National 5: Multicellular Organisms

Sub-topics include:

3.1 Cells, Tissues and Organs
3.2 Stem Cells and Meristems
3.3 Control and Communication
3.4 Reproduction
3.5 Variation and Inheritance
3.6 Transport Systems in Plants
3.7 Animal Transport and Exchange Systems
3.8 Effects of Lifestyle Choices
UNIT 3   TOPIC 1

1. Cells, Tissues and Organs

1.1 Multicellular Organisms

Cells and Specialisation

- A Multicellular organism is an organism that consists of more than one cell. Cells are subunits of such organisms.
- Multicellular organisms have three major structural levels above the cell. Similar cells are grouped into tissues. Specific arrangements of different tissues form organs. Cells within organs are specialised for their function and may be part of systems.
- Multicellular organisms contain many specialised cells each of which carries out a unique task. The organism that is recognised as an animal or plant is not a random collection of cells but a highly organised collaboration of cells.
- Multicellular organisms exhibit growth. Growth is normally associated with an increase in body size. Growth is defined as an irreversible increase in the dry mass of an organism normally accompanied by an increase in cell number.
<table>
<thead>
<tr>
<th>Cell</th>
<th>Function</th>
<th>Adaption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf cell</td>
<td>Absorbs light energy for photosynthesis</td>
<td>Packed with chloroplasts. Regular shaped, closely packed cells form a continuous layer for efficient absorption of sunlight.</td>
</tr>
<tr>
<td>Root hair cell</td>
<td>Absorbs water and mineral ions from the soil</td>
<td>Long 'finger-like' process with very thin wall, which gives a large surface area. To absorb water</td>
</tr>
<tr>
<td>Sperm cell</td>
<td>Fertilizes an egg cell - female gamete</td>
<td>The head contains genetic information and an enzyme to help penetrate the egg cell membrane. The tail moves the sperm,</td>
</tr>
<tr>
<td>Red blood cells</td>
<td>Contain haemoglobin to carry oxygen to the cells.</td>
<td>Thin outer membrane to let oxygen diffuse through easily. Shape increases the surface area to allow more oxygen to be absorbed efficiently. No nucleus, so the whole cell is full of haemoglobin.</td>
</tr>
</tbody>
</table>
1.2 Organs

An organ is a specialised part composed of several different types of tissue.

An example of a plant organ is a leaf. The diagram below shows how complex the leaf is. Note that the diagram points to various parts of the leaf each of which has a different function.

The leaf is organised to maximise its ability to photosynthesise. This involves transport of the raw materials required for photosynthesis, the removal of product (glucose) and the removal of waste.

In an animals organs there is a similar high level of organisation the heart is an example of this. The diagram below is of a human heart. The function of the Heart is to pump blood round the body. The Heart is mainly composed of muscle and connective tissue but it also contains nervous and fat tissue.
The organs of multicellular organisms are highly specialised structures where form and function are closely linked.

1.3 Differentiation

As all cells in a multicellular organism have arisen from the original zygote by repeated cell division (mitosis), every cell possesses all the genes for constructing a whole organism.

The cells of multcellular organisms continually turn certain genes on and off in response to signals they receive from the environment (internal and external). Highly specialised cells express only a small number of their total number of genes. For example, muscle cells only express about 3% of their genes at any one time. This expression of particular genes in controlled sequences leads to differentiation which gives rise to specialised cells and therefore tissues, organs and systems.

There are 2 types of genes involved in all cells. The first are switched on in every cell and code for vital substances necessary for basic biological processes e.g. enzymes, these are General Genes. The second, the Specific Genes are switched on in only certain cells and code for proteins made only by that type of cell e.g. pancreatic cells that produce Insulin or Glucagon.
Unit 3: Topic 2

Stem Cells and Meristems

2.1 Stem Cells

All the 200 or more types of cell in the Human Body originate from Stem Cells. Stem Cells are unspecialised/undifferentiated cells with the ability to renew “indefinitely” and produce new cells in the body.

What are Stem Cells?

Stem cells are undifferentiated cells that are able to change into specialised cell types. Commonly, stem cells come from two main sources:

1. Embryos (embryonic stem cells)
2. Adult tissue (adult stem cells).

Both types are generally characterised by their potential to differentiate into different cell types (such as skin, muscle, bone, etc.).

Adult stem cells

Adult or somatic stem cells exist throughout the body after embryonic development and are found inside different types of tissue. These stem cells have been found in tissues such as the brain, bone marrow, blood, blood vessels, skeletal muscles, skin, and the liver. They remain in a non-dividing state for years until activated by disease or tissue injury.

