actions may seem to exploit consumers.
    - National Credit Act:
      → states the requirements to access capital. If a farmer expects to receive capital due to the existence of this Act but they are unsuccessful, it may cause their business to collapse.

6 Main risk management strategies/techniques

- Diversification strategies
  These ensure that farmers do not rely on one type of business or market segment. So if, for example, veld fire destroys the cane plantation and forests, the farmer can still get income from the livestock and dairy farming.
  - Concentric diversification
    - Related new products are introduced in concentric diversification to increase farm profits. This takes place when there is a relationship between the products and new markets. An example of this might be a farm that produces tomatoes and goes on to produce tomato sauce.
  - Horizontal diversification
    - This is when new products are not related to the older ones, but can be marketed in the same environment and to the same market segment. The example here is the farmer who has realised that the market segment needs salad dressings as well as vegetables for salads.
  - Conglomerate diversification
    - Non-related new products are introduced in conglomerate diversification to increase farm profits. In this form of diversification the farmer introduces non-related products to increase profit. An example here might be a vegetable farmer who keeps a few cows and sells their dung as organic manure.
- Risk sharing strategies
  This involves sharing the burden of loss or the benefit of gain from a risk, and the measures to reduce the risk, with another party.
  - Risk spread
    - This is when farmers in an insurance pool share the risks of other members in that pool. They can also form a syndicate to spread common risks.
  - Risk sharing partnerships
    - Farmers form a partnership in order to share suppliers' profits and losses equally. This can be through backward integration (business increases its control of inputs/suppliers) or forward integration (increases control over the distribution of products).
  - Risk transfer and retention
    - There are two ways to transfer the risks.
      → Retain risk exposure The farmer might decide to reduce the cover of a less risky operation. For example, the farmer could set aside cash to cover accidents instead of insuring experienced tractor drivers.
      → Transfer exposure There are two ways to transfer risk exposure. Insurance exposure involves the farmer transferring risks to an insurance company. In comparison, non-insurance exposure can be done by hiring a company to offer certain services (outsourcing), hiring equipment and vehicles, or utilising services on a special order basis.

Topic 6

Topic questions

- Answer the questions below. Check your answers afterwards and do corrections.
- Give yourself one hour.
- Marks: 100

1 Choose the correct answer for each question below.

1.1 In agricultural industries the production factors are:

a soil, land, labour and entrepreneur

b land, labour, capital and entrepreneur

c land and entrepreneur

d inputs and outputs.

1.2 ONE of the following is NOT a form of capital:

a Fixed capital

b Working capital

c Product capital

d Movable capital

1.3 Land is regarded as a safe investment because of its _____

a durability.

b variation in production potential.

c restrictedness.

d susceptibility to the law of diminishing returns.

1.4 The Act that deals with labour practices and procedures for labour disputes is the:

a Basic Conditions of Employment Act

b Compensation for Occupational Injuries and Diseases Act

c Skills Development Act

d Labour Relations Act.

1.5 A tractor is an example of _____.

a fixed capital

b working capital

c movable capital

d credit. (5 × 2 = 10)

Topic 6

Topic questions

2 Decide whether the descriptions in the first column match (i) only, (ii) only, both (i) and (ii), or neither (i) nor (ii). Indicate your answer using these keys:

A i only
B ii only
C both i and ii
D neither i nor ii. (6 × 2 = 12)

2.1 Restrictedness	i	Soil fertility decreases with time
	ii	Crops do well in a specific type of soil
2.2 Ways of getting enough information on the suitability of land for production	i	Soil analysis
	ii	Soil tests
2.3 Durability	i	The life of the soil is unlimited
	ii	The soil regenerates
2.4 Availability of the soil is limited	i	12% of the soil can be ploughed
	ii	Located in a specific environment
2.5 Consolidation of uneconomical farm units	i	Similar farm units combined
	ii	Running costs reduced
2.6 Labour practices and procedures for labour disputes	i	Basic Conditions of Employment Act
	ii	Skills Development Act

3 Select the most appropriate definition of capital as a production factor:

A Capital is the budget and how you spend it.

B Capital is wealth accumulated through savings and employed in the production process.

C Capital only refers to money used in the production process. (1 × 2 = 2)

4 Differentiate between:

4.1 assets and liabilities

4.2 fixed capital and movable capital. (2 × 4 = 8)

5 Describe the three sources of capital and give one example of each. (3 × 3 = 9)

6 Substitute the underlined term in the following statements to make them correct.

6.1 Labour is accumulated through saving and employed in the production process.

6.2 The strategy in farming where farmers share common risks is called risk sharing.

6.3 Casual labourers are employed during a particular season.

6.4 Motivation is the management principle dealing with who will do what, when and how.

6.5 Human resource management is the form of management that involves developing the vision, mission and objectives of a business. (5 × 1 = 5)

7 Provide FOUR conditions of service as a method of increasing labour productivity. (4)

Topic 6

Topic questions

8 List the FOUR main components or features of a good employment contract. (4)

9 Name the Act that:

9.1 Addresses the safety of workers in the workplace (1)

9.2 States that workers injured at work should be compensated. (1)

10 Compare a whole farm budget and an enterprise budget. (6)

11 A farm manager should be able to plan activities in advance for labour productivity.

11.1 Briefly explain the necessity of using seasonal workers for the shearing of sheep. (3)

11.2 Name THREE techniques that the sheep farmer can apply to manage climatic risks. (3)

11.3 Mention THREE ways the farmer can increase labour productivity. (3)

11.4 Suggest THREE ways the farmer can increase labour productivity. (3)

12 Farmer Brown gathered this data about the financial operations of his farm in this financial year. Study the table and answer the questions that follow.

Description of item	Amount
Bought 2 000 chicks	R2 each
Paid for labour	R15 000
Sold chicken manure	R19 000
Bought chicken feeders	R10 000
Paid for water	R2 000
Paid for holiday from investments	R7 000
Bought vaccines	R500

12.1 Use the data to design a budget for Farmer Brown. (4)

12.2 Predict the profit of Farmer Brown's business. (3)

12.3 Is his a viable and healthy business? Give a reason for your answer. (2)

13 Describe FOUR ways you could use to solve the problem of the shortage of farm labourers and discourage them from leaving farms and going to work in cities. (4)

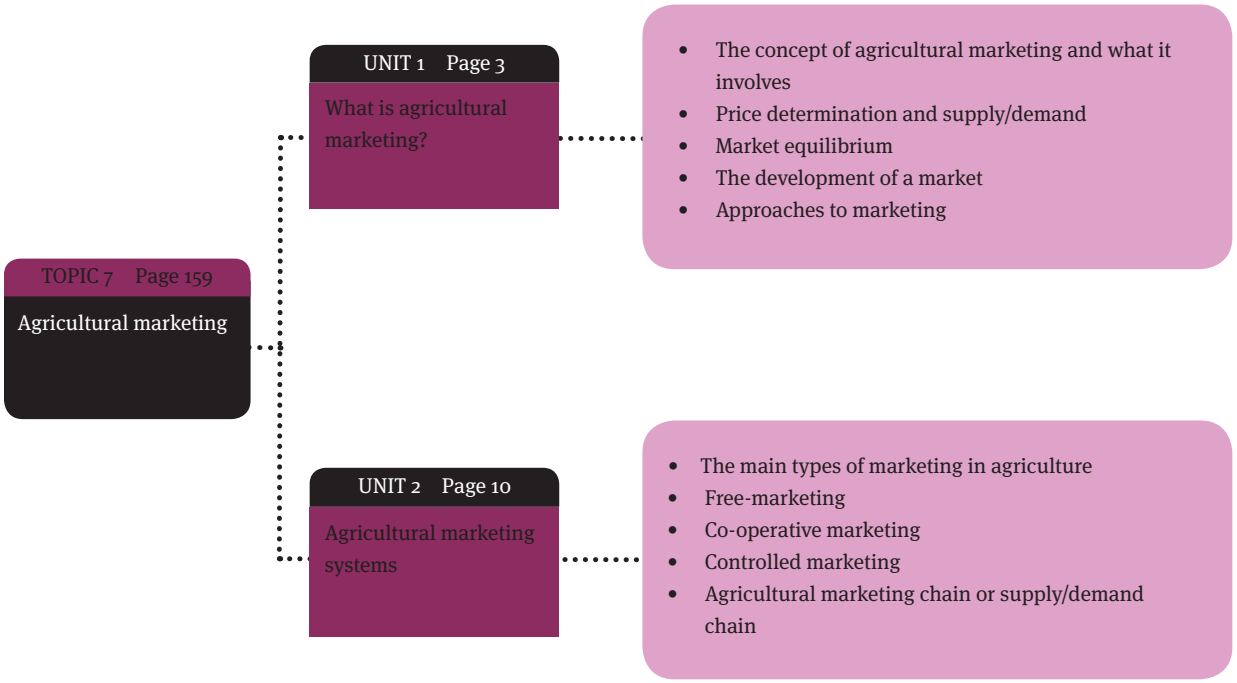
14 Briefly explain the difference between permanent and temporary labourers. (6)

15 Discuss lack of skilled labour as a problem related to labour as a production factor. (7)

Topic 7

Agricultural marketing

Overview



Unit 1

What is agricultural marketing?

1 Concept of agricultural marketing and what it involves

Agricultural marketing refers to the actions that producers of agricultural products take to make retailers and consumers aware of and able to access products from the agricultural sector.

- Retailers and consumers represent the demand side of marketing.
- Agricultural producers and their products represent the supply side of marketing.

Differences between marketing and selling

Differences between marketing and selling	
Marketing	**Selling**
Profit orientated	Product orientated
Long terms plans are made	Short-term objective is to sell the product
Emphasis on consumer needs and satisfaction	Needs and satisfaction of the consumer are neglected
Different departments work together	Sales department does not work with other departments
Technological innovation is important	Costs are reduced to achieve maximum sales and profit

Main functions of agricultural marketing

Agricultural marketing involves identifying people's needs and desires and determining how these can be satisfied. Farmers make a profit in return.

Agricultural marketing performs four functions.

- Transport in agricultural marketing
  - Transport bridges the gap between producer, manufacturer and consumer. Choice of transport is determined by the distance involved, the cost, the nature of the product and the speed of delivery required. Challenges include the expense and the difficulty of transporting perishable products.
- Storage in agricultural marketing
  - Storage is important in the agricultural sector. The storage function is performed by co-operative societies, warehouse owners, cold storage owners, manufacturers, wholesalers and retailers. They perform the following functions:
    - ensure that the products remain fresh
    - maintain the quality of agricultural products
    - bridge the time between production and purchasing
    - ensure a continuous supply of the agricultural product
    - ensure that prices stay constant
    - prevent an oversupply or shortage of goods.

- Packaging in agricultural marketing
  - Packaging should protect, contain, deliver and display the product in a way that appeals to the consumer.

Steps of packaging a product

- Design different forms
- Choose the design
- Choose materials and colour schemes
- Placement of labels and trademarks.

Forms of packaging

- Primary packaging: is for direct sale to the consumer, for example tomatoes packed in small pockets for sale.
- Secondary packaging: involves the packaging of sales units, for example pockets of tomatoes packed in cardboard boxes for transportation and handling.
- Tertiary packaging: involves the grouping of secondary packed units to further facilitate handling and transportation, for example boxes of tomatoes packed in a wooden pallet.

