SESSION 10: TRANSPORT SYSTEMS IN MAMMALS (HUMAN) 2

KEY CONCEPTS:

- Blood vessels
- Lymphatic system
- Diseases of heart & circulatory

X-PLANATION:

BLOOD VESSELS

- Mammals have a **closed** blood system – as blood flows in tubes called blood vessels.
- **Arteries** carry blood **AWAY** from the heart.
- **Veins** carry blood back **TO** the heart.
- **Capillaries** are located **between** the arteries and the veins.
Blood

- Blood is fluid connective tissue. Adult humans have about 5.5 litres of blood flowing through their blood vessels. Blood consists of plasma (the watery part) and haemocrit (the cells). Blood transports substances to and from the cells.
- The optimum blood pH in humans is 7.4.
  - Plasma
  - Haemocrit
    - Red blood cells
    - White blood cells
    - Blood platelets
Blood Groups and Transfusions

- When a person loses a lot of blood during an operation or because of an accident, blood must be replaced.
- A blood transfusion is when blood is taken from another source and placed into the recipient via a vein.
- In many cases, blood is donated and stored in blood banks.
- This donated blood is tested to check that it is not infected with any antigens and also to determine the blood type.
- In some cases, especially when a blood type is rare, a family member is able to donate blood directly to the recipient.
- If the blood is not compatible with the recipient’s blood, the donor blood will clot and cause death to the recipient.

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<tr>
<th>BLOOD TYPE COMBINATION</th>
<th>COMPATABLE DONOR BLOOD</th>
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<tr>
<td>A - I^A</td>
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<td>A - I^Ai</td>
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Universal donors: blood type O-compatible to all other blood types.
Universal recipients: blood type AB -able to receive blood from any of the groups.
Rhesus factor plays a role in determining blood type.
When the rhesus antigen on the surface of the red blood cell is present = Rh-positive.
When the rhesus antigen is absent = Rh-negative.
The rhesus system can cause complications during blood transfusions, pregnancy and birth.

The Lymphatic System:

- The fluid in the human body:
  - blood (plasma and cells)
  - tissue fluid (bathes cells)
  - lymph fluid (drains excess fluid and carries fats).

- Lymph vessels are located as a network throughout all tissues in the body.
- Lymph vessels assist the circulatory system and all the cells of the body by removing wastes, germs and excess water from the tissue fluid.
- Lymph vessels carry lymph fluid in ONE direction only, from the bottom of the body up towards the heart.
- Valves prevent the lymph fluid from flowing backwards.
- Muscle contractions push the fluid upwards.
- Lymph vessels play a major role at two sites, namely:
  - at tissue level
  - in the villi
Lymph at Tissue Level:

- Arteriole blood is under high pressure, causing some of the blood plasma to move from the capillaries to the tissue fluid.
- Tissue fluid bathes cells.
- **Oxygen and glucose** diffuse into the cells and waste products diffuse out into the tissue fluid.
- Tissue fluid constantly drains into the capillaries, which lead into venules and then veins.
- Tissue fluid also moves into the **lymph vessels** to be carried away by the lymphatic system.
- The lymphatic system empties into the **subclavian vein**.
- Lymph fluid moves up the body because of **muscle contractions**.
- **Valves** are present in the lymph vessels, preventing the back-flow of lymph fluid.
- When a person stands or sits still for long periods, the lymph collects in the feet and lower legs causing swelling (also called **oedema**).

Lymph in the Villi of the Digestive System:

- **Villi** are small finger-like outgrowths, lining the small intestine.
- In the centre of each villus, a tiny structure called a **lacteal** is found.
- Nutrients and water are absorbed into tiny capillaries in the villi and pass into the bloodstream.
- **Fat molecules** are hydrolysed into fatty acids and glycerol.
- These monomers pass through the columnar epithelium and immediately join up again into fat molecules.
- Fats are now **too large** to diffuse into the capillaries so they bypass the capillaries and enter the **lacteal** of the villi.
- The lacteal contains a fluid called **chyle**.
- The chyle drains into the **lymph vessel**.
Functions of the Lymphatic System:

- Drainage of excess tissue fluid
- Return of plasma proteins to circulation
- Removal of bacteria and toxins
- Transport of absorbed fat from the villi
- Manufacture of lymphocytes.