Adult stem cells can divide or self-renew indefinitely, enabling them to produce a range of cell types from the originating organ or even regenerate the entire original organ. It is generally thought that adult stem cells are limited in their ability to differentiate based on the tissue they come from.

Embryonic stem cells

Embryonic stem cells come from a four- or five-day-old human embryo. The embryos are usually extras that have been created in IVF (in vitro fertilisation) clinics where several eggs are fertilised in a test tube, but only one is implanted into a woman.
Stem cell cultures

Stem cells are either extracted from adult tissue or from a dividing zygote in a culture dish. Once extracted, scientists place the cells in a controlled culture that stops them from further specialising or differentiating but usually allows them to divide and replicate.

Stem cell lines

Once stem cells have been allowed to divide and grow in a controlled culture, the collection of healthy, dividing, and undifferentiated cells is called a stem cell line. These stem cell lines are subsequently managed and shared among researchers. Once under control, the stem cells can be stimulated to specialize as directed by a researcher - a process known as directed differentiation. Embryonic stem cells are able to differentiate into more cell types than adult stem cells.

Potential

Stem cells are grouped by their ability to differentiate into other types of cells. Embryonic stem cells are the most potent since they must become every type of cell in the body.
Identification of stem cells

Although there is not complete agreement among scientists on how to identify stem cells, most tests are based on ensuring that stem cells are undifferentiated and capable of self-renewal. Tests are often conducted in the laboratory to check for these properties.

Research with stem cells

Scientists and researchers are interested in stem cells for several reasons. Although stem cells do not serve any one function, many have the capacity to serve any function after they are instructed to specialize. Every cell in the body, for example, is derived from first few stem cells formed in the early stages of embryonic development. Therefore, stem cells extracted from embryos can be made to become any desired cell type. This property makes stem cells powerful enough to regenerate damaged tissue under the right conditions.

Organ and tissue regeneration

Tissue regeneration is probably the most important possible application of stem cell research. Currently, organs must be donated and transplanted, but the demand for organs far exceeds supply. Stem cells could potentially be used to grow a particular type of tissue or organ if directed to differentiate in a certain way. Stem cells that lie just beneath the skin, for example, have been used to engineer new skin tissue that can be grafted on to burn victims.

Brain disease treatment

Additionally, replacement cells and tissues may be used to treat brain disease such as Parkinson’s and Alzheimer’s by renewing damaged tissue, bringing back the specialized brain cells that keep unneeded muscles from moving. Embryonic stem cells have recently been directed to differentiate into these types of cells, and so treatments are promising.

Cell deficiency therapy

Healthy heart cells developed in a laboratory may one day be transplanted into patients with heart disease, repopulating the heart with healthy tissue. Similarly, people with type I diabetes may receive pancreatic cells to replace the insulin-producing cells that have been lost or destroyed by the patient’s own immune system. The only current therapy (apart from insulin injections) is a pancreatic transplant, and it is unlikely to occur due to a small supply of organs available for transplant.
Blood disease treatments

Adult hematopoietic are stem cells found in blood and bone marrow have been used for years to treat diseases such as leukemia, sickle cell anemia, and other immunodeficiencies. These cells are capable of producing all blood cell types, such as red blood cells that carry oxygen and white blood cells that fight disease. Difficulties arise in the extraction of these cells through the use of invasive bone marrow transplants. However hematopoietic stem cells have also been found in the umbilical cord and placenta. This has led some scientists to call for an umbilical cord blood bank to make these powerful cells more easily obtainable and to decrease the chances of a body’s rejecting therapy.

Stem cell controversy

The debates surrounding stem cell research primarily are driven by methods concerning embryonic stem cell research. It was only in 1998 that researchers from the University of Wisconsin-Madison extracted the first human embryonic stem cells that were able to be kept alive in the laboratory. The main critique of this research is that it required the destruction of a human blastocyst. That is, a fertilized egg was not given the chance to develop into a fully-developed human.

When does life begin?

The core of this debate - similar to debates about abortion, for example - centre’s on the question, "When does life begin?" Many assert that life begins at conception, when the egg is fertilised. It is often argued that the embryo deserves the same status as any other full grown human. Therefore, destroying it is akin to murder. Others, in contrast, have identified different points in gestational development that mark the beginning of life - after the development of certain organs or after a certain time period.

Chimeras

People also take issue with the creation of chimeras. A chimera is an organism that has both human, and animal cells or tissues. Often in stem cell research, human cells are inserted into animals (like mice or rats) and allowed to develop. This creates the opportunity for researchers to see what happens when stem cells are implanted. Many people, however, object to the creation of an organism that is "part human".