Guidelines for packaging

- It should improve shelf life.
- The materials used should be environmentally friendly and either biodegradable or recyclable, but also strong and easy to handle.
- The container should be suitable for the product.
- The product should fit well in the container.
- It should have its own identity and strong sales appeal.
- The package should be appropriately designed for the target market.
- There should be a variety to suit both bulk packages and small packages.

Advantages of packaging

- It improves shelf life.
- It gives the product appeal.
- It advertises the trademark.

- Processing in agricultural marketing
  - Processing involves changing an agricultural product from its original form or condition into a consumable commodity. This is done to increase its utility value, keeping quality and shelf life. Processing is also called value adding.
  - Forms of processing
    - Indigenous processing: changes the original product into a consumable product using indigenous knowledge and traditional practices (e.g. drying up of meat to make *ikhuthu* and the preparation of traditional beer and silage).
    - Agro-processing: is the conversion of a raw product to make it more consumable and increase its value. It takes place in the agro-industries and involves milling, blending, cutting, fermenting and moulding.

Advantages and disadvantages of processing	
Advantages	**Disadvantages**
Improves the quality of a product (value adding)	Difficult to access capital for new industries
Increases the shelf life	New products compete with established products in the market
Increases the appeal of the product	Business owners might lack experience and expertise
Solves the oversupply problem and reduces wastage	
Enhances food security (ensures a continuous supply of food for homesteads)	
Creates job opportunities for low-income groups	

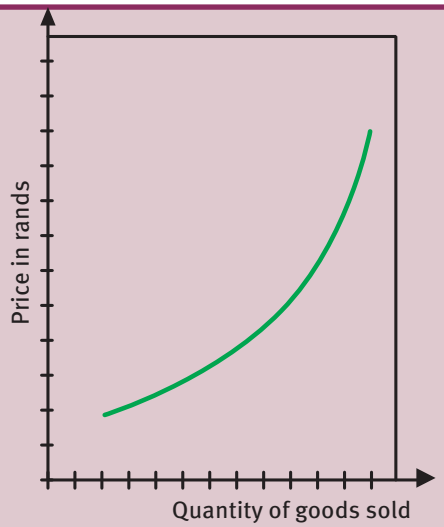
2 Price determination and supply/demand

Price determination is the process involved in finding the price consumers are willing to pay for a particular product at a particular time. This involves supply of and demand for the product.

- Supply
  - Supply is the quantity of goods on the market offered / sold at a particular price at a particular time. It can also be defined as quantities of goods or services that producers plan to sell at each price level during a particular period. Supply is determined by producers, although consumer demand can influence how much or what producers supply.

Supply curve

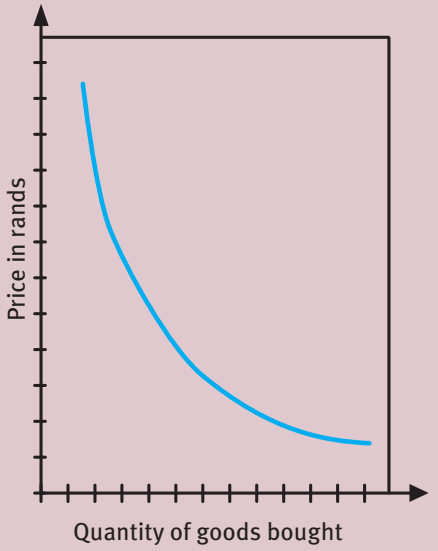
Supply can be indicated by a hypothetical supply graph. It shows that when the price of goods increases, the quantity of goods supplied increases too, since increased prices (up to a level determined by consumers) means increased income for producers, which drives them to supply more product.



- Demand
  - Demand is the quantity of goods bought at a particular price at a particular moment. Demand implies that the consumer intends to buy and has the necessary purchasing power. (Purchasing power should be equal to or greater than the price of a product.) Demand is therefore influenced by the price of the product and it is determined by consumers.

Demand curve

Demand can be indicated by a hypothetical supply graph. It shows that when the price of goods increases, the quantity of goods bought will decrease. Demand will increase if the price is low. In other words, the lower the price the higher the demand of a product.



Factors influencing supply and demand of a product

Production factors have an impact on supply. On the other hand, consumers have an impact on demand.

The law of supply and demand

The law of supply and demand states that there is a higher demand for agricultural products when more customers buy a particular product. When there is a high demand, the price of the product will increase. On the other hand, the price will decrease when there is a low demand. This will result in many people buying the product which can lead to a product shortage. The price of the product will then increase. There is a stage in the market when supply and demand are equal and there is neither an oversupply nor a shortage. This is called market equilibrium. The price that consumers pay is determined by the market equilibrium.

Factors that influence supply

Producers determine supply of a product to the market. However, there are production factors that influence their decision and ability to supply a product to the market.

- The price of alternative products
- Seasonal production
- Weather conditions
- The profit margin of the product
- Specialised scientific knowledge
- The ability to increase supply
- Expected future prices
- The state of technology

Factors that influence demand

Demand plays an important role in determining how much of the product will be bought by the consumers. There are several factors that influence consumers and thus product demand.

- The price of the product
- Usefulness of the product
- Quality of the product
- The price of competitive goods
- Number of consumers
- The preferences of consumers
- The buying (purchasing) power of consumers
- Tradition and religions
- The size of the household

Price elasticity and price inelasticity of supply/demand

Price elasticity of supply (Pes) measures the relationship between change in quantity supplied and a change in price. If supply is elastic, producers can increase output without a rise in cost or a time delay. If supply is inelastic, producers find it difficult to change production in a given time period.

What factors affect the elasticity of supply?

- Spare production capacity
- Stocks of finished products and components
- The ease and cost of factor substitution
- Time period and production speed

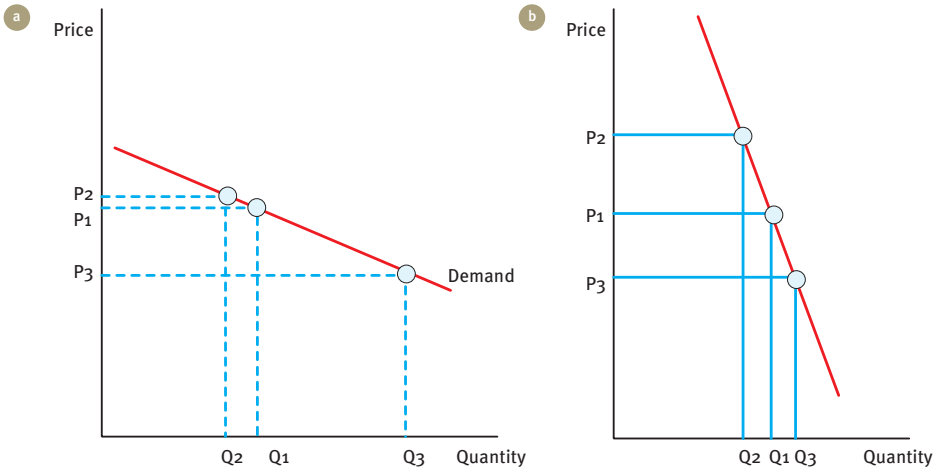


FIGURE 1 Impact of price on supply: (a) price elasticity of supply; and (b) price inelasticity of supply

Price elasticity of demand (Ped) measures the responsiveness of demand after a change in price. When demand is elastic, a fall in price leads to an increase in demand and results in a rise in income. When demand is inelastic, a rise in price does not lead to a big decrease in demand and results in an increase in income.

What factors affect the elasticity of demand?

- The number of close substitutes
- The cost of switching between products
- The degree of necessity or whether the good is a luxury
- The proportion of a consumer's income allocated to spending on the product
- The time period following a price change
- Whether the product is subject to habitual consumption
- Peak and off-peak demand

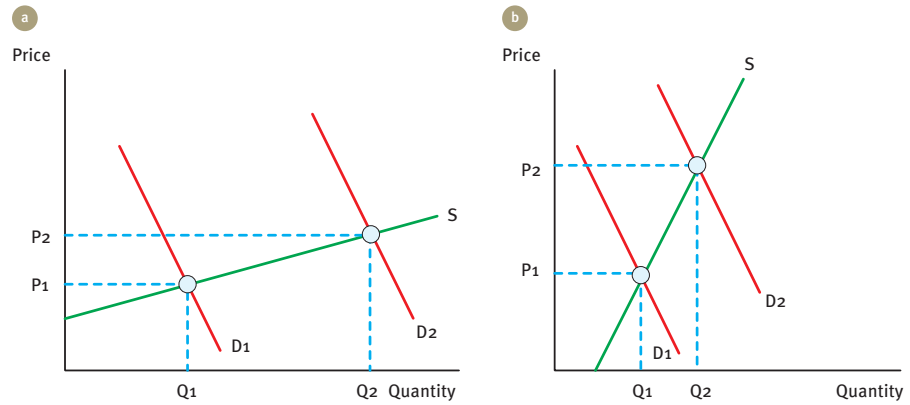
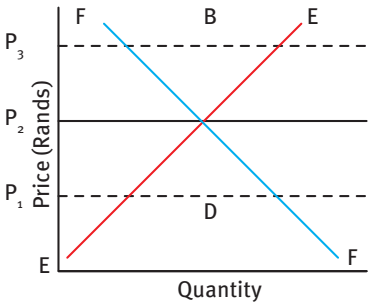


FIGURE 2 Impact of price on demand: (a) price elasticity of demand; and (b) price inelasticity of demand

3 Market equilibrium

Market equilibrium is when supply and demand are equal. The price of goods at this point is called the equilibrium price. Market equilibrium can be shown on a market equilibrium graph.

- **P1 represents a low price** It affects supply (shown by E) and demand (shown by F). This occurs as a low price will encourage customers to buy more of a product which will increase the demand for that product. On the other hand, a low price will encourage producers to offer fewer products to the market as they will not make much profit. So high demand and low supply coincide at the line labelled D. This means that there will be high demand for the product and a low supply at D. This will result in a shortage of the product.



- **P3 represents a high price** It will cause the demand to decrease and the supply to increase. The demand will decrease because high prices will discourage consumers from buying the agricultural product. The supply will increase because farmers will offer more products to the market in order to increase their profit. Low demand and high supply coincide at the line labelled B. This means that there will be low demand for the product and a high supply at B. This will results in an oversupply of the product.
- **P2 represents the equilibrium price** It is a healthy situation in which demand is equal to supply. It is a state where the price is balanced between the high price and the low price. In other words, the products supplied are able to meet the demand in the market.

4 The development of a market

Marketing involves the planning, implementation and control of business activities to bring together buyers and sellers for the exchange of goods and services. It helps to fix prices, satisfy the target market and promote products.

- Consumers must be in the market to buy products.
- Producers and suppliers must ensure that products are in the market for consumers to buy.

Fixing prices

In a free market system (as we mainly have in South Africa) the interaction between supply and demand influences consumer prices. The South African government cannot fix prices but there ways that it can help to control them.

- Set floor prices for basic foodstuffs
  - This keeps the prices of basic foodstuffs as low as possible.
- Set the ceiling prices for foodstuffs
  - This sets the maximum price for certain products.
- Combat inflation
  - When there is inflation, money loses buying power. This leads to an increase in prices. The average person will not be able to afford basic foodstuffs. So the government should try to control inflation.

Types of buyers (target markets)

Before starting a farming business, the farmer should identify and research a target market to find out its needs and wants, and how much it would be willing to pay to satisfy these. This will enable the farmer to produce appropriate products.