Cardiovascular Diseases:

- Cardiovascular disorders are a major cause of death in modern societies like heart attacks and strokes.
- Angina is caused when the heart muscle receives an inadequate supply of blood, resulting in very painful cramps in the chest area.

Myocardial Infarction:

- Myocardial infarction is the proper name for a heart attack - extreme pain in the chest and in the left arm.
- A severe heart attack can lead to death.
- Causes are:
  - hypertension (high blood pressure)
  - stress
  - smoking
  - unhealthy eating habits and poor diet
  - Being very overweight / obesity
  - high levels of cholesterol in the blood.

Atherosclerosis:

- With this disease fat, calcium and cholesterol are deposited on arterial walls.
- This reduces the diameter and makes the walls thicker, harder and less elastic.
- Blood gets caught in the cavities and blood clots form and may cause the myocardial infarctions.
- When a patient is diagnosed with atherosclerosis, a surgeon performs a coronary bypass to remove the blockage.
- In some cases laser angioplasty is prescribed, where laser beams are used to dissolve the blockage.
- Sometimes, the blockage can be removed by inserting a balloon into the artery called a percutaneous transluminal coronary angioplasty (PTCA).
- Causes of atherosclerosis are:
  - unhealthy eating habits and poor diet
  - lack of exercise
  - stress.
Arrhythmia:

- Arrhythmia results when there are abnormalities in the heart rhythm, because there is a problem with the sino-atrial node (pacemaker).
- Implanting an artificial pacemaker under the skin to regulate the heartbeat can correct this condition.
- Arrhythmia is generally caused by genetics and degeneration of the pacemaker region of the heart wall.

Strokes:

- A stroke is a disturbance in the brain function due to either a blockage in a blood vessel supplying the brain (80%) or the bleeding out by a ruptured blood vessel causing a haemorrhage (20%).
- An obstacle in the brain’s blood supply prevents oxygen and nutrients from being carried to the nerve cells.
- Brain cell and nerve pathway damage occurs, which disturbs the brain function and central nervous system control.
- Blood from the ruptured vessels within the cranium compresses the brain tissue, causing paralysis, speech loss and possibly death.
- It is a major cause of disability and death among elderly people.
- Strokes are often associated with:
  - high blood pressure
  - atherosclerosis

Anaemia:

- Anaemia results from a lack of iron in the diet.
- When this happens, haemoglobin cannot be produced.
- Haemoglobin carries the oxygen to all the cells.
- If there is a lack of haemoglobin, the cells are not provided with the correct amount of oxygen to produce energy.
The person will feel faint and weak.
When the person stands up quickly he or she will feel dizzy.
The heart will be stressed, as it must pump more blood through the vessels so that cells can receive oxygen.
Can cause palpitations of the heart.

Prof. Chris Barnard:

- Professor Christiaan Barnard was a South African heart surgeon who performed the first human heart transplant on 3 December 1967 at the Groote Schuur Hospital in Cape Town.
- The recipient was Mr Louis Washkansky who lived for 18 days but passed away due to pneumonia with his new heart beating strongly to the end.
- The surgery where this historical heart transplant took place has been converted into a museum, in honour of these pioneers of medicine.
- Cardiac surgery is a highly specialised branch of surgery that deals with repairs to or replacement of the heart.