Legal issues

The stem cell debate has risen to the highest level of courts in several countries. Production of embryonic stem cell lines is illegal in Austria, Denmark, France, Germany, and Ireland, but permitted in Finland, Greece, the Netherlands, Sweden, and the UK.
2.2 Meristems: Growth in Plants

Growth occurs all over a developing animal’s body. In plants, growth is restricted to regions called Meristems. A meristem is a group of undifferentiated plant cells which are capable of dividing repeatedly.

Plant growth is concentrated at:

(a) - The Root & Shoot Tips

**Apical Meristems**: These are areas of growth found in the root and shoot tip areas of plants and can be easily categorised into 4 distinct zones:

(i) **Region of Mitosis & Cell Division**

(ii) **Region of Cell Elongation & Vacuolation**

(iii) **Region of Differentiation**

(iv) **Permanent Tissue**
Unit 3: Topic 3

Control and Communication

3.1 Nervous Control

The Central Nervous System (C.N.S.)

The central nervous system is made up of the brain and spinal cord.

The nervous system consists of the brain, spinal cord and neurons (nerves).

Neurons connect the central system to all the parts of our body. Neurons ensure information flows to and from the CNS. This is essential because in multicellular organisms cells do not work independently and internal communication is required for survival of a multicellular organism.

The Structure and Function of the Brain

The brain is divided into different areas, each of which has a specific function. The three key areas shown below are the cerebrum, the cerebellum and the medulla.
Neurons

Neurons are nerve cells. They carry information as electrical impulses. There are three different types of neurons:

- **Sensory neurons** carry impulses from receptors in the sense organs to the spinal cord and brain (C.N.S).
- **Relay neurons** carry impulses from one part of the CNS to another.
- **Motor neurons** carry impulses from the CNS to effectors.

**Synapse**

Where two neurons meet, there is a tiny gap called a synapse. Electrical impulses cross this gap using chemicals. One neuron releases the chemical into the gap. The chemical diffuses across the gap and makes the next neuron transmit an electrical signal.
Responses

Receptors in our sense organs - skin, eyes, ears, tongue, nose - can detect changes in the environment. These changes are called stimuli.

An electrical impulse is then sent to the CNS via a sensory neuron. Information arrives at the CNS and is sorted. Some of this information may be stored but if the body needs to perform a physical activity the CNS sends a message to a muscle or gland (an effector) via a motor neuron. The motor neuron then makes the effector respond e.g. a muscle may contracts quickly or a gland may release a hormone at a slightly slower rate.
3.2 Neurons and reflex arc

A reflex action is a rapid, involuntary, protective response. Reflex reactions are not under conscious control and take place to keep the body from harm.

A potentially dangerous stimulus triggers nerve endings in a sense organ (eye, ear, tongue, skin or nose). An impulse is sent along a sensory neurone then along a relay neurone in the spinal cord. The impulse is then passed along a motor neurone to an effector (a muscle or gland) causing a response e.g. muscle contraction or hormone secretion.

1. If the hand touches something very hot the receptors in the skin detect the pain.
2. The pain acts as a stimulus for the reflex action.
3. An impulse travels from the receptor along the sensory neurone to the spinal cord.
4. A relay neurone connects the sensory neurone to the motor neurone - the reflex arc.
5. An impulse leaves the spinal cord in the motor neurone nerve and travels to the muscle.
6. The muscle responds by contracting and the hand is removed from danger.

Other examples of reflex actions include coughing, blinking, sneezing and pupil dilation.

A reflex action does not always involve the brain - the reactions happened so fast that there is often no time for the nerve impulse to reach the brain. The impulse often only goes to the spinal cord and the brain becomes aware of the action after it has happened.
3.3 Hormonal Control

Hormones are chemical messengers and are released from Endocrine glands. These hormones are carried around the body in the bloodstream.

The tissues that hormones act on are known as target organs. The target organs contain target tissues, which have specific receptor proteins for a specific hormone.

This means that hormones only have an effect on the tissues which contain the appropriate receptor proteins, whilst other tissues which lack the protein remain unaffected.

Hormones and their effects

<table>
<thead>
<tr>
<th>Endocrine Gland</th>
<th>Hormone</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pituitary</td>
<td>Growth Hormone</td>
<td>Stimulates growth during development</td>
</tr>
<tr>
<td>Ovary</td>
<td>Progesterone</td>
<td>Promotes thickening of uterine lining</td>
</tr>
<tr>
<td>Testis</td>
<td>Testosterone</td>
<td>Controls growth and development of male sex organs and secondary sexual characteristics</td>
</tr>
<tr>
<td>Islets of Langerhans in Pancreas</td>
<td>Insulin</td>
<td>Controls conversion of excess glucose in bloodstream to glycogen (stored in liver)</td>
</tr>
</tbody>
</table>
Control of blood sugar levels

The body must ensure it has a regular supply of glucose available for use by cells, regardless of when or how often food is eaten.

