1.1 Introduction to Cells

Unicellular Organisms

In order to survive, unicellular organisms must be able to carry out the functions of life

Metabolism- all the chemical reactions inside a cell
Response- reacts to environmental changes
Homeostasis- the ability to keep internal conditions balanced
Growth
Reproduction
Excretion
Nutrition

The **volume** of a cell will determine how much

- Consume resources
- Produce waste products

The **surface area** of a cell will determine how quickly a cell can move materials in or out of a cell
The important feature of a cell is the ratio of surface are to volume; **SA:Vol**

The **bigger** the cell, the smaller the SA:Vol.

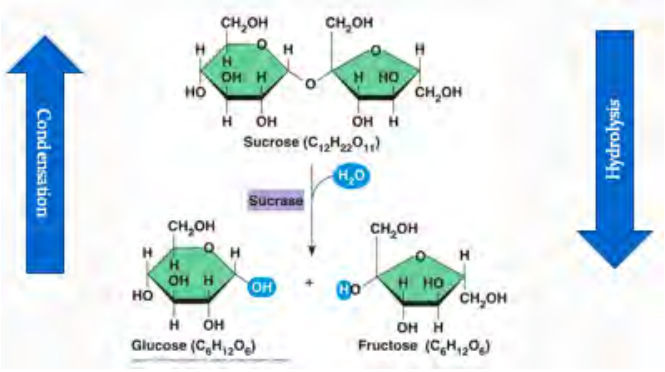
Cells with a high SA: Vol are able to effectively transport material in an out of a cell due to the shorter distance to the membrane.
To maintain a high SA:Vol cells;

- Divide- 2 small cells are more efficient that 1 larger cell
- Fold up/extend their membrane

Multicellular Organisms

- When cell starts working together in multicellular organisms in tissues, organs and organ system, they start to display properties which individual cells do not have.
- These are called **emergent properties** e.g. the cells of the digestive system cannot individually digest and absorb nutrients, but by working together, the whole system is able to.
- The emergent properties arise in multicellular organisms because cells become specialized e.g. heart cells, and kidney cell- **220 different types in humans**
- They become specialized through the process called **differentiation,** where the genes are 'turned on and off' as required. Turning genes on and off is called **gene expression**
- For the majority of cells once they have gone through differentiation, they remain that cell type during its life cycles
- There are special cells which have the ability to change into many cell types, these are called **stem cells**

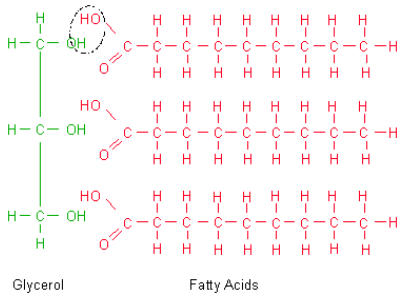
- Glycogen
  - Similar to starch but more branched
  - Store of carbohydrates in the liver and muscles



Name of Carbohydrate	Where it is found	Composition	Use
Cellulose	It is mainly found in the cell walls of plant cells	Made up of chains of **β-glucose** which are linked together by using **hydrogen bonds**	It has a high tensile strength, so it is used in in cell walls of **plants**
Starch	In plants	Made of curved chains of **α-glucose**; amylose and amylopectin	It is used for energy storage **in plants**
Glycogen	Liver and muscles of animals	Made of curved chains of **α-glucose**; amylose and amylopectin, similar to starch, but more branched	It is used for the storage of carbohydrates in the liver and muscles of **animals**

Lipids

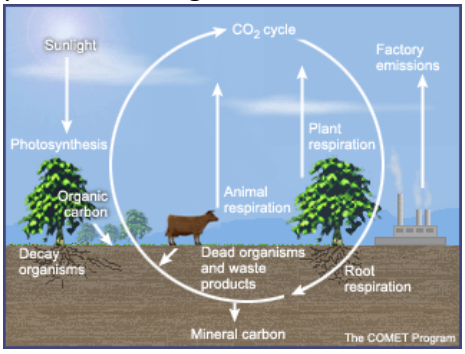
- Lipids are used as long-term **energy storage** in human
- Stored in adipose tissue under the skin
- Lipids store twice as much energy per gram than carbohydrates
- Poor conductor of heat, therefore acts as a layer of **insulation**
- Triglycerides
  - Triglycerides are formed by a condensation reaction between a glycerol and 3 fatty acids
  - Fatty acids can be
    - Saturated
    - Unsaturated
      - Monounsaturated



