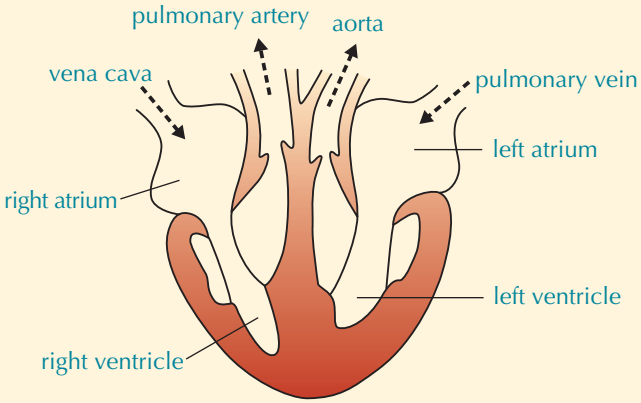
Activity 6A: Internal transport in animals

1. Distinguish between open and closed transport systems.
2. Explain why oxygen-carrying pigments are common in animal internal transport systems.
3. Explain how the function of the following blood cells is related to their structure:
   a. red blood cells
   b. phagocytes.
4. Compare and contrast the structure of arteries and veins.
5. Using the diagram following to assist you, explain how the structure of the heart is related to its function.



6. Explain why fish can live successfully with a single-loop circulatory system, while a double system is needed by birds and mammals.
7. The metabolic processes of cells require a constant supply of nutrients and oxygen and constant removal of metabolic wastes. Discuss the ways in which the animals of three named taxonomic or functional groups have solved the problem of transporting these substances from one part of their body to another part.
8. Circulatory systems may be classified into 'open or closed' systems, and 'single or double' systems. Most animals fall into one or more of these categories. Select three different taxonomic or functional groups, and, using named animals as examples, discuss the structure of their circulatory systems and the reasons for their differences. In your answer:
   - describe the system for each of the named animals
   - explain how each of these systems operates
   - explain the differences in the systems in relation to the different ways of life of the three animal groups.

ESA PUBLICATIONS ISBN 978-0-947504-91-5

Activity 6A answers: Internal transport in animals

1. In open transport systems, the blood is not carried in vessels but circulates in the body cavity, the coelom. In closed systems, the blood circulates in blood vessels (arteries and veins).

2. Oxygen-carrying pigments (haemocyanin, haemoglobin) are common because they transport large amounts of O_2 around the body. The pigments can carry more O_2 than the equivalent volume of water (e.g. haemoglobin can carry up to 60 times more).

3. a. RBCs are *round, thin biconcave cells* containing *haemoglobin* (Hb) – this allows them to *transport* O_2. The biconcave shape of the cells *increases the surface area*, allowing increased quantities of O_2 to enter/leave (per unit time); their packaging with Hb allows for *large quantities of* O_2 *to be transported*; their size and shape allow them to travel through the tiny capillaries to supply the cells with O_2.

b. Phagocytes are cells that can *move and change their shape*, allowing them to *engulf pathogens*. Phagocytes need energy to move, find and engulf pathogens. The presence of the nucleus (to control activities), mitochondria (to supply energy), the nature of the membrane, are all essential in allowing the phagocyte to move, leave the blood capillaries and engulf (by flowing around) pathogens.

4. Arteries take blood away from the heart, veins return the blood to the heart. To do so:

- arteries have a thick layer of elastic and connective tissue to allow for expansion to withstand high blood pressure; veins have a thinner layer, because blood is not under high pressure in veins
- arteries have a thick layer of elastic tissue and smooth muscle to allow arterial contractions to even out blood flow from heart pumping; veins have a thinner layer, because blood flow is much more even / no surging
- veins have valves to prevent the backflow of blood, as the flow is sluggish in veins compared with that in arteries
- arteries have a smaller lumen to keep the blood under pressure; veins have a large lumen, to deal with larger volumes of blood under low pressure.