Insulin is a hormone which is secreted by the pancreas. When blood sugar levels are too high, insulin converts an excess glucose into a chemical called **GLYCOGEN**, which is stored in the liver.

\[
\text{Insulin} 
\quad \text{Glucose} \rightarrow \text{Glycogen}
\]

This has the effect of lowering the blood glucose levels.

**GLUCAGON** is a second hormone secreted by the pancreas. When blood sugar levels become too low, glucagon has the job of converting glycogen in the liver, back into glucose in the blood.

\[
\text{Glucagon} 
\quad \text{Glycogen} \rightarrow \text{Glucose}
\]

This has the effect of increasing the blood glucose level.

Insulin and Glucagon work together to make sure that there is a steady blood sugar level, so even in the middle of the night, hours after you’ve eaten, there will be a constant supply of glucose for respiration to occur.

The flow chart below shows part of the control of glucose concentration in the blood of a human.

**REMEMBER!!**

When Glucose is gone, the pancreas makes “**Glucagon**”
Unit 3: Topic 4

Reproduction

Gamete (sex cell) Production and Fertilisation

In both animals and flowering plants sex cells are collectively called **gametes**.

**Gametes** are **haploid**. This means they have **one set of chromosomes**. Gametes are produced during a process called **meiosis**. The cells which undergo meiosis and produce the gametes have **2 sets of chromosomes** and are described as being **diploid**.

**In flowering plants.**

The **anther** produces **pollen grains** which **contain** the male **gamete**.

The **ovary** produces **ovules** which **contain** the female **gamete**.
<table>
<thead>
<tr>
<th>Name of Structure</th>
<th>Function of Part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stamen</td>
<td>Male part of flower made up of the filament and the anther</td>
</tr>
<tr>
<td>Anther</td>
<td>Produces pollen grains, which contain the male gamete.</td>
</tr>
<tr>
<td>Stigma</td>
<td>Female part of the flower.</td>
</tr>
<tr>
<td></td>
<td>Traps pollen grains on its sticky surface.</td>
</tr>
<tr>
<td>Ovary</td>
<td>Produces ovules</td>
</tr>
<tr>
<td>Ovules</td>
<td>Contain the female gametes</td>
</tr>
</tbody>
</table>

**Pollination** is the transfer of pollen from the anther to the stigma. This can be performed by either wind or insects.

When a pollen grain lands on the stigma a sugary substance on the surface causes it to grow a pollen tube.
The pollen tube grows down into the ovary. The male sex cell nucleus then leaves the pollen grain and travels down the pollen tube into the ovary to reach the female sex cell nucleus.

The fusion of the male and female sex cell nucleus is called fertilisation. The fertilised egg is zygote which is referred to as a seed. The zygote is diploid.
In Mammals.

In mammals, the male gametes (sperm) which are haploid are produced in the **testes** and female gametes (eggs) which are also haploid are produced in the **ovaries**.

### Male reproductive system

<table>
<thead>
<tr>
<th>Letter</th>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Testes</td>
<td>Site of Sperm Production</td>
</tr>
<tr>
<td>B</td>
<td>Sperm Duct</td>
<td>Carries sperm to penis</td>
</tr>
<tr>
<td>C</td>
<td>Penis</td>
<td>Enters into vagina and releases sperm cells</td>
</tr>
</tbody>
</table>

### Female reproductive system

<table>
<thead>
<tr>
<th>Letter</th>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Oviduct</td>
<td>Site of fertilisation</td>
</tr>
<tr>
<td>B</td>
<td>Ovary</td>
<td>Produces and releases eggs</td>
</tr>
<tr>
<td>C</td>
<td>Uterus</td>
<td>Embryo attaches to uterus wall and develops</td>
</tr>
<tr>
<td>D</td>
<td>Vagina</td>
<td>Sperm swim up through vagina to uterus then oviduct</td>
</tr>
</tbody>
</table>

**Fertilisation**
Fertilisation is the **fusion** of the **nucleus** of a sperm with the **nucleus** of an egg.

![Diagram of fertilisation](image)

After fertilisation the **fertilised egg**, called a **zygote**, which is **diploid**, divides repeatedly by mitosis to form a ball of cells called an **embryo**.

All body cells, except red blood cells in humans are diploid. Red blood cells have no nucleus and therefore no chromosomes.
Unit 3:  Topic 5

Variation and Inheritance

**Variation in a species**

Members of a *species* can *interbreed and produce fertile young*. Individuals in a species are not all identical, but show slight *differences*. The differences that occur within a *population* (a group of organisms of the same species) are called *variations*. These genetic variations occur because the *fusion of gametes*, from separate parents, which take place during fertilisation is a random process.