Methods used to promote products

- Advertising
- Personal selling
- Sales promotion
- Publicity

Market research information should be included in the farmer's business plan.

5 Approaches to marketing

- Niche marketing
  - This is a form of marketing in which the product is sold to a small segment of the market. There are three rules for niche marketing:
    - meet the unique needs of the segment of the market
    - focus on the interest and motivations for the segment when you develop promotional materials
    - test the market by starting small, but with focus.
- Mass marketing
  - In this form of marketing the farming business ignores market segment differences and addresses the whole market. It is also called undifferentiated marketing.
    - Strategies are used to reach as many consumers as possible.
- Multi-segment marketing
  - This type of marketing involves marketing to two or more segments of the market.
    - A unique marketing strategy is then developed to suit those segments.

Sustainable agricultural marketing

This involves the application of an environmental educative approach to marketing. It takes social, ethical and environmental issues into account. This form of marketing ensures that with all the intensive production and marketing taking place, that the environment retains the potential to support future generations.

- Green markets
  - A green market distributes used, refurbished, reconditioned, repaired and recycled products that are in working condition through brokers and resellers.
- Eco-labelling
  - Eco-labelling is a method of labelling that communicates information, educates and increases consumer awareness on the impact of a product on the environment. It encourages consumers to buy products with a low environmental impact.

Unit 2

Agricultural marketing systems

1 The main types of marketing in agriculture

Farmers choose marketing methods based on the type of product that they need to sell.

Free-marketing

In South Africa the deregulation of the marketing systems led to the establishment of the free-market system. This form of marketing allows farmers or producers to market their products in any way.

Advantages and disadvantages of free-marketing

Advantages	Disadvantages
Sales are usually for cash which is more convenient	Farmers may not have all the necessary skills
Producers receive their money immediately	It is riskier because if natural disaster affects production, the farmer bears all the risk alone
It is cheaper because there are no middlemen such as agents or intermediaries	Prices will fluctuate because of the force of supply
Farmers can control how much profit they can make by analysing the demand	A small-scale farmer will have less bargaining power
Farmers are motivated to work harder	Production and marketing costs are high
Farmers are encouraged to produce quality products because of competition	Small-scale farmers struggle to keep up production and focus on marketing
The producer can show initiative and drive	Some farmers may form cartels to protect themselves from competition and consumers could be exploited
More farmers will be encouraged to enter as entrepreneurs as this form of marketing is cheaper	Marketing is now more commercialised and specialised so experts are needed to perform this role

The main channels/options of free-marketing

Different channels have to be used to market agricultural products so that producers can maximise their profits.

- Farm gate market: the farmer erects a structure near the farm (a farm stall) and sells the products directly to the consumers. This is also called bakkie trade.
  - Advantages of the farm gate market
    - The farmer will get cash immediately.
    - There is less expense in terms of labour and transport.
    - The middlemen, intermediaries and agents are eliminated.
    - The producers fix the price.
    - There is less competition as the farmers only sell their products in their own locality.
  - Disadvantages of the farm gate market
    - There might be few buyers.
    - Marketing is restricted.
    - Products may spoil if they take a long time to sell.

- Fresh produce markets (FPM): built and controlled by the local authorities or municipalities. By-laws of municipalities affect the fresh produce market. Agents sell products on behalf of the producers and are paid a commission on their sales. Examples of FPMs in South Africa are the Durban FPM and the Johannesburg FPM.
  - Disadvantages of FPMs
    - Any financial difficulties of the municipal councils would have a negative effect on the functioning of the markets.
    - Municipalities may use the by-laws to maximise profits and therefore prevent free and fair competition.
    - The infrastructure and market share of FPMs has declined.
    - Transformation has been slow to accommodate black producers and buyers.
    - The wholesalers are not part of the marketing channel.
    - Agricultural Produce Agents Council (APAC) only represents interests of agents.
  - Recommendations for improvements to FPMs
    - The Interim Ministerial Committee made these recommendations in 2009.
    - FPMs are now owned by the municipalities and rented out to the agents (separate ownership and management). A moratorium was placed on any planned privatisation by local authorities.
    - The FPMs are now nationalised and so they are called National Fresh Produce Markets (NFPMs).
    - The Agricultural Produce Agents Act was amended which had several implications. The sectoral quota for markets and agents, as well as a transformational score card system was introduced. The Fresh Produce Market Development Agency (FPMDA) was established to address the commission system by agents. Commissions for producers have to be negotiated and paid within five days. Producers and buyers must be treated fairly. Individual agents can register with Agricultural Produce Agents Council (APAC). Agents must record their business transactions.
    - Municipal by-laws were standardised.
    - The FPMDA improves the infrastructure of the FPMs and negotiates with the Treasury to fund these improvements.
- Stock sales: involve the selling of shares on the agricultural markets on the Johannesburg Stock Exchange (JSE).

Advantages and disadvantages of stock sales

Advantages	Disadvantages
It improves profit margins; there are greater returns if one picks the right company	Not everyone has access to the JSE
It attracts international investors	There are high risks
Price changes are limited by price hedging	The general economy of the country determines success on the stock exchange
It is easy to get ownership of stock	Costs are higher due to brokerage fees
Stock can easily be converted into cash	It is expensive
It reduces tax to be paid on capital gains	

- Direct marketing: takes place when the farmer or producer markets products directly to the consumer using online marketing, social networks, text messaging or e-mail. Another form of direct marketing is telesales in which agents make calls to potential customers. Pre-harvesting and post-harvesting contracts can also be used as a form of direct marketing.

Advantages and disadvantages of direct marketing	
Advantages	**Disadvantages**
Many customers can be attracted very quickly	Customers do not know what they are buying
Agents are motivated to get as many customers as possible because they are paid on commission	Many customers cancel the transactions upon delivery if the product is not what they wanted
It is cheaper to market products because it saves time, money and labour	Products may reach the expiry date before delivery especially when transported by ship
Results are obtained quickly	
It is environmentally friendly because less paper is used	

- Internet marketing: uses of e-commerce to advertise and conduct a transaction.
  - Advantages of internet marketing
    - You can reach wide audiences with a small budget.
    - It is convenient and can be done from home.
    - Results are obtained quickly.
    - You can research the target market by recording each time a consumer goes to the website. The results are also easy to access.
    - Marketers are able to meet consumer demands.
    - It saves time, money and labour.
  - Disadvantages of internet marketing
    - There are many dishonest schemes.
    - Customers do not know what they are buying.
    - Pyramid schemes are common.

2 Co-operative marketing

An agricultural co-operative is an organisation where farmers pool their resources to conduct their different business activities for the benefit of its members.

Agricultural co-operative principles

- Democratic member control
  - The highest authority of a co-operative is in the hands of members during a general meeting. They have the democratic right to vote for their directors.
  - In business operations of a co-operative, the size of members bonuses depends on their capital contributions.
- Open and voluntary membership
  - Anyone who fulfils the membership requirements is entitled to join the co-operative. No discrimination is allowed.

- Autonomy and independence
  - A co-operative is an independent and autonomous body controlled by its own members and no outside influence or decision should affect the running of the co-operative. Decisions are binding on all members. Each member has one vote.
- Distribution based on the value of a business
  - The co-operative distributes profits to each member based on the value that they add to the business.
- Economic participation/financing of co-operatives
  - Members of a co-operative finance it through entrance and membership fees, membership shares and member loans. Profits are divided amongst members based on their number of shares.
- Concern for the community
  - Co-operative society members belong to a certain community and therefore their success should benefit that particular community.
- Co-operation among members
  - Co-operative society members are committed to working together, pooling their resources and using their strengths to ensure the success of their co-operative.

The types of agricultural co-operatives

The agricultural co-operative are organised according to different levels and, within these levels, according to the functions that they perform.

- Primary co-operatives
  - Formed by individuals. Their purpose is to provide employment and services for their members and to promote community development.
- Secondary co-operatives
  - Formed by two or more primary co-operatives. The aim of this co-operative is to service its members. It is usually organised at the district level.
- Tertiary agricultural co-operatives
  - Formed by two secondary co-operatives. The purpose is to present and advocate the interests of members to government, the private sector and other stakeholders. This co-operative is organised mostly at the provincial level.

The advantages of agri-co-operatives

The main strategy of agricultural co-operatives is pooling, which provides co-operatives with the following benefits:

- Members share skills, experience and knowledge, which results in improved products and services.
- Bargaining power – which reduces input costs (e.g. seeds and fertilisers) and costs of production. Bargaining power also results in:
  - reduced marketing and distribution costs
  - improved access to finance.
- Collective financing of undertakings, which reduces infrastructure costs.
- Collective representation to local, provincial and national government structures, which enables co-operatives to influence agricultural policy.

3 Controlled marketing

In controlled marketing, the marketing of products is regulated by control boards. These were mainly set up during apartheid. Many people believed that the control board measures prevented black farmers from entering agricultural businesses. So it was not surprising that the marketing systems were deregulated in 1994 when South Africa's first post-apartheid government came into power.

A new act was then passed called the Marketing Act of 1996.

Activities in controlled marketing

- Stabilisation of prices
- Orderly marketing
- Market development
- Standardisation of products
- Involvement of co-operatives
- Processors and distributors
- Research

4 Agricultural marketing chain or supply/demand chain

The agri-business chain has two parts: the production chain and the marketing chain.

- Before being harvested, the product goes through the production chain so that it is ready for harvesting and thereafter marketing.
  - The marketing chain is also known as the supply/demand chain.
  - It involves all the stages that a product passes through after being produced and harvested on a farm until it reaches the consumer:
    → cleaning, drying, grading, processing, transporting, storage, packaging, labelling and branding.

Factors that hamper the marketing chain of agricultural products

- Seasonal fluctuation
- Perishability
- Standardisation
- Ineffective control over production
- Long-term production
- Wide product distribution
- Locality-restricted production
- Intermediaries (middlemen) are required for marketing

Ways to streamline and improve the agri-business chain

- Participatory market chain approach
  - All the participants play an active role in the agri-business chain. Their involvement as a group yields new strategies and leads to trust, collaboration and the interest of all participants. It ensures that the small-scale farmers get access to the markets and everyone in the chain knows what is expected of them.
- Vertical co-ordination
  - Involves activities that reinforce contractual agreements. It does not include the physical provision of input and services. Some agreements between small-scale farmers and the participants in the agri-business chain need to be strengthened so that they are fair and transparent to both parties. Government intervention through policies and legislation can ensure that producers, suppliers, processors and marketers work together harmoniously.
- Adequate infrastructure
  - Ensures that there is enough space and shelter for storage and processing. Once their infrastructure is adequate, smaller businesses can concentrate on other activities such as marketing of products.
- Business linkages and value chains
  - A value chain is an alliance of agricultural enterprises working together at different stages such as production, processing and marketing. They add value to products so that they have a high value when they are presented to the consumer.
- Vertical integration
  - The process in which government and farmers, especially small-scale farmers, work together. It involves physical intervention by government to help the farmers. Government departments provide fertilisers, training and finance to help the private and the small agri-business chains to thrive.
- Creation of market organisations to assist producers and processors
  - Sharing of information is important in the agri-business chain. Market organisations can ensure that producers and processors know exactly what is expected of them. They can also set the right standards to make agricultural products more marketable.
- Government involvement
  - Government departments should play a pivotal role in helping small-scale farmers. This will ensure that the legislation and policy passed allows the businesses to operate effectively. The legislation can ensure the smooth running of the agri-business chain and remove any hindrances or risks.
- Specialisation
  - Farmers must consider their expertise, knowledge and experience before they start a particular type of business in the agri-business chain. This will ensure that they produce quality products.