Nutrients

- Autotrophs/producers
  - Produce organic matter from CO_2 (plants)
- Heterotrophs
  - Obtain organic matter from other organisms
  - Consumers
    - Feed on living matter
    - Primary
      - Feed on producers
    - Secondary
      - Feed on other consumers
  - Decomposers
    - Feed on dead matter
    - Detrivores
      - Ingests non-living matter
    - Saprotrophs
      - Secretes extracellular enzymes

- All living things require a range of elements
  - C, H and O for carbohydrates and many other carbon compounds
  - N for proteins
  - P for ATP
- Autotrophs gain these from the abiotic environment as inorganic nutrients
- Heterotrophs gain organic nutrients by consumption and inorganic from the environment



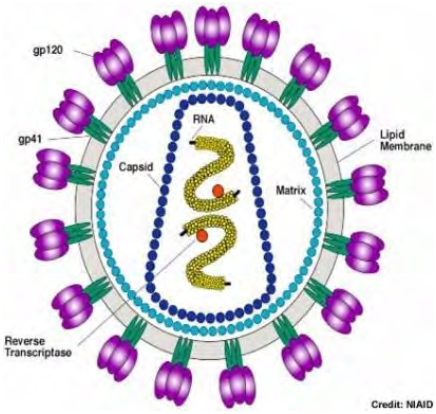
Nutrient cycles

- There is a limit to the number of elements on Earth, therefore, to maintain a supply to living organisms, inorganic nutrients are recycled once a living organism dies

Sustainability

- Sustainability is the capacity to maintain process and functions of an ecosystem over a long period of time
- Ecosystems are sustainable is there is
  - A nutrient recycling to maintain nutrient availability
  - Detoxification of waste products
  - Energy available
- On way of testing if an ecosystem is sustainable is by using a **mesocosm**
  - A mesocosm is a small-scale ecosystem
    Can be made in a jar, tank, or fenced off enclosures ect.

- HIV (Human Immunodeficiency Virus)
  - A virus's life cycle requires it to infect a host cell, hijacking its metabolic pathways to replicate new virus particles
  - HIV infects a particular type of lymphocyte called a **CD4 T helper cell** (or CD4 for short)
  - These CD4 cells have a central role in an immune response by **helping and controlling other immune cells** e.g. B cells need these in order to produce antibodies
  - Following HIV infection, the virus continues to replicate and infect other CD4 cells, lowering the number of these cells in the body
  - HIV can be transmitted from person to person by a number of different ways
    - Sharing hypodermic needles with a HIV positive person
    - Blood transfusion or treatment with blood products e.g. haemophilia (Although most countries test for HIV)
    - Unprotected sex with a HIV positive person
    - From mother to child during pregnancy, childbirth or breastfeeding