There are two types of variation: *continuous* and *discrete*.

**Continuous variation**

This is where a characteristic of an animal or plant shows a *wide range of variations between two extremes*.

E.g. Height, hand span, weight, shoe size, tail length in mice, diameter of a shell, length of a leaf

Continuous variation can be shown by a *bell-shaped curve* on a line graph or histogram.

**Discrete Variation**

This is where the variation in a characteristic is *clear-cut*, with the organism either belonging to *two or more distinct groups*.

E.g. eye colour, fingerprints, blood group, ability or not to roll tongue, presence or absence of ear-lobes.
Discrete variation can be shown by a bar graph.

**Genetics**

When organisms reproduce, information is passed from parents to offspring on the chromosomes in the **gametes** (sex cells).

The way in which inherited characteristics are passed on from parents follows a pattern. The study of this pattern of inheritance is called **genetics**.

**Phenotype**

The **physical characteristics** that an organism shows are referred to as its **phenotype**, e.g. hair colour, stem length.

Some physical characteristics have more than one phenotype:

<table>
<thead>
<tr>
<th>Physical Characteristic</th>
<th>Phenotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye colour</td>
<td>Blue, Brown, Green, Hazel and Grey</td>
</tr>
<tr>
<td>Blood group</td>
<td>A, B, AB and O</td>
</tr>
<tr>
<td>Seed shape</td>
<td>Round and Wrinkled</td>
</tr>
</tbody>
</table>

The phenotype of an organism shows up as a result of the combination of genes it inherits.

This combination of genes (the genetic make up of the organism) is called the **genotype**.

**Alleles**

Genes are parts of chromosomes, which code for a particular characteristic.

Genes can exist in more than one form. A pair of genes may contain two of the same form, or two different forms.

The characteristics of an organism are mainly controlled by the combination of different forms of gene in a pair.

The different forms of a gene are called **alleles**.

Body cells carry two alleles, one inherited from each parent.

Therefore, each gamete carries one allele of the gene.
Polygenic inheritance

Many of the features possessed by an individual in terms of their phenotype have been caused by the interaction of the alleles of several genes. This is referred to as polygenic inheritance. Skin colour in humans and seed mass in plants are good examples of this.

Dominant and Recessive Alleles

Alleles can be either dominant (stronger) or recessive (weaker form).

Capital letters are used for dominant genes and small case for recessive genes.

e.g. In eye colour brown eyes are dominant to green.

So B=brown b=green.

If both alleles are the same they are said to be homozygous - BB or bb

Homozygous is also known as true breeding or pure breeding.

If the alleles are different (one dominant & one recessive) they are said to be heterozygous e.g. Bb

- So if the genotype BB - the phenotype is brown.
- If the genotype Bb - the phenotype is brown.
- If the genotype bb - gives the phenotype green.

It is therefore possible for organisms to have a different genotype but the same phenotype.
The dominant allele will always show up in the inherited characteristic of an organism, even when both alleles are present in the pair.

For example:

Gold angelfish × Black angelfish

P:

True breeding gold body

F₁

black bodied fish

All the baby angelfish in the F₁ are black therefore black must be dominant.

Genetic Crosses

When studying genetics, shorthand symbols are used:

- The original generation i.e. the parents $P$
- The offspring of $P$ / the first generation $F₁$
- The offspring of the $F₁$ / the second generation $F₂$

Genetics crosses involving only one characteristic are called monohybrid crosses. The parents used in these crosses will usually have different phenotypes and be homozygous.
For example:

In onions the gene for colour exists in two forms; red and white. The gene for red colour is dominant and the gene for white colour is recessive. True breeding parents were used in the following cross:

\[
P \quad \text{Red} \quad \times \quad \text{White} \quad \text{F}_1 \quad \text{all Red}
\]

All the \textbf{F}_1 generation have the same phenotype. They show the dominant characteristic, \textbf{red colour}. This shows that \textbf{red is dominant to white}. Although the recessive characteristic (white coat) does not show up, all the \textbf{F}_1 individuals will be carrying both dominant and recessive characteristics.

If two of the \textbf{F}_1 generation offspring are then crossed, both phenotypes will appear in the \textbf{F}_2 generation.
Heterozygous cross

In experimental genetics crosses, the alleles are represented by letters. The dominant allele is represented by a capital letter, and the recessive allele is represented by the lower case of the same letter e.g. T and t, R and r and so on.

E.g. In pea plants, tall is dominant to dwarf.