- Diversification
  - This is when a farmer has different farming enterprises in the same environment. For example, a sugar cane farmer might need to consider diversifying his farming business because it takes a long time for sugar cane to grow and produce profits. So the farmer might decide to add broiler, wood and feed production enterprises to the same farm.
- Hedging
  - This is the fixing of prices so that they are not affected by supply and demand. This can be useful because supply and demand can affect business profits. Once suppliers know that the price of a product is constant, they can plan their production activities in such a way that they are able to make a profit.

The role of legislation in the marketing of agricultural products

Government Notice 360 of 1952

The Government Notice proposed that inspectors be introduced. The inspectors had to ensure that farmers complied with regulations in agricultural marketing.

The Marketing Act of 1996

The Government Notice was amended and replaced with the Marketing Act No 68 of 1996. It provided for the appointment of a National Agricultural Marketing Council to advise the Minister in his decision making. Two main aims of the Act were to increase market access to all farmers and promote efficient marketing of agricultural products.

Marketing of Agricultural Products Act of 2001

This Act proposed the constitution of the National Agricultural Marketing Council and its committees. Its mandate was to align financial matters to the Public Financial Management Act of 1999. The Act of 2001 also made provisions for the following:

- Terminate the role of parliamentary committees in the marketing of agricultural products
- Utilise and audit levies collected from agents
- Liquidate boards established through the Marketing Act of 1968
- Consultations between the Minister of Agriculture and Agricultural Marketing Council before prohibiting exports and imports
- Prohibit the import and the export of chosen agricultural products
- Submit budgets for approval by the council.

Agricultural Produce Agents Act of 1952

This Act provided for the establishment of Agricultural Produce Agents Councils and the fidelity funds. It stated how the fidelity funds would be collected and used to fund agent activities. It also stated that agents had to hold Fidelity Fund Certificates to operate.

Agricultural Produce Amendment Act of 2004

This Act made provisions to:

- Change the constitution of the Agricultural Produce Agents Councils
- Extend the jurisdiction of the councils
- Enhance the regulating powers of the council
- Apply certain conditions to fresh produce only
- Make text (wording) alternations in the Agricultural Produce Agents Act of 2004 which prevented the control boards, people acting on behalf of the control boards and local authorities from working as agents
- Alter the description of agricultural produce.

Security Services Board Act No 36 of 2004

This Act replaced the Insolvency Act No 24 of 1936 and the Companies Act No 61 of 1973. The main aim of the Act was to regulate the capital markets. It also established the Financial Services Board (FSB). The objectives of the FSB were to:

- protect investors
- ensure fair, transparent and efficient financial markets
- reduce risks associated with marketing systems.

Consumer Protection Act of 2008

This Act set out the minimum requirements to ensure that consumers are protected. It provides a framework for consumer protection that should be read together with other Acts and policies for consumer protection. This Act applies to high capacity municipalities. It therefore excludes the ordinary municipalities. It provides guidelines on the following aspects:

- When consumers may not be contacted for direct marketing purposes
- Information to be disclosed by the intermediary or the agents
- Reporting and record-keeping requirements for promotional competitions
- Advertising of auctions
- Maximum period of a fixed-term contract and cancellation fees.

Code of Advertising Practices

This is a guiding document for advertising. It was drawn up by the Advertising Standards Authority of South Africa and representatives of the marketing communication industry. It is based on the International Code Advertising Practice of which the Marketing Association is a member. The Advertising Standards Authority of South Africa is a body set up by the marketing communication industry. Its aim is to set and regulate advertising standards in South Africa.

Topic 7

Topic questions

- Answer the questions below. Check your answers afterwards and do corrections.
- Give yourself one hour.
- Marks: 100

1 Match each statement in column A with a statement in column B. (7 × 2 = 14)

COLUMN A	COLUMN B
1.1 Marketing Act of 1996	A Formation of the National Agricultural Marketing Council
1.2 Advertising Standards	B Financial markets are fair and transparent
1.3 Consumer Protection Act of 2008	C Marketing licence from the director of marketing
1.4 Marketing of Agricultural Products Act of 2001	D Fidelity Funds certificates
1.5 Security Services Act No 36 of 2004	E Dates and times for contacting clients
1.6 Agricultural Produce Agents Act of 1952	F Enhanced the jurisdiction of the agents councils
1.7 Agricultural Produce Amendment Act of 2004	G Set up by the marketing communication industry
	H Proposed the introduction of inspectors

2 Define the following terms:

2.1 marketing chain

2.2 value chain

2.3 grading (3 × 2 = 6)

3 Name THREE factors that complicate the marketing of agricultural products. (3 × 1 = 3)

4 Ongoing improvements to the agri-business chain are vital.

4.1 Explain how infrastructure development can improve the agri-business chain. (1 × 5 = 5)

4.2 Suggest FOUR other ways to streamline and improve the agri-business chain. (4 × 1 = 4)

5 Choose the best answer to each question. Write only the answer number (i–iv) next to the question number (1.1–1.5).

5.1 Demand is affected by _____

i weather conditions.

ii the price of the product.

iii the stability of the product.

iv the state of technology.

5.2 Free-marketing is a form of marketing in which the farmer markets his/her products _____

i as directed by control boards.

ii as he pleases.

Topic questions

iii with the aid of agents.

iv as per agreement by members of the society.

5.3 The form of marketing where a small segment of the market is targeted is called _____

i multi-segment marketing.

ii mass marketing.

iii niche marketing.

iv eco-labelling.

5.4 The channel of marketing in which a municipality builds a market and rents it out is called _____

i fresh produce markets.

ii farm gate sales.

iii a stock market.

iv internet marketing.

5.5 Which one of these is not an advantage of free-marketing?

i Sales are for cash

ii No middlemen

iii Farmers receive payments immediately

iv Farmers are motivated to work harder (5 × 2 = 10)

6 Match the items in column A with those in column B. Write only the correct numbers and letters. (5 × 2 = 10)

COLUMN A	COLUMN B
6.1 Advertising	A Farmers Weekly
6.2 Personal selling	B Discounts
6.3 Sales promotion	C PRO
6.4 Publicity	D Talking to customers
6.5 Print media	E Radio and television
	F Labelling

7 Give one word or phrase for each of the following:

7.1 A quantity of goods offered for sale at a particular price at a particular moment

7.2 A situation in which the demand for a product is affected by price change.

7.3 A number of activities that a product goes through after production until it reaches the consumer

7.4 The marketing act that protects consumers from exploitation

7.5 The form of market in which refurbished and reconditioned goods are sold. (5 × 1 = 5)

Topic questions

8 The following statements are false. Replace the underlined words to make the statements correct.

8.1 Packaging involves covering and labelling the product so that it appeals to the <u>marketer</u>.

8.2 The marketing chain starts after the product has been harvested and ends when the product reaches the <u>producer</u>.

8.3 Grading, packaging, cleaning and processing are part of the <u>agri-business chain</u>.

8.4 The <u>standardisation</u> of products means the sorting of products in terms of quality.

8.5 <u>The Marketing of Agricultural Product Act of 2001</u> increased the access to markets for all farmers. (5 × 1 = 5)

9 Define each term below. Then, for each term, outline FOUR factors that affect it.

9.1 Supply (2 + 4 × 2 = 10)

9.2 Demand (2 + 4 × 2 = 10)

10 Read the passage below and the answer questions that follow.

Jabu Sithole wanted to establish a co-operative society. She made copies of the identity documents of her relatives and registered the co-operative society under the name Siyakhisana. This society would concentrate on vegetable production and processing. She used all her money to finance the activities. Unfortunately, the business failed.

10.1 Give two reasons for the failure of Siyakhisana Co-operative Society. (2 × 1 = 2)

10.2 Suggest and discuss three principles that should be applied in the functioning of a co-operative. (3 × 2 = 6)

10.3 Describe how directors of a co-operative society are selected. (1 × 1 = 1)

10.4 Give the term used to describe working together and sharing among co-operative society members. (1 × 2 = 2)

11 Compare the following:

11.1 Primary and tertiary co-operative (2 × 1 = 2)

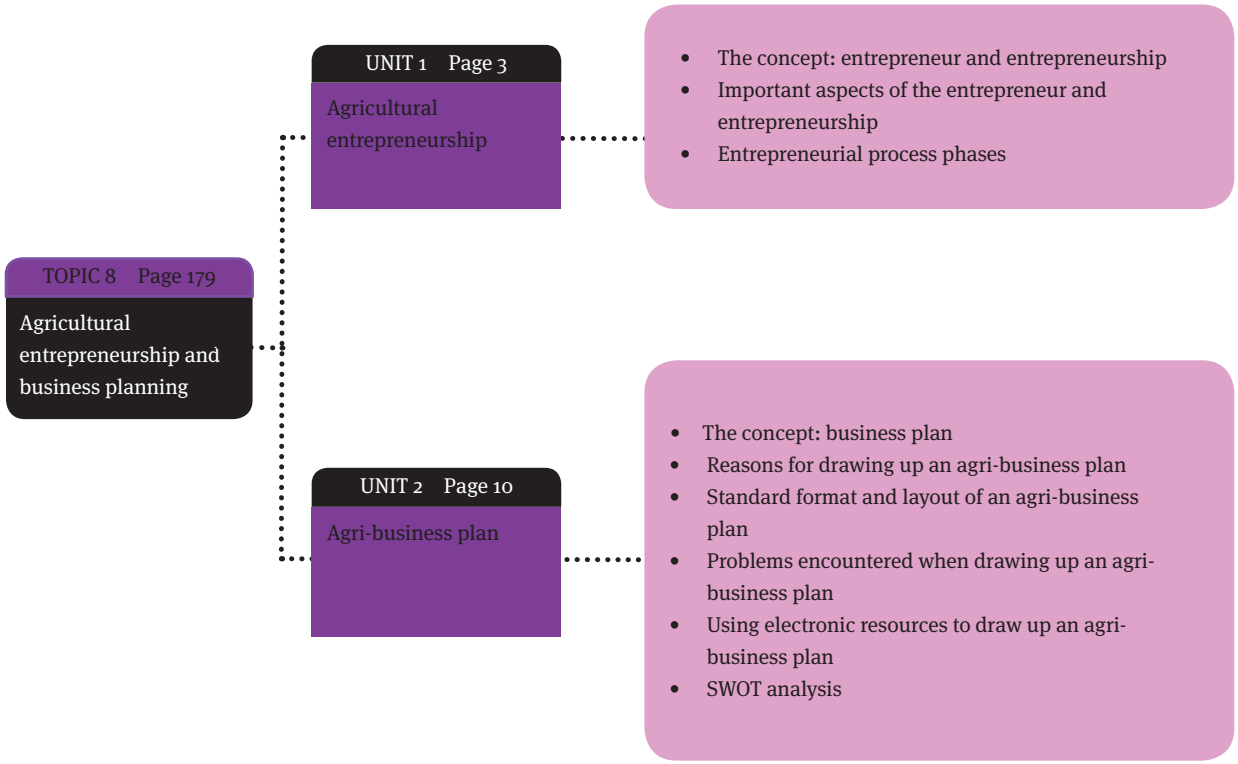
11.2 Co-operative and controlled marketing (2 × 1 = 2)

12 List three disadvantages of free-marketing. (3 × 1 = 3)

Topic 8

Agricultural entrepreneurship and business planning

Overview



Unit 1

Agricultural entrepreneurship

1 Entrepreneur and entrepreneurship

Important aspects of entrepreneurs

Successful entrepreneurs must have the ability to identify market needs and find profitable ways to provide goods or services to cater for these needs. For this reason, most successful entrepreneurs are:

- creative and innovative
- achievement-orientated
- independent thinkers
- well-educated, technically knowledgeable and experienced in their fields
- risk takers
- good leaders who are team builders
- good at working with people
- committed and have perseverance.