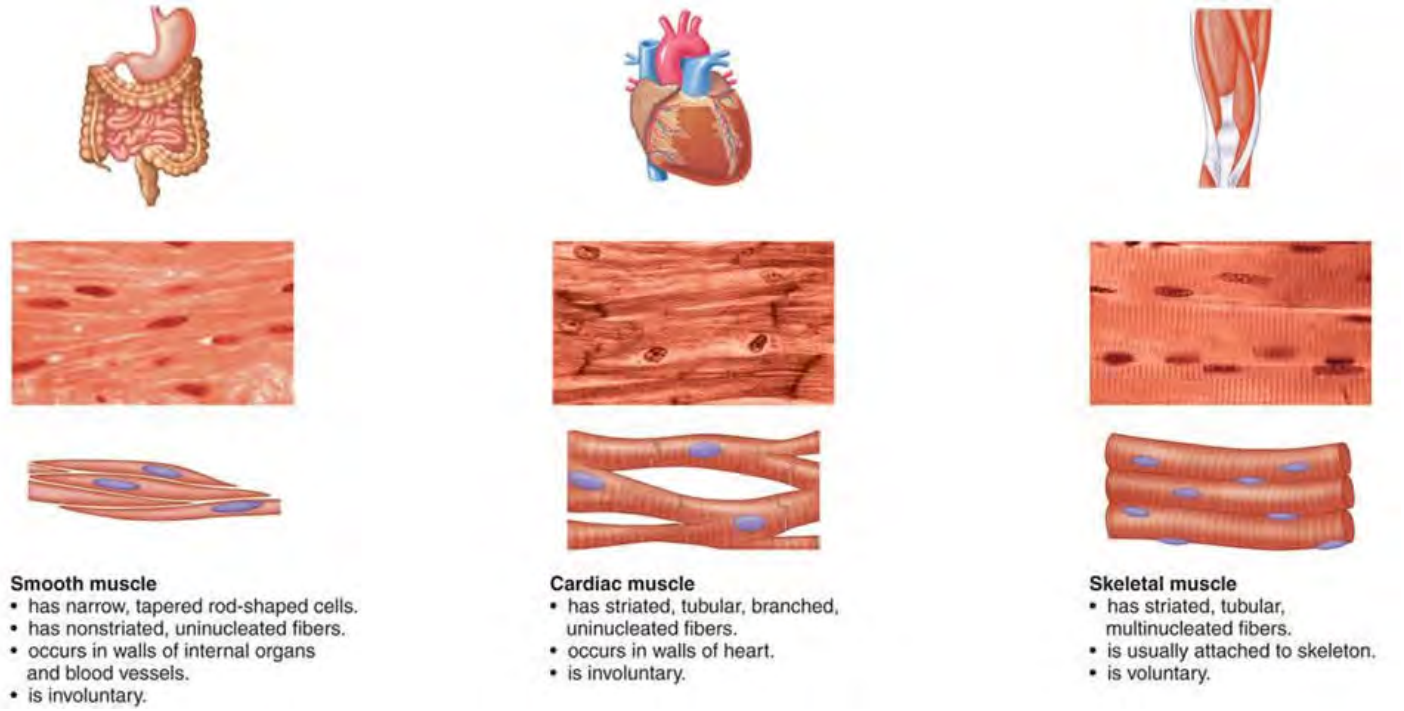


- AIDS
  - When the CD4 count becomes too low, the body's immune response is compromised, and the body is unable to fight infections it would normally be able to deal with
  - This leads to the development of **AIDS (Acquired Immune Deficiency Syndrome)**
  - An AIDS patient will die from a secondary infection such as
    - Pneumonia
    - Tuberculosis

Adaptions for Water Conservation

- **Xerophytes** are plants which have adapted to survive in very arid environments e.g. deserts
    - Have a reduced number of stomata which open at night
    - Spines or rolled leaves with stomata in pits and hair to trap the water vapour
    - Waxy cuticle to reduce evaporation
    - Very deep roots to reach water
    - Able to store large amount of water during wet season
- **Halophytes** are plants that have adapted to survive in salty conditions
    - Leaves are shed when water in scarce and stems take over photosynthesis
    - Small leaves/spines within sunken stomata
    - Structures to remove salt
    - Store water
    - Thick cuticle
    - Long roots to reach fresh water

Muscles



3 types of muscle:

- **Smooth** (involuntary muscles): are present in the walls of internal organs (digestive track, bladder), They form the structure of blood vessels. They can dilatate or constrict. The contraction is slow, gradual and involuntary. They are formed by narrow, long and uninucleate cells. The tissue is non-striated.

- **Cardiac** (circulatory system) (involuntary muscles)

- **Skeletal** (voluntary muscles): they allow body movement. They are joint to bones. They are made by very long and multinucleated cells (exception to cell theory, they are fuse during embryonic development). The tissue is striated tissue. The muscles that are used to move the body are attached to bones
  Ligament: bone to bone Tendon: muscle to bone

Animal physiology: they are ANTAGONISTIC
The bones are also called exoskeleton which are made up of CHITIN (polysaccharides)
They are the anchorage of muscles

Skeletal muscles (or insect leg muscle): they are **antagonist** muscles. In general, to move a leg we are going to need a pair of muscles that are going to work in a opposite way. When one contracts, the other one relaxes. Antagonistic muscles produce opposite movements at a joint. For example, in the elbow, the triceps extends the forearm while the biceps flex the forearm.