A pure bred tall pea plant would have the genotype TT

A pure bred dwarf pea plant would have the genotype tt

A pea plant carrying one of each type of allele would have the genotype Tt and would appear TALL

In an experimental cross, the expected ratio of offspring can be calculated using a punnet square.

Cross

P. Phenotypes    Tall    X    Tall
P. Genotypes    Tt
P. Gametes    T or t

F₁ Punnet Square

<table>
<thead>
<tr>
<th></th>
<th>T</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>TT</td>
<td>Tt</td>
</tr>
<tr>
<td>T</td>
<td>Tt</td>
<td>tt</td>
</tr>
</tbody>
</table>

F₁ Genotypes    TT, Tt, Tt, tt
F₁ Phenotypes    TALL, TALL, TALL, DWARF
F₁ Ratio    3:1

REMEMBER!

Expected ratios are not always achieved because:

1. Fertilisation is a random process.
2. The sample size may be too small.

There are 3 plants in the F₁ generation that all have the same phenotype. They all appear tall; TT, Tt and Tt. If we were to take one of these F₁ tall plants and cross it
with a dwarf plant, how would we know if the one we chose was true breeding (TT), or was carrying one of each allele (Tt)?

To establish whether an organism with a dominant phenotype is true breeding or not a backcross is carried out.

**The Monohybrid Backcross (testcross)**

When carrying out a backcross, to establish whether an organism with a dominant phenotype is pure breeding or not, you cross the organism in question with a recessive organism of the same species.

i.e.

**Backcross 1:**

\[
TT \times tt \\
T, t \quad t, t
\]

**Backcross 2:**

\[
Tt \times tt \\
T, t \quad t, t
\]

All offspring are Tt i.e. are *TALL*

Half the offspring are Tt i.e. are *Tall*

Half the offspring are tt i.e. are *dwarf*

All tall offspring indicates parent was TT

1 tall : 1 dwarf ratio in offspring indicates the parent was Tt
Ratios

A cross between TT (homozygous dominant) and tt (homozygous recessive) will always give offspring which are all like the dominant parent.

A cross between Tt and Tt (heterozygous) will usually give the ratio of 3 dominant : 1 recessive for the characteristic.

In reality the actual ratios of offspring in crosses do not match the predicted ratios. This is because fertilisation is a random process which involves an element of chance.

Genetic Counselling

Individuals who are heterozygous for a particular medical condition are said to be carriers. This means that while they are not affected, if the trait is recessive they may pass the allele onto their offspring. If the allele from their partner is also recessive they may have a child who is a sufferer. Known carriers are therefore often offered genetic counselling.

Genetic counselling is the process by which patients or relatives, at risk of an inherited disorder, are advised of the consequences and nature of the disorder, the probability of developing or transmitting it, and the options open to them in management and family planning.
The Need for Transport

Transport Systems

Multicellular organisms require to transport a variety of materials around their structure. Many of these transport systems require diffusion or osmosis to take place.

Many of these transport systems have evolved a large surface area to overcome the surface area to volume issue and allow transport to take place efficiently.

6.a) Plant Transport Systems

Need for Water

Plants need water to photosynthesise. Water is also needed for transporting materials which are dissolved in the water.

Transport of Water

Water and minerals are transported up through the stem of a plant in xylem.

Xylem cells are lignified to withstand the pressure changes as water moves through the plant.
Transpiration

Transpiration is the evaporation of water from the aerial parts of a plant. The continuous passage of water through a plant from root to leaf is called the transpiration stream.

Transpiration occurs through the following processes:

- Water is being used by **mesophyll cells for photosynthesis** and is also being lost from the leaves by **evaporation** through stomata which causes water to be drawn up the **xylem**.
- This transpiration pull causes continuous, thin, tense columns of water to be **drawn up the xylem**.
- At the same time **root hairs** spread out from the roots and greatly increase the surface area for absorption.
- Water in the soil enters the cells of the root hairs by **osmosis** and diffuses through permeable cell walls.
- Water moves from cell to cell by osmosis until it enters the **xylem**.
**Structure of Stomata**

Stomata are found on the bottom surface of a leaf in the **epidermis**. Stomata are small **pores** which allow leaves to exchange gases, water can also leave through the stomata. Stomatal opening and closing is dependent on changes in turgor in the **guard cells** (which are sausage shaped, and also contain chloroplasts).

![Diagram of stomata and guard cells](image)

**Structure of the leaf**

![Diagram of leaf structure](image)
Transport of Sugar

Sugars are carried up and down the plant in special living vessels called **phloem vessels**.

![Diagram of plant cells with labeled parts: sieve plate, cytoplasm, cell wall, sieve cell, sieve tube, nucleus, companion cell, holes between cells.]