An **entrepreneur** is a person who takes a novel business idea, sees an opportunity for that novel idea and converts it to a healthy and functional business.

Entrepreneurship is the practice of starting, running and growing a business that an entrepreneur sets up.

Important aspects of entrepreneurship

Certain factors (aspects) are important for an entrepreneurial business to thrive. These factors are called **entrepreneurial success factors**.

- Skilled strategic and general management
- Sufficient start-up capital, adequate resources and availability of appropriate technology
- Financial insight and skilled financial management, including the ability to keep costs and prices down
- Knowledge of the target market and of competitors
- Willingness to take risks
- Strategic partnerships and the use of experts
- Good client service
- Good product or service quality.

2 Entrepreneurial process phases

There are four distinct phases of the entrepreneurial process

- **Phase 1: Identify and evaluate the business opportunity**

Three scenarios can be used to identify a business opportunity. The business opportunity must then be evaluated.

- Scenarios to identify a business opportunity
  - need for a new product.
  - available products are inadequate.
  - a challenge faced in the current business.
- Evaluating a business opportunity: A business opportunity should be evaluated by assessing:
  - the time it takes for the product to be ready for consumers
  - the value of the product
  - the risks involved
  - uniqueness of the product
  - whether the business venture matches the personal skills and goals of the entrepreneur
  - the profits or returns to be made.

Sources of a business opportunity

The source or need for a new product may be identified by:

- consumers
- technical people
- business associates
- businesspeople in the distribution system.

- **Phase 2: Develop a business plan**
  - A business plan provides answers to these types of questions:
    - Where will the business be located and how will the product or service be produced?
    - Who will buy the product or service and how much will it cost?
    - How will the product or service be marketed and advertised?
    - Who are the company's competitors?
    - What standard is the business going to set in terms of quality and how will the business maintain quality?
    - How will the product or service be delivered to the market?
    - How will records be kept of stock and other operations in the business?
    - What staff is needed and what skills and educational qualifications should they have?
    - How start-up capital is needed, and how will initial operating and production expenses be covered?
    - What resources will be needed?
- **Phase 3: Determine the required resources**
  - The type of business will determine the resources and equipment required.
- **Phase 4: Manage the enterprise**
  - After resources are acquired, including premises, the business plan must be implemented and managed. This includes:
    - putting the operational plan into effect and monitoring it.
    - implementing a suitable management style
    - implementing suitable control measures to ensure that every activity is monitored and corrective measures are implemented if needed
    - making critical decisions to overcome risks and develop a growth strategy.

Unit 2

Agri-business plan

1 The business plan

A business plan is a document that describes how a business will operate. It also states the business goals, the reasons they can be achieved and the plan for how to achieve them.

In an agri-business, a business plan is a detailed short-term and long-term goal plan, which includes activities and outcomes within a certain time frame to produce a viable income within a specific agricultural environment.

Reasons for drawing up an agri-business plan

- **To document your novel idea**
  - Every business starts with a novel idea.
    - The business plan sets out the vision and the mission of the entrepreneur in writing, and includes the operational plan of the business.
- **To calculate costs**
  - A start-up farming business needs a lot of capital and capital goods to operate.
    - The business plan works out complete cost calculations and anticipated income.
    - This then becomes the financial plan of the business, which can also be used to raise capital through, for example, bank loans.
- **To advertise the farming business**
  - The business plan contains information on the product and the channels of marketing that may be useful for the product.
    - This can help to create market linkages even before production starts.
- **To attract partner(s) to your farming business**
  - Capital and resources are required. So is expertise and linkages (networks) with markets and suppliers.
    - A good business plan can attract partners who can help provide finance, resources, expertise and back-up, and share the expenses and resources which will reduce the risk.
- **To assess and improve the plan**
  - Potential funders may identify loopholes and mistakes when they read the business plan.
    - This will enable the entrepreneur to correct these mistakes.
  - When the business plan is implemented, some aspects may not be practical.
    - So the entrepreneur can then go back to the business plan and make the necessary changes.

2 Standard format and layout of an agri-business plan

A standard format should be followed, which provides a general overview of the business, a marketing plan, staff (human resources) details, and financial details.

- **General overview of the business (executive summary)**
  - It should outline the business proposal and provide a written overview of the aims of the business. It should contain the:
    - type of business and form of ownership, including how it will be registered
    - location of the business
    - mission statement
    - operational plan of the business, and how the business will grow and develop
    - expertise required to run the business
    - an analysis of the business strengths, weaknesses, opportunities and threats.
- **Market information**
  - The main target market for the product
    - Consider the needs of the main target market. Describe how your product or service will meet their needs. How will you tell them about your products (your marketing plan)? How will you promote the products (your advertising plan)? What market research have you done and what were the results?
  - Products to be produced
    - Define your products or services and their position in the market. You need to show that you know about industry trends and your market. Show how your product matches or fits with the market definition. What is the estimated price of the product? Show your product development schedule.
  - Distribution
    - Indicate the sales channels for the distribution of the product. Any partnership with the distributors should be indicated. Show how the agricultural product will reach the customers.
  - Competition
    - The nature and the number of competitors should be mentioned. Differentiate between your product and that of the competitors and how your product will have a competitive advantage.
- **Management and staff details**
  - Management team
    - background and experience of management
    - composition of the Board of Directors
  - Labour force
    - number of workers employed
    - salaries and wages of workers
    - qualifications and skills required
    - the specialists in the farming business (but the workers can also be trained)
    - operational or work plans with regard to labour (a list of activities with the time frames for each).

- **Financial details**

The following financial details should be included in the business plan:

- valuation of present farming business
- current balance sheet
- amount of capital required to start the business
  - how the available capital will be used
  - projected profit and loss per year
  - projected cash flow – demonstrate how you will reach cash-flow positive status and outline your projected revenue growth
  - loan repayments per month
  - equipment and materials, who will do stock control and how it will be kept
  - how investors will obtain high returns
  - how the product or service will be priced.

Standard layout of an agri-business plan

The following standard layout will ensure that the business plan is presentable.

Guidelines for the layout of an agri-business plan

- Keep the plan concise about 12–20 pages).
- The plan should be realistic. Do not be over-optimistic or over-estimate aspects such as the product or service, the target market and the profits.
- Show how the business will become profitable.
- Present a strong management team.

- **Cover sheet**
  - This contains your name, the name of the company and contact details.
- **Executive summary**
  - This should be highlighted for any business person or potential funder to see clearly. It should be clearly written in a font size of 10 points or bigger. The summary should be one or two pages and it should contain objectives, mission and keys to success.
- **Contents page**
  - This is needed with page and section numbers to enable easy reference through the document.
- **Company description**
  - This should include the type of ownership, the history for existing companies or a start-up plan for new companies, and company locations and facilities.
- **Product or service to be rendered**
  - This must be stated and described. You must also compare your product with competitive goods and describe possible outsourcing, technology to be used or needed, and future products and services.
- **Market analysis**
  - This should include market segmentation, target market, segment strategy, market needs, market trends, market growth, industry analysis and patterns, distribution patterns, competition and buying patterns.

- **Business strategy and implementation**
  - It should include management responsibilities and schedules with dates and budgets.
  - It should also include business strategy, marketing strategy, pricing strategy, promotion strategy, distribution patterns, marketing programmes, sales strategy, sales forecast, sales programmes, strategic alliances and milestones.
- **Web plan summary**
  - It should describe the website, development costs, operations, sales and marketing strategies.
- **Management team**
  - It must include the key members and a description of the organisation. Also include the organisational structure, management team and the personnel plan.
- **Financial analyses in the form of tables and charts**
  - It must include projected profit and loss and cash flow tables, projected profit and loss and cash flow statements, projected balance sheet, personnel listings, market analysis tables and long-term plans.

Problems encountered when drawing up an agri-business plan

Entrepreneurs may face common problems when they develop a business plan:

- They may not know what to write.
- They may not know how to structure the content.
- It might take a long time to write.
- It might contain too much detail.
- They might over-estimate and be overly optimistic in terms of figures.
- It might be difficult to translate a novel thought into a business plan.

3 Solutions when drawing up and implementing an agri-business plan

- Use electronic resources to draw up an agri-business plan
  - You can download a template for a business plan from the Internet.
    - These are usually easy to use and the entrepreneur just needs to fill in the blank spaces.
    - The templates contain the key information needed in a business plan.
    - This is convenient and it saves the entrepreneur time.
- Use a SWOT analysis. SWOT is an acronym for strengths, weaknesses, opportunities and threats. It is also called a situational analysis. It gives a farming entrepreneur full insight into what lies ahead in a farming business venture. It involves assessing and describing the strengths and weaknesses of the farm business, as well as opportunities and threats to the farming business.
  - Assessing and describing farm business strengths

A SWOT analysis is also called a situational analysis.

- Strengths of a business are things that can contribute to its success. These are internal factors which the entrepreneur can control. Strengths are all available resources, things and processes that the farming business has done and can do, and what you can offer that your competitors cannot offer. Examples of strengths in a farming business include reputation, skills and experience of the labour force, capital, machinery, equipment, credit, established marketing channels and modern technology.

- Assessing and describing farm business weaknesses
  - The weaknesses of the farming business include factors within the business environment that prevent you from being successful, but which you can improve. The ability to change weaknesses into strengths has been the key in most business success stories. Weaknesses can include a lack of technology, poor location of the farming business, limited resources, lack of skills and undercapitalisation.
- Assessing and describing farm business opportunities
  - Opportunities are the external motivating factors that are needed for a farming business to prosper. In order to assess opportunities, you must look at the potential of the farming business to perform in the market or environment. Examples of opportunities are market growth, new trends, lifestyle changes and the provision of supplies needed for various traditions. It is crucial to put a time-frame on the opportunity identified. These opportunities can then be classified as strengths.
- Assessing and describing threats to the farming business
  - Threats are the external factors that can put your farming business at risk. These might include price increases by suppliers, competition, a shift in consumer behaviour, economic down turns and the introduction of more advanced technology that makes your agricultural products obsolete. Contingency plans will be required to address these threats.

- Answer the questions below. Check your answers afterwards and do corrections.

Topic 8

Topic questions

- Give yourself one hour.
- Marks: 100

1 Various options are provided as answers to the following questions. Choose the best answer and write only the number (i–iv) next to the question number (1.1–1.5).

1.1 A business plan is set up to provide all planning information needed for a specific farming operation. Which ONE of the following aspects is NOT normally part of a business plan?

i a farm budget
ii marketing plan
iii soil surveyance detail
iv details of employees.

1.2 In an agricultural business, a _____ is an entrepreneur.

i production factor
ii capital
iii labourer
iv farmer

1.3 The characteristic of an entrepreneur that has a bearing on strategic management is:

i team builder
ii technically knowledgeable
iii visionary
iv independent thinker.