- Cardiothoracic surgeons and their teams perform operations to surgically repair or completely replace a diseased heart with a healthy one from a donor.
- During heart surgery, the patient is placed on a heart-lung machine so that the blood remains oxygenated and pumping through the systems.
- Coronary artery disease, heart valve disease and congenital heart defects can all be surgically treated.
- A coronary bypass operation involves the removal of a piece of vein from the patient's leg – then used to bypass the blocked arteries around the heart.
- Heart transplants are only considered as a last option, when the heart cannot be repaired.
- There is clearly a shortage of heart organs, as donors must match the specific tissue and proteins of the recipient as closely as possible.
Hamilton Naki:

- Hamilton Naki was a gardener at UCT medical school.
- Dr. Robert Goetz recognised Naki's potential and asked him to take care of lab animals.
- With observation, he became an expert in anaesthetising animals and performed transplants.
- 2003 – National Order of Mapungubwe and an honorary degree in medicine awarded to him.

Treatment of Heart Disease:

- Medicine
- Stents
- Valve replacement
- Bypass surgery
- Pacemakers
- Transplants

Organ Transplants:

**Legislation:**

- In SA we may not sell organs.
- Organ transplants are arranged by hospitals and the specialist surgeons based on very strict rules and regulations.
- Organ recipients are placed on a rating list based on life expectancy, chances of rejection and tissue typing.
- Related donors are thoroughly screened first to ensure that they are left with a 100% functioning organ and certainty that their life will not be impacted in any way by the donation.

**Ethics and Belief Systems:**

- Registering on a donor list
- Blood donation
- Organ donation
- Organ receipt
X-AMPLE QUESTIONS:

Question 1:

Study the diagrams which show two cross-sections of mammalian blood vessels and answer the questions that follow:

![Diagram of blood vessels]

1.1. Which vessel, A or B is the artery? (1)
1.2. Provide TWO reasons for your answer to question 1.1. (2)
1.3. Which vessel carries blood at low pressure? (1)
1.4. Provide ONE reason for your answer to question 1.3. (1)
1.5. Identify the parts numbered 1 to 4. (4)
1.6. How do capillaries differ from larger blood vessels? (1)
1.7. In which vessel, A or B would you expect to find valves? (1)
1.8. What is the function of the valves in question 1.7? (1)
1.9. Name the blood vessel that:
   a) carries deoxygenated blood from the heart to the lungs (1)
   b) carries oxygenated blood from the heart for systemic circulation (1)
   c) carries blood from the digestive system to the liver (1)
Question 2:

Study the diagram of the lymphatic system and answer the questions that follow:

2.1 Name the components of the lymphatic system. (4)
2.2 Identify the:
   a) blood vessel numbered 3 (1)
   b) duct numbered 4 (1)
   c) structure numbered 6 (1)
2.3 Name TWO factors that assist movement of the lymph fluid. (2)
2.4 State FOUR functions of lymph in the human body. (4)

Question 3:

Read the article and answer the questions: [http://www.health24.com](http://www.health24.com)

The latest figures from the Organ Donor Foundation show that there are currently over 3 500 South Africans waiting for organ and tissue transplants. Sadly, as a result of this critical shortage less than 1 000 of them will receive a transplant and the "Gift of Life" in 2009.

In South Africa, in 2007, there were 688 organ and cornea transplants. Exactly 288 of these were solid organ transplants broken down into the following:

- Hearts: 24 adults and 2 paediatric
- Heart/lung: 0
- Lungs: 7 adults
- Livers: 24 adults, 2 adolescent and 9 paediatric
- Simultaneous kidney/pancreas: 10 adults. These transplants were all carried out in Johannesburg.
- Simultaneous kidney/liver: 1 paediatric
• Kidneys: 195 adult, 7 adolescent and 7 paediatric of which:
  – 57 adult, 7 adolescent and 7 paediatric transplants were live related
  – 14 adult kidney transplants were non-related
  – 34% of kidney donors were related to the recipient
• 356 adults, 29 adolescents and 15 children had their sight restored through a cornea transplant.

3.1 What percentage do heart transplants constitute among total transplants done in 2007?
3.2 How many of the kidney transplant recipients received kidneys from their relatives?
3.3 Suggest possible reasons for the huge backlog in the number of transplants.
3.4 Draw a pie chart to show the percentage adults who received heart, lung, kidney and liver transplant in 2007.