6. b) Animal Transport and Exchange Systems

**Circulatory System**

The circulatory system consists of

i. Blood vessels - tubes
ii. The heart - a pump
iii. Blood - liquid

The circulatory system **transports**

- **Nutrients** from where they are obtained to where they are needed *e.g.* oxygen, amino acids, glucose.
- **Wastes** from where they are produced to where they are excreted *e.g.* urea, carbon dioxide.
- **Hormones** so that different areas of the body can communicate *e.g.* ADH, insulin.
- **Heat** so that all areas of the body are kept close to the optimum temperature of 37°C.
Pathway of Blood

The circulatory system is a **double circulation** where the blood flows **twice** through the heart for each complete circuit. This is because the **lungs have a separate circulation** from the rest of the body.

**NOTE**

Blood shown in **RED** is oxygen rich, but poor in carbon dioxide.

Blood shown in **BLUE** is oxygen poor, but rich in carbon dioxide.

The Heart

The Four Chambers of the Heart

There are **two atria**

- The **right atrium** (RA)
- The **left atrium** (LA)

There are **two ventricles**

- The **right ventricle** (RV)
- The **left ventricle** (LV)
The Major Blood Vessels of the Heart

- These carry blood into and out of the heart.
- They connect to all parts of the body.
- The veins (pulmonary vein and vena cava) return blood under low pressure back to the heart.
- The arteries (pulmonary artery and aorta) take blood under high pressure out of the heart.

Pathway of Blood Through the Heart

**Deoxygenated** blood from the body

- In the vena cava (VC)
- Enters the right atrium (RA)
- Into the right ventricle (RV)
- Out through the pulmonary artery (PA)
- To the lungs where it picks up oxygen (L)

**Oxygenated** blood from the lungs

- In the pulmonary vein (PV)
- Enters the left atrium (LA)
- Into the left ventricle (LV)
- Out through the aorta (A)
- To the body (B)
The Coronary Blood Vessels

The heart muscle requires its own blood supply which is provided by the coronary blood vessels which can be seen on the outside of the heart.

- Coronary arteries branch off the aorta
- Coronary veins join the vena cava
## Blood Vessels

<table>
<thead>
<tr>
<th>Blood Vessel</th>
<th>Function</th>
<th>Features</th>
</tr>
</thead>
</table>
| Artery       | Carry blood **away from the heart**. | Thick muscular wall.  
Narrow channel.  
Pulse.  
Blood at **high** pressure. |
| **Capillaries** | Carry blood **through tissues and organs**.  
Exchange of materials. | Wall only **one cell thick**. |
| Vein         | Carry blood **towards the heart**. (ven) | Thin muscular wall.  
Wide channel.  
**No pulse**.  
Blood at **low** pressure.  
Many valves to prevent backflow of blood. |
Connection Between Blood Vessels

When an artery reaches an organ it splits up into very narrow capillaries. Capillaries form networks through the organ and cover a large surface area. They are also thin walled which allows diffusion to easily take place. Capillaries join up into a vein to carry blood out of an organ.

(note: arteries and veins are like motorways between cities, capillaries are like streets within the city)

Blood

Blood is made up of the following:

- **Plasma** (55%)
- **Blood cells** (45%) of which there are three types
  - Platelets which are tiny cell fragments involved in clotting
  - Red blood cells
  - White blood cells

Red Blood Cells

- Are biconcave in shape
- Transport oxygen
- Are filled with the red pigment haemoglobin
- Haemoglobin combines with oxygen to form oxy-haemoglobin. When the red blood cells then reach their target organ the oxy-haemoglobin releases the oxygen.
The lungs are where the gases $O_2$ and $CO_2$ are exchanged between the blood and the air.

The rings of cartilage keep the airways open.

Inhaled air (high in $O_2$, low in $CO_2$) passes down the trachea, bronchi, bronchioles and finally reaches the tiny alveoli (singular- alveolus).

Exhaled air (low in $O_2$, high in $CO_2$) passes out of the lungs in the reverse direction.
The Alveoli

$O_2$ from the air in the alveolus

- **dissolves** in the layer of fluid lining the alveolus
- **diffuses** rapidly into the blood through the single celled walls of the alveolus and blood capillary.