1.4 The _____ indicates a condition where the quantity of a product required by consumers, is exactly equal to the quantity which producers wish to sell.

i market niche
ii market penetration
iii market equilibrium
iv market value

1.5 ONE of the following factors would influence the supply as well as the demand for a product:

i The possibility of increasing the supply of products
ii The range of products available
iii The price of the products
iv The attitude and values of consumers

(5 × 2 = 10)

Topic 8

Topic questions

2 Match the items in column A with those in column B. Write only the correct numbers and letters. (5 × 2 = 10)

Column A	Column B
2.1 start-up capital	A novel idea
2.2 entrepreneur	B Board of Directors
2.3 business plan	C current balance sheet
2.4 management team	D how the business operates
2.5 financial details of a business plan	E takes a long time
	F fundraising
	G market analysis data

3 Give ONE word/term/phrase for each of the following descriptions. Write only the word/term/phrase next to the question number. (2 × 2 = 4)

3.1 A source of capital resulting from farming profits that have been allowed to accumulate in a bank

3.2 The management function that encourages farm workers to do their best at all times

4 Define the following:

4.1 entrepreneur

4.2 entrepreneurship

4.3 start-up costs (3 × 2 = 6)

5 The following statements are incorrect. Change the underlined words to make them correct.

5.1 Threats are the external motivating factors that are needed for a farming business to prosper.

5.2 The target entrepreneurs are the end users of the products. (2 × 2 = 4)

6 List five personal characteristics of a successful entrepreneur. (5 × 1 =5)

7 The entrepreneurial process involves the starting of a new business venture.

7.1 Summarise the four phases of the entrepreneurial process using a mind map. (4 × 2 = 8)

7.2 Describe the first phase of the entrepreneurial process. (1 × 5 = 5)

Topic 8

Topic questions

8 A business plan is a plan that an entrepreneur develops to create an action plan for his or her business.

8.1 State THREE reasons why an entrepreneur should develop a business plan. (3 × 2 = 6)

8.2 List the FOUR main components of a good business plan, and briefly describe each one. (4 × 3 = 12)

9 Read and analyse the case study about Nomakhosi and answer the following questions.

> Nomakhosi owns three hectares of arable land with access to irrigation and has previously grown vegetables. She has heard that there is a strong demand for baby vegetables and for organic beef in Europe. The South African government supports Black Economic Empowerment initiatives and provides favourable loan arrangements.
>
> Nomakhosi does not have experience in the production of baby vegetables or the export of produce. She has access to technical expertise from her local extension officer. She also has to consider the fact that vegetable production is intensive and minimum wages are fairly high. Exchange rates are also very unstable.

9.1 Name the four different aspects of SWOT analysis and give two examples of each. (4 × 3 = 12)

9.2 List TWO weaknesses that Nomakhosi has. (2 × 1 = 2)

9.3 Select an opportunity and a challenge that Nomakhosi can exploit if she decides to pursue/take up this challenge. (1 × 2 = 2)

9.4 Determine TWO managerial strategies that she could implement to take advantage of this opportunity. (2 × 1 = 2)

9.5 Advise Nomakhosi with regard to where she can obtain financial assistance. (1 × 1 = 1)

Topic questions

9.6 There are TWO important types of budgets that she must draw up as a farm manager. Name these budgets AND state how they differ from each other. (2 × 2 = 4)

9.7 Indicate TWO types of records that must be kept by Nomakhosi as a farm manager. (2 × 1 = 2)

10 Qinisani Mzimela has thought about starting a farming business to produce maize. He has spent many hours trying to write a business plan.

10.1 Suggest TWO reasons why Qinisani may not being able to write a business plan. (2 × 1= 2)

10.2 What advice can you give to Qinisani to solve his problem? (1 × 1 = 1)

10.3 Motivate the advice that you provided in (10.2). (2 × 1 = 2)

Answers to Topic questions

Answers to Topic 1

1 Chewing, enzymatic action and microbial digestion. (3)

2 Saliva has these functions: softening, lubricating and digestion with amylase. (3)

3 Bovine stomach compartments:

3.1 Rumen; reticulum; omasum; abomasum. (4)

3.2 Rumen: mixing and absorption; reticulum: regurgitation; omasum: removing water; abomasum: enzyme digestion. (8)

4 Ruminant regurgitation:

4.1 Feed is chewed, swallowed and then comes up into the mouth from the rumen; after being thoroughly chewed it passes into the reticulum and then the omasum. (4)

4.2 Allows ruminants to eat large quantities of roughage at once, then chew it for digestion later. (3)

5 Fat, carbohydtaes and proteins. (3)

6 Word or phrase:

6.1 Silage/green feeds

6.2 Mineral licks/Lick (2)

7 Fat, protein, carbs, minerals and vitamins. (5)

8 Ventriculus.

9 Trace elements:

9.1 Iron and copper. (2)

9.2 Anaemia. (1)

10 Nutrient deficiencies:

10.1 Zinc

10.2 Vitamin B2;

10.3 Vitamin A

10.4 Calcium

10.5 Selenium (5)

Answers to Topic questions

11 Strength, oxygen, transport, muscle, enzymes. (5)

12 Energy for metabolic processes and to grow and reproduce:

12.1 Chemical (1)

12.2 Mechanical and heat energy. (2)

13 Goat

14 Mechanical breaking, heating, additives, pelleting (4)

15 High weight to volume ratio, high nutrient levels, low fibre percentage. (3)

16 maize meal, sorghum meal, animal meals, milk powder, soy bean meal, oil seed cake (any four) (4)

17 Supplement protein in the ruminant diet:

17.1 Because rumen microbes can use them to synthesise amino acids. (2)

17.2 Ruminants can use NPN because rumen microbes can use them to synthesise amino acids which can be used by the animal. (3)

18 It is a method to calculate the amounts of two different feeds which can be mixed to give a chosen percentage of nutrients. (1)

19 Maintenance rations keep the animal body in the same state while production rations are higher in nutrients supplying enough to produce product or offspring. (4)

20 Table:

20.1 Blood meal, fish meal, soy and ground nut meal. (4)

20.2 Fish and blood meal. (2)

20.3 Soy and ground nut. (2)

20.4 Veld grass. (1)

20.5 No; they can't utilise the fibre for energy. (3)

20.6 Sorghum, maize, milk powder, soy meal. (5)

20.7 They are all concentrates. (3)

20.8 Sorghum and maize (starch), milk and soy (protein). (4)

Answers to Topic questions

Answers to Topic 2

1 Nutrition, breeding, environment, general management. (4)

2 More natural – space, sunlight, prevent boredom, exercise. (4)

3 Poor ventilation, wet bedding, crowding, build-up of micro-organisms. (4)

4 Trees, shade cloth, open housing (any other suitable point). (3)

5 Fatal hypothermia, energy use, disease (any two). (4)

6 Pigs and chickens (2)

7 Open house to provide shade, mud wallow or hosepipe/ sprinkler systems. (3)

8 Insulation, N/S orientation of long side, good air flow design. (3)

9 Feed is biggest expense of all input costs therefore one must prevent waste and fouling. (4)

10 Free range pig production systems provide a shelter and open pens. Sometimes they also provide pigs with a mud wallow or a sprinkler system to keep them cool. The shelter is in the form of permanent open-sided houses or mobile houses like corrugated barrels. The pigs use the pens to move around in, rootle in soil and to defecate. The pens can be rotated around the house or the house can be moved to keep the pen area hygienic. Crops can be planted where the pigs have fertilised the soil. Pigs can forage for some of their food but they can also be provided with feed. The amount of feed given will depend on the level of production. (8)

11 Egg production drops in response to the decreased daylight hours in autumn/winter so providing extra light hours during this season keeps constant production. (5)

12 Camps, holding pens, crush, foot bath, parlour with roof, washable sloping non-slip floors, milk stalls, milk room, calf houses. (10)

13 Briefly explain the following types of animal behaviour:

13.1 Dominance is when a particular animal heads the hierarchy in the group; submissive behaviour: individual animal tried to appease an dominant one through behaviour such as infantile behaviour or exposing its most vulnerable spot, such as the throat, to the dominant animal

Answers to Topic questions

13.2 Carried out to attract a partner/indicates being on heat

13.3 Most directly related to social organisation of chickens, but is also applied to social organisation among other groups as well; dominant animals 'peck' those that are less dominant, all the way from the most to the least dominant

13.4 Refers to animals cleaning/looking after themselves or one another. (8)

14 Air and light should NOT be allowed to enter the part of the truck where animals are kept. (2)

15 Pawing ground, snorting, bellowing, charging. (4)

16 Stay calm, quiet, and slow. (3)

17 Cattle-leading; restraining; hobbling at milking; lifting hooves; pigs-snout snare (any four) (8)

18 Halters, nose tongs, head clamps. (6)

19 ONE word/term/phrase for each of the following descriptions.

19.1 Holding pen/crush. (2)

19.2 Feedlot. (2)

20 Clean, non-slip surface, separate crates for different ages, good ventilation and light. (5)

21 Overcrowding, causing hygiene problems such as a build-up of ammonia from the faeces of large numbers of birds; poorly ventilated, causing respiratory problems; insufficient feeders and watering points for the number of birds in the house; high concentration of birds; failure to develop and implement an intensive vaccination and medication programme. (6)

Answers to Topic questions

Answers to Topic 3

1 Name the reproductive organ in which the following processes take place:

1.1 ovary

1.2 fallopian tubes

1.3 testes

1.4 uterus

1.5 mammary gland

1.6 uterus/vagina. (6)

2 Hormone functions:

2.1 Prepare the uterus for the reception of the fertilised ovum; Supporting the attachment of the embryo; Maintain pregnancy (any one)

2.2 Characteristics of oestrus; Increased blood supply to uterus to prepare it for the reception of the fertilised ovum (any one) (2)

3 Sterility is permanent infertility ; infertility is a temporary inability to reproduce which can be reversed. (2)

4 Prevent chilling during collection and handling, keep the sample as clean as possible, ensure the specimen is of good quality, use a suitable diluent which will protect the spermatozoa during storage, store at the correct temperature. (5)

5 Oestrus detection in a cow.

5.1 To enable cow to be mated as close to ovulation as possible. (1)

5.2 Cow off her food, shows as "bullstring" from vagina, mounts or is mounted by other cows, head butting, shows interest in bull (any two) (4)

5.3 When cow stands to be mated by bull (2)

5.4 Beef cattle as soon as heat is detected; dairy cattle 12 hours after heat detection (2)

5.5 No, it is a 21 day cycle. (1)

Answers to Topic questions

6 Takes place in the cows fallopian tube. If the cow has been mated or inseminated at the correct time the sperm cells will be waiting in the FT s for the release of the ovum from the ovary. The cilia or hairs of the fallopian tubes help the ovum down the tubules where the sperm are then able to attach to the egg. One sperm cell finally penetrates the ovum after other sperm have achieved the process of capacitation. (5)

7 No, monozygous twins arise from division of the same fertilised egg and are therefore same sex. A freemartin is the result of twins being different sexes. (3)

8 Resoprtion occurs early in pregnancy before the foetus develops the skeleton so the tissues are reabsorbed. If the foetus dies off once the skeleton has developed it has to be aborted out through the vagina. (5)