Example: an insect leg has antagonistic muscles: GRASSHOPPER

Flexor contracts – extensor relaxes: tibia flexes Flexor relaxes- extensor contracts: tibia extenses

Structure of muscle fibres

The muscles are organised in MUSCLE FIBER that consist of muscle cells called MYOFIBILS. They are the functional structure, it is what really makes the muscle contract. The myofibrils are organised in FASCICLES that are surrounded by the ENDOMYSIUM (connective tissue, they are in charge of connecting everything).

1. Arrival of sperm: sperm are attracted by a chemical signal and swim up the oviduct to reach the egg.
2. Binding: the first sperm to break through the layers of the follicle cell binds to the zona pellucida. This triggers the acrosome reaction

3. The acrosome reaction: the contents of the acrosome are released, by the separation of the acrosomal cap from the sperm. Enzymes from the acrosome digest a route for the sperm through the zona pellucida, allowing the sperm to reach the plasma membrane of the egg.

4. Fusion: the plasma membrane of the sperm and egg fuse and the sperm nucleus enters the egg and joins the egg nucleus. Fusion causes the cortical reaction.

5. Cortical reaction: small vesicles move to the plasma membrane of the egg and fuse with it, releasing their contents by exocytosis. Enzymes from the cortical granules causes cross-linking of glycoproteins in the zona pellucida, making it hard and preventing polyspermy.

6. Mitosis: the nuclei from the egg and sperm do not fuse together. Instead, both nuclei carry out mitosis, using the same centrioles and spindle of microtubules. A two-cell embryo is produced

Pregnancy and childbirth

The zygote produced by fertilization in the oviduct is a new human individual. It starts to divide by mitosis to for a two-cell embryo and so on until a hollow ball of cells called a BLASTOCYTE is formed. While these early stages in the development of the embryo are happening, the embryo is transported down the oviduct to the uterus. When it is about 7 days old, the embryo implants itself into the endometrium (lining wall of blood) where it continues to grow and develop. If implantation does not occur, then the embryo is not supplied with enough food and the pregnancy does not continue.

Hormonal control of pregnancy: human embryos secrete the hormone hCG (human chorionic gonadotrophin) from a very early stage. hCG stimulates the ovary to maintain the secretion of progesterone during the first three months of pregnancy. Progesterone causes the uterus lining to continue to thicken so it can support the embryo after implantation. By about 12 weeks, the ovary stops secreting progesterone, but by this time the placenta has develop and takes over the task of secreting the progesterone that is needed to sustain the pregnancy. The placenta also releases estrogen.

Hormone control of childbirth

Rising levels of progesterone ensure that the uterus develops and sustain the growing fetus. It also prevents uterine contractions and so prevents spontaneous abortions. The level of progesterone starts to fall in the last third of the pregnancy and at the end. This allows the mother´s body to secrete another hormone oxytocin. There is also a rise in estrogen, which causes and increase in the number of oxytocin receptors on the muscle in the uterus wall. When oxytocin binds, it causes the muscle to contract. Uterine contractions stimulate the secretion of more oxytocin. The contraction become stronger and stronger. POSITIVE FEEDBACK.

While the muscle in the wall of the uterus is contracting, the cervix relaxes and becomes wider. The amniotic sac burst, and the amniotic fluid is released. The baby is pushed out through the cervix and the vagina. The umbilical cord is cut, and the baby begins its independent life. Contractions continue for some time until the placenta is expelled as the afterbirth.

PLACNETA:

By the time that the embryo is 8 weeks old, it starts to develop bone tissue and is known as fetus

The fetus develops a placenta and an umbilical cord. The placenta is a disc-shaped structure with many projections called placental villi embedded in the uterus wall. In the placenta the blood of the fetus flows closes to the blood of the mother in the uterus wall. This facilitates the exchange of materials between maternal and fetal blood.

The placenta has two important functions throughout the pregnancy:

- Exchange of material to keep the fetus alive during pregnancy
- Production of progesterone and estrogen. At the beginning of the pregnancy, this task is performed by the corpus luteum.