$CO_2$ **diffuses** out of the blood and into the air in the alveolus.
**Efficiency of Gas Exchange Surface**

The internal structure of the lungs provide many features which make them **efficient** at gas exchange.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Provided by</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large <strong>surface area</strong></td>
<td>Many alveoli</td>
<td>Large <strong>volumes</strong> of gases can be exchanged</td>
</tr>
<tr>
<td></td>
<td>Large capillary network</td>
<td></td>
</tr>
<tr>
<td><strong>Good blood supply</strong></td>
<td>Large capillary network</td>
<td>Blood has a continual $O_2$ uptake and $CO_2$ removal</td>
</tr>
<tr>
<td><strong>Very thin walls</strong></td>
<td>Single <em>celled</em> wall of alveolus and capillary</td>
<td>Reduces the distance which gases have to diffuse</td>
</tr>
<tr>
<td><strong>Moist surfaces</strong></td>
<td>Fluid lining the alveoli</td>
<td>$O_2$ must <strong>dissolve</strong> before it can diffuse through cells</td>
</tr>
</tbody>
</table>
The Lining of Trachea and Bronchi

Mucus lines the air sac, to allow the gases to dissolve so that they can diffuse. Mucus also lines the trachea and bronchi – this sticky mucus traps any dust and micro-organisms which are breathed in.

The cells that line the air tubes (trachea and bronchi) are covered in tiny hair-like structures called cilia.

The cilia move back and forth to sweep the mucus upwards towards the throat. This helps to remove the dust and micro-organisms trapped by the mucus (the mucus is usually swallowed).
**Digestive System**

**Peristalsis**

The oesophagus is a tube which connects the back of the **mouth to the stomach**.

The walls of the oesophagus contain muscles which move food along the oesophagus towards the stomach.

This muscular activity is called **peristalsis**.

Peristalsis takes place throughout the **alimentary canal**.
Small Intestine

When food leaves the stomach and passes into the small intestine, digestion is completed by the action of a number of enzymes.

The soluble molecules produced by digestion then pass across the small intestine wall and enter the bloodstream.

The structure of the small intestine allows maximum absorption in the following ways:

- The small intestine is long.
- The inner lining is folded.
- The inner lining has many finger like projections called villi.

Each of these features increases the surface area available for the absorption of soluble food molecules.

Villi

The thin wall is only one cell thick. This allows dissolved molecules to pass through quickly and easily.

The blood capillaries ensure a good blood supply is present to receive absorbed molecules.

Glucose, amino acids, vitamins and minerals all pass into the blood.

The lacteal receives fatty acids and glycerol produced by the digestion of fats.
UNIT 3: TOPIC 7

Effects of Lifestyle Choices

Lifestyle Choices
Individuals have mental, social and physical aspects to their health. Individuals make choices about the way they live which can affect their health. Healthier lifestyle choices can improve the physical and mental health of an individual.

Healthier lifestyle choices include:

- regular exercise
- eating a balanced diet
- no smoking tobacco
- no excess alcohol intake
- relaxation activities
- socialising with friends

Some individuals make poor lifestyle choices which can increase the chances of health problems.

Poor lifestyle choices include:

- high fat diet
- high salt diet
- lack of exercise
- Smoking tobacco
- Excess alcohol intake
- high stress experiences
These poor lifestyle choices can increase the chances of:

- fatty deposits in blood vessels
- blood clots
- heart attacks
- stroke
- diabetes
- high blood pressure

A person is more at risk from these conditions if their parents or grandparents suffered from them. This is known as heredity.

Environmental factors can also affect health. Heavy metals like lead, pollution and radiation can all affect health.

If a person has a poor diet lacking in iron then they can become anaemic. A person who is anaemic can feel tired and looks pale. Iron is needed to make haemoglobin. Haemoglobin is a chemical that binds with oxygen. It is found on the surface of red blood cells. Lack of iron means haemoglobin cannot be made and this causes anaemia.

Physiological Measurements.

Physiological measurements can be taken to measure an individual’s health. Physiological measurements include:

- pulse rate
- breathing rate
- temperature
- blood pressure
- peak flow
Most physiological measurements have a normal range. **Pulse rate** in a normal healthy individual should be between 60 and 80 bpm. Pulse rate is measured with a stopwatch and fingers placed on the wrist, temple or neck. Pulse rate is the number of times the heart beats in a minute.

**Breathing rate** is how many breaths you take in a minute and can be measured using a stopwatch and counting your breaths.

Both breathing rate and pulse rate **increase** during exercise.

Normal body **temperature** is 37°C, above 40°C can indicate a fever whereas a body temperature of 35°C or below can indicate hypothermia.

Temperature can be measured using a thermometer. Temperature is a measure of how hot or cold our body is.

**Peak flow** can be measured using a peak flow meter and is used to indicate asthma. Peak flow depends on gender, age, size and level of fitness. Peak flow is the maximum rate at which air can be forced out of the lungs.

**Blood pressure** can be measured using a digital sphygmomanometer. Normal blood pressure is about 120/80. Obesity and lack of exercise can cause high blood pressure. High blood pressure can lead to a stroke or heart attack. Low blood pressure can cause fainting.