9 Involuntary contraction of the uterus which pushes the foetus against the opening cervix, rupturing allantois and releases allantoic fluid ; cow now strains with abdominal muscles pushing foetus into vagina, rupturing amnion. Cow pushes until calf is expelled ; umbilicus detaches and afterbirth is expelled a few hours later. (10)

10 Dystocia in cows:

10.1 Retained head or limbs. (3)

10.2 Head or limb must be straightened out by vet/farmer. (1)

11 Milk production is under hormonal control.

11.1 Somatotrophin (1)

11.2 Infections (mastitis), fever, poor nutrition, and heat stress. (5)

11.3 Oestrus (1)

12 Lack of libido in bulls:

12.1 Immaturity, inexperience, nutrition, old age, disease/pain, overwork, breed, temperament/stress. (8)

13 Infections such as venereal diseases can prevent fertilisation, implantation or may cause resorption or abortion of the developing foetus. Infection of the genital tract will prevent successful conception. (6)

Answers to Topic questions

14 Cloning:

14.1 No. (1)

14.2 cloning of animals is at present not very successful, so using it to improve a herd or increase the number of animals with a desired characteristic such as disease resistance, is not practical. AI or ET are at present more effective means of herd improvemenr. (4)

15 Optimum nutrition is essential for fertility of the both the cow and bull, is essential for sustaining a successful pregnancy and for good milk production and return to oestrus after calving. (6)

16 Foetal presentations can cause dystocia:

16.1 Breech presentation

16.2 Anterior presentation with head retained

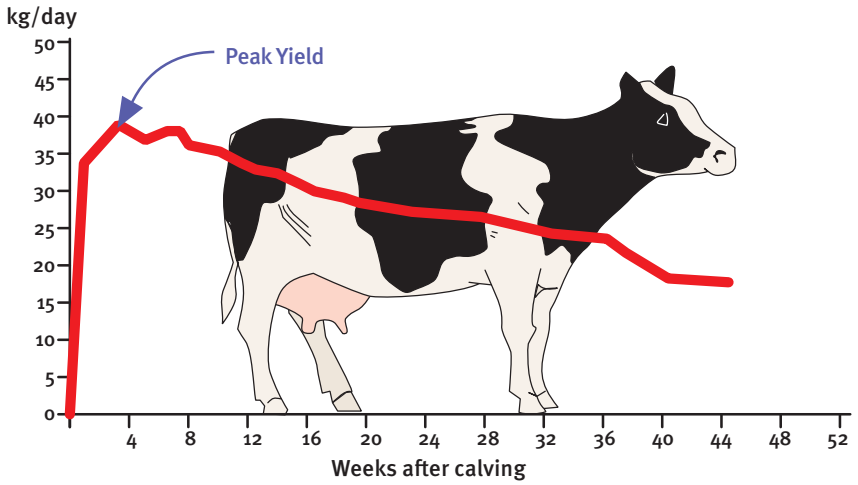
16.3 Posterior presentation with limb retained (3)

17 Twins, extra limbs, hydrocephalus (swollen head). (3)

18 Enlarged abdomen, lactation, vaginal discharge, relaxation of pelvic ligaments, behavioural changes. (4)

19 The release of milk from the udder which allows the calf to drink or the cow to be milked. (1)

20 Lactation curve (give one mark for each of: X-axis; Y-axis; increments on each axis; graph line; indication of peak yield). (5)



Answers to Topic questions

Answers to Topic 4

1 test for signs of roundworm (2)

2 Angora goats can suffer from anaemia: (4)

2.1 Liver fluke, blue lice, heavy tick infestation.

2.2 For wireworm and flukes do examination for eggs in faeces, blue lice and ticks can be detected by examining the skin/hair (4)

3 Infectious disease that causes deaths in newborn animals:

3.1 Rift valley fever. (1)

3.2 Mothers must be vaccinated. (1)

4 To prevent a loss of income because of drop in production in intensive farming and exports of agricultural products to FMD free countries prevented. (5)

5 Animal health iand livestock production:

5.1 A damage to fleece; B external parasite; C internal parasiter. (3)

5.2 Pesticides and herbicides; Organophosphates; copper sulphate overdose. (2)

5.3 Bloating, nervous symptoms; dminister vinegar into the rumen or by mouth to treat alkalosis. This treatment will restore the pH to normal levels. (3)

6 Rabies, brucella, anthrax, RVF. (4)

7 Depressed, lack of appetite, reluctant to move, loss of fear of humans. (4)

8 BTB, anaplasmosis. (2)

9 Control viral diseases:

9.1 No (1)

9.2 Vaccination (1)

10 Fever, nervous symptoms such as loss of balance, difficult breathing and fluid from nose, lying down and paddling (any five) (5)

Answers to Topic questions

11 Internal parasites:

11.1 Tapeworms and flukes (2 × 1 = 2)

11.2 Milk tapeworm; liver fluke. (2)

11.3 Soil mite; water snail. (2)

12 Ticks have various effects on animals.

12.1 Anemia, appetite suppression, paralysis, transmission of diseases, damage to skin and organs from abscesses resulting from bites. (4 × 2 = 8)

12.2 Heartwater, redwater, anaplasma. (3 × 1 = 3)

12.3 They continue to 'vaccinate' the animal with the tick borne organism. (2)

13 African swine, fever, hog cholera, FMD, anthrax. (4)

14 Cattle, sheep, goats, pigs (any three) (3)

15 Poisonous plants:

15.1 Lantana camara (1)

15.2 Gifblaar and tulp. (2)

15.3 Stenocarpella, the maize fungus (1)

15.4 Don't allow the herd to graze in a field that has them. (1)

15.5 Organophosphate dips. (1)

16 Because of the damage it causes to fleece. (2)

17 Sheep scab, lice infestation, lumpy wool and blowfly strike. (4)

18 An external parasite lays live larvae on its host.

18.1 Oestrus ovis; nasal worm. (2)

18.2 Nasal discharge. (1)

19 Feed urea gradually to allow rumen flora to adjust and do not interrupt feeding; do not exceed 1% intake; don't allow urea blocks to dissolve in water. (4)

Answers to Topic questions

20 Explain the differences between the terms:

20.1 Infection refers to disease caused by microorganisms; infestation refers to parasites on animals

20.2 Macroscopic and microscopic macroscopic means visible to eye; microscopic objects can only be seen under the microscope (2 × 2 = 4)

21 Define the terms:

21.1 Testing blood for antibody.

21.2 Analysing tissue with microscope.

21.3 Examination of dead animal. (3 × 2 = 6)

22 Regulating the sale of medication for farm animals:

22.1 Stock remedies Act 36 of 1947. (1)

22.2 Ensures efficacy and safety of products sold to animal owners. (2)

Answers to Topic questions

Answers to Topic 5

1 Study the diagram.

1.1 C Punnet square

A dihybrid cross (1)

1.2 B dominant allele (1)

1.3 C genotype Bb (1)

1.4 C 75% ; 25% (2)

2 Fill in the missing words.

2.1 mitosis; chromatids. (2)

2.2 separates; meiosis; haploidl. (3 × 1 = 3)

3 Cow parsley produces a purple-leafed variant called Ravenswing:

3.1 RR × rr = all 4 are Rr. (2)

3.2 All purple and green spotted (2)

3.3 RR (purple), 2 Rr (spotted), rr (green). (3)

4 Tortoise shell cats Punnet square: (6)

Females	Red	Black	Tortoiseshell
Red male **O**	**O O**	O o	**O O** O o
Black male **O**	O o	**o o**	O o **o o**

5 Sex is a qualitative characteristic in humans and most animals:

5.1 Female

5.2 Tortoise shell colouring in cats.

5.3 50:50 (3 × 1 = 3)

6 Quantitative genetic characteristics:

6.1 Milk production/ tallness, etc. (any acceptable answer. (1)

6.2 cumulative (1)

6.3 Milk or other production attributes. (2)

Answers to Topic questions

7 Non-genetic factors such as nutrition, climate and disease can cause variation in genetically similar animals. (2)

8 replication (1)

9 Spontaneous mutations arise in the DNA of all living organisms.

9.1 Point mutations such as apurination, due to base substitution; sequence mutation such as indels; chromosome translocations, substitutions or replicationss. (4)

9.2 Mutations cause a change in the protein for which the gene encodes; this change in the protein causes either the loss of a function or gain of function. The effect will depend on the importance of the function affected. (5)

9.3 Harmful, beneficial or neutral. (3)

10 Mutations in somatic cells (e.g. cancer) are not inherited while those occurring in the gametes are inherited. (2)

11 Sexual reproduction brings about recombination of new alleles which gives rise to offspring that vary from their parents; asexual reproduction as in cloning produces the exact replica of the parent, with no genetic variation. (4)

12 X-rays, UV radiation, alkylating agents, intercalating agents, and base analogues. (5)

13 Natural selection. (2)

14 succulent leaves, waxy leaves, thorny leaves and long roots to search for water. (5)

15 Artificial selection:

15.1 Must be heritable, measurable and economically important. (3)

15.2 Can select unwanted characteristics such as disease susceptibility. (2)

15.3 Hybridisation is the crossing of two purebred individuals to produce a new variant; in agronomy it is used to produce vigorous F1 offspring (hybrid vigour). (5)

15.4 Harmful genes are selected, gradual decline in vigour. (2)

15.5 Different chromosome numbers make fertilisation impossible. (1)

15.6 Polyploidy or chromosome replication occurs often in plants and can make the chromosome number compatible (1)

Answers to Topic questions

16 Transgenics provides genes which are not otherwise available to the species. (2)

17 Increased production, disease resistance, drought resistance, herbicide resistance. (4)

18 GMOs are used widely in agriculture.

18.1 Escape of genes which are used to produce toxic substances (for example pharmacological substances) (3)

18.2 Laboratory analysis for a genetic marker or detecting the inserted gene. (1)

18.3 Agrobacterium (1)

18.4 It inserts itself into the DNA of the host plant so carries the new genes into the genome of the plant. (4)

19 Breeding systems used in agriculture:

19.1 Mule, or any other acceptable answer.

19.2 Bonsmara, or any other acceptable answer.

19.3 Friesland, or any other acceptable answer.

19.4 Pedigree breeding ($4 \times 1 = 4$)

20 Progeny testing (1)

21 Breeding value (1)

22 It is used to evaluate the measurable traits which are being selected (improvement or not). (1)

Answers to Topic questions

Answers to Topic 6

1 Choose the correct answer:

1.1 land, labour, capital and entrepreneur (b)

1.2 Product capital (c)

1.3 durability (a)

1.4 Labour Relations Act (d)

1.5 movable capital (c) (5 × 2 = 10)

2 Table:

2.1 A

2.2 C

2.3 C

2.4 A

2.5 C (5 × 2 = 10)

3 Capital is wealth accumulated through savings and employed in the production process (B). (1 × 2 = 2)

4 Differentiate between:

4.1 Assets: Items of financial value owned by the farmer; Listed in an asset registry; Should always be worth more than liabilities as they improve the net worth of a farming business; Appears in the balance sheet / Liabilities: Items (money, loans, etc.) that the farmer/business still owes other people; Should be less than assets; Appears in the balance sheet

4.2 Fixed capital: Involves fixed assets (land, buildings); Long term credit is used to buy these capital goods / Movable capital: Working capital involves goods used in the production process (seeds, fertilisers, salaries and wages, and fuel); Short term credit can be used to buy these capital goods. (2 × 4 = 8)

Answers to Topic questions

5 Long-term credit: Takes a long time to repay, namely 10–35 years. It is used for big capital goods such as land, or for big projects such as the construction of buildings and dams. The source for long-term credit is the Land Bank. / Medium-term credit: Is used to buy movable capital. This usually takes about 2–10 years to repay. The sources of this finance are co-operative societies, NGOs and commercial banks. Umthombo is an NGO that provides loans to sugar cane producers. / Short-term credit: Is used as working capital to buy goods for the production process such as seeds, pesticides and fertilisers, salaries and wages, and fuel. Types of short-term credit include overdraft, credit cards and advance personal loans. The loans must be repaid within two years. Commercial banks are the source of this credit.. (3 × 3 = 9)

6 Substitute the underlined term in the following statements to make them correct.

6.1 Capital

6.2 pooling

6.3 Seasonal labourers

6.4 Planning

6.5 Strategic management (5 × 1 = 5)

7 Appropriate wages; and a well-negotiated contract are important; secure housing must be provided with clean water and nutritious food; energy in the form of wood and paraffin or electricity is essential; workers should belong to medical aid schemes to help keep them healthy and productive; they also need paid leave to revitalise themselves; schooling (including transport) should be provided for their children (any four). (4)

8 Particulars of the employer; particulars of the employee; employment details (job description and pay); general conditions (leave, pension, etc.). (4)

Answers to Topic questions

9 Acts:

9.1 Occupational Health and Safety Act (1)

9.2 Compensation for Occupational Injuries and Diseases Act. (1)

10 Compare the following aspects and give examples:

10.1 Whole farm budget: Incorporates budgets of all enterprises on the farm; Allows farmer to have overall control of the whole farm business; Spreads the risk / Enterprise budget: Concentrates on budget for each enterprise; Allows farmer to control the income and expenses of each enterprise; Risk is concentrated on one enterprise.

11 Planning for productivity:

11.1 It is a seasonal activity/it only occurs at a particular season/done in October. (3)

11.2 Provision of shelter for protection against extreme conditions; The farmer needs to find out whether climatic disasters is a common occurrence in the area (looking at historical data); Use a breed of sheep that is more adaptable to extreme climatic conditions prevalent in the area. (3)

11.3 Enrol labourers for skills development; Organise short-term courses for labourers; Allow labourers to specialise in certain tasks. (3)

11.4 Provide financial incentives/performance rewards; Provide adequate living conditions (adequate housing, food, recreation facilities, wages, pension, bonus, leave, medical aid); provide training possibilities; Show appreciation for work done (any three). (3)

12 Farmer Brown's budget:

12.1 Expenses: R40 000,00 / Income: R19 000,00. (4)

12.2 No profit: big loss of R21 000,00. (3)

12.3 No; his expenses are far greater than his income. (2)

Answers to Topic questions

13 Improve salaries; improve the living conditions; provide incentives and bonuses; well-negotiated contracts are important; secure housing must be provided with clean water and nutritious food; energy in the form of wood and paraffin or electricity is essential; workers should belong to medical aid schemes to help keep them healthy and productive; they also need paid leave to revitalise themselves; schooling (including transport) should be provided for their children (any four) (4)

14 Permanent or fixed labour refers to farm workers that are employed on the farm throughout the year. They usually live on the farm and have certain rights and privileges, such as housing and food rations. Most permanent labourers are skilled. / Part-time or temporary labour refers to farm workers that do not stay permanently on the farm and do not work throughout the year. There are two types of part-time labourers: seasonal labourers – they are employed during a particular season or at peak periods to perform a particular task such as harvesting, pruning or weeding. These are repetitive tasks AND casual labourers – they are employed to do a particular task such as fencing or building. The tasks they perform are non-repetitive tasks. (6)

15 Skilled labour ensures the maximum output; low wages chase skilled people out of the farming industry; the farm industry is competing with the industries for skilled labour; most labourers are poorly educated and they lack training; modern farming methods such as precision farming are sophisticated and require skilled labourers; therefore the agricultural sector needs life-long learning programmes to ensure that labourers' skills are up to date. (7)

Answers to Topic questions

Answers to Topic 7

1 Match each statement in column A with a statement in column B.

1.1 A

1.2 G

1.3 E

1.4 C

1.5 B

1.6 D

1.7 F (7 × 2 = 14)

2 Define the terms:

2.1 The sequence/processes the product goes through from harvesting to consumer

2.2 An alliance of agricultural enterprises working together at different stages in production, processing and marketing

2.3 Involves the sorting of produce according quality criteria. (3 × 2 = 6)

3 Seasonal fluctuation; perishability, as well as factors like (any one): standardisation; ineffective control over production; low value in relation to volume (bulkiness); long-term production; wide product distribution; locality restricted production; intermediaries (middlemen) are required for marketing (3 × 1 = 3)

4 Improvements to the agri-business chain:

4.1 Infrastructure will ensure that there is enough space and shelter for storage and processing. Additional roads will make it easier to transport agricultural goods from the production site to the markets. Suitable shelters for storage must be built will enable products to last longer. These aspects work together to make the agri-business chain more effective. (1 × 5 = 5)

4.2 participatory market chain approach; vertical co-ordination; adequate infrastructure; business linkages and value chains; vertical integration;

Answers to Topic questions

creation of market organisations to assist producers and processors;

government involvement; specialisation; diversification; hedging. (4 × 1 = 4)

5 Choose the best answer:

5.1 the price of the product (ii).

5.2 as he pleases (ii)

5.3 niche marketing (iii)

5.4 fresh produce markets (i)

5.5 They are all advantages. (5 × 2 = 10)

6 Match the items:

6.1 E

6.2 D

6.3 B

6.4 C

6.5 A (5 × 2 = 10)

7 One word or phrase for the following:

7.1 Supply

7.2 Price elasticity

7.3 Marketing chain

7.4 Consumer Protection Act

7.5 Green market. (5 × 1 = 5)

8 Correct the statements:

8.1 Consumer

8.2 Retailer

8.3 Agri-marketing chain

8.4 Grading

8.5 Marketing Act of 1996 (5 × 1 = 5)

Answers to Topic questions

9 Define the terms:

9.1 Supply is the quantity of goods on the market at a particular price at a particular time. It is affected by seasonal production; weather conditions; the profit margin of the product; specialised scientific knowledge; the ability to increase supply; expected future prices; the state of technology (any four) (2 + 4 × 2 = 10)

9.2 emand is the quantity of goods bought at a particular price at a particular moment. It is affected by the price of the product; usefulness of the produc; quality of the product; the price of competitive goods; number of consumers; preferences of consumers; the buying (purchasing) power of consumers; tradition and religions of conumers; size of households (any four) (2 + 4 × 2 = 10)

10 Read the passage below and the answer questions that follow.

10.1 Not a broad enough membership base; poor cash flow management. (2 × 1 = 2)

10.2 Democratic member control; Autonomy and

10.3 Independence; Distribution based on the value of a business; Economic participation/financing of co-operatives; Concern for the community; Co-operation among members. (3 × 2 = 6)

10.4 Democratic vote. (1 × 1 = 1)

10.5 Pool system. (1 × 2 = 2)

11 Compare the following:

11.1 Primary is the first level with members directly represented; two or more secondary make up a tertiary, which represents interests of members of primary and secondary to government. (2 × 1 = 2)

11.2 Co-operative marketing is organised according to the members through votes or their constitution, and it can involve marketing according to groups of

products; controlled marketing is restricted or regulated marketing that can set limits on supply and determine prices. (2 × 1 = 2)

12 Farmers may not have all the necessary skills; It is riskier because if natural disaster affects production, the farmer bears all the risk alone; Prices will fluctuate because of the force of supply; A small-scale farmer will have less bargaining power; Production and marketing costs are high; farmers that operate as a one person enterprise will struggle to keep up production and focus on marketing; Some farmers may form cartels to protect themselves from competition and consumers could be exploited; Marketing is now more commercialised and specialised so experts are needed to perform this role (any three) (3 × 1 = 3)

Answers to Topic questions

Answers to Topic 8

1 Choose the best answer:

1.1 soil surveyance detail (iii)

1.2 farmer (iv)

1.3 visionary (iii)

1.4 market equilibrium (iii)

1.5 The price of the products (iii) (5 × 2 = 10)

2 Match the items:

2.1 F

2.2 A

2.3 D

2.4 B

2.5 C (5 × 2 = 10)

3 Give ONE word/term/phrase:

3.1 Land

3.2 Productivity (2 × 2 = 4)

4 Define the following:

4.1 An entrepreneur is a person who takes a novel idea, sees an opportunity and converts it into a successful business.

4.2 Entrepreneurship is the capacity and practice of starting, running and growing a business.

4.3 These are the costs incurred to start and enterprise (e.g. to buy or rent land and equipment; to buy inputs; to pay overheads) (3 × 2 = 6)

5 Change the underlined words to make them correct:

5.1 Opportunties

5.2 market (2 × 2 = 4)

Answers to Topic questions

6 Creative and innovative; achievement-orientated; independent thinker; well educated in the field; experienced in the field (lengthy and quality work experience); technically knowledgeable; risk taker; good leader; good at working with people; committed; perseverant; team builder (any five) (5 × 1 =5)

7 The entrepreneurial process:

7.1 The following should go in the mind map: Phase 1: identifying and evaluating a business; Phase 2: Developing a business plan; Phase 3: Determining the required resources; Phase 4: Managing the entrepreneurial process.. (4 × 2 = 8)

7.2 Identification of a business idea; (ii) sources of a business opportunity; (iii) evaluation of a business opportunity. (1 × 5 = 5)

8 A business plan:

8.1 To document your novel idea; To fundraise; To advertise the farming business; To attract partners; To assess and improve it (any three) (3 × 2 = 6)

8.2 General overview of the business; Market information; Management and staff details; Financial details. (4 × 3 = 12)

9 Read and analyse the case study:

9.1 Strengths; Weaknesses; Opportunities; Threats. (Any valid examples: remember that strengths and weaknesses are internal to the business and opportunities and threats are external). (4 × 3 = 12)

9.2 Does not have experience in the production of baby vegetables or the export of products. (2 × 1 = 2)

9.3 South African government supports Black Economic Empowerment initiatives and provides favourable loan arrangements ; Access to technical expertise from her local extension officer. (any one) (1 × 2 = 2)

9.4 Develop a vision; Develop a mission statement; Develop a business strategy; Develop an enterprise strategy (any two) (2 × 1 = 2)

Answers to Topic questions

9.5 Land Bank; Development Bank of SA; she could approach any financial institution (any one) (1 × 1 = 1)

9.6 Enterprise budget; Whole-farm budget. Enterprise budget is a budget of one particular enterprise on a farm whereas the whole-farm budget combines all the farm enterprises to show the net returns on the farm business (2 × 2 = 4)

9.7 Crop records; labour records (2 × 1 = 2)

10 Qinisani Mzimela:

10.1 He does not know what to write; he does not know how to structure the content; it might take a long time to write; it might contain too much/too little detail; he might over-estimate and be overly optimistic in terms of figures; it might be difficult to translate a novel thought into a business plan; any sensible points (any two) (2 × 1= 2)

10.2 He should use an electronic template. (1 × 1 = 1)

10.3 It is easy to fill in; it is easily accessible; it guides you about what to write; many are free; the structure and format, including headings, are standardised to business norms; any other sensible points (any two) (2 × 1 = 2)