5. The heart is four chambered; two, thin-walled atria collect blood from the body (right) and lungs (left); two muscular-walled ventricles pump blood to lungs (right) and body (left). Veins bring blood to the atria; arteries take blood away from the ventricles. Atria have thin, non-muscular walls, so they can expand to fill with blood brought in from the body by the vena cava, and from the lungs by the pulmonary veins. The ventricles have thick, muscular walls because they are the pumping chambers. The right ventricle pumps blood to the lungs, via the pulmonary vein; the left ventricle pumps blood to the rest of the body, via the aorta. The right ventricle is less muscular than the left, keeping the blood under lower pressure so it does not damage the delicate tissue of the lungs – which are only a short distance away. The two sides of the heart are separated by a septum, ensuring that oxygenated and deoxygenated blood do not mix.

6. Fish have a single-loop system with blood being pumped by a two-chambered heart. Blood passes through the gills to collect O_2 and offload CO_2, then continues around the body. This is sufficient to meet the needs of fish, which live in an aquatic environment. Birds and mammals have a completely separate double system (two separate loops – one heart–lungs, other heart–rest of body). No mixing of oxygenated and deoxygenated blood occurs with a four-chambered heart. One loop circulates to the lungs to get O_2 and offload CO_2, the other circulates around the body supplying the cells' needs. A completely separate double system is needed to meet the high energy demands

 ISBN 978-0-947504-91-5

of these animal groups. In fish, blood loses a lot of pressure as it flows through the gills. This leaves only low pressure to continue the circulation of the blood around the body and back to the heart. Muscular movements from swimming are needed to help circulation. Buoyancy of water assists, as fish do not have to pump blood upwards against gravity (unlike terrestrial animals). The double circulation of birds and mammals, with two circuits involving the heart, assists in maintaining pressure for efficient circulation around the body. This allows for an active terrestrial lifestyle.

7. Three clearly different taxonomic (e.g. earthworms, insects, mammals) or functional groups (e.g. open blood system, single-circulation closed system, double-circulation closed system) need to be selected. For *each* group:

- *Describe* the ways in which the animals *transport the substances* around their bodies, from where substances enter the system to where they leave the system. Include the *structures* concerned (e.g. heart, vessels (arteries, veins, capillaries), haemocoel, plasma, oxygen-carrying pigments, blood cells) as well as *naming* the substances carried (e.g. O_2, CO_2, urea, mineral ions, nutrient, glucose, amino acids, hormones, blood proteins).
- *Explain* the ways in which the animals transport the substances around their bodies, from where substances enter the system to where they leave the system. Include how the structures *function* in transporting substances (e.g. how blood circulates – pumping of the heart, operation of valves, muscular movements), the need for oxygen-carrying pigments, the composition of plasma and changes to it, oxygenation and deoxygenation of blood (where and how it occurs), and changes in blood pressure.
- *Discuss* the ways in which the animals transport the substances around their bodies, from where substances enter the system to where they leave the system. This *compares* the groups of animals and gives *reasons for similarities and differences* – e.g. whether the animals are aquatic or terrestrial, whether they obtain oxygen from water or air and different gas exchange sites and structures, comparative activity levels of the animals, and comparative size of the animals.

8. Three clearly different taxonomic (e.g. earthworms, insects, mammals) or functional groups (e.g. open blood system, single-circulation closed system, double-circulation closed system) need to be selected. For *each* group, the *structures* associated with the transport of substances and the circulation of the blood need to be *described fully and carefully*, *using correct terms*, e.g.:

- the pumping device ('heart') present, and its structure
- the parts (e.g. arteries, veins, capillaries, valves, haemocoel, blood cells, plasma) of the circulatory system, and their structure
- composition of plasma; what substances are transported
- blood cells.

For *each* group, *how* these structures perform their particular function needs to be *explained*, e.g.:

- how the heart pumps blood; how backflow is prevented
- how blood pressure affects circulation
- the role of pigments in transporting oxygen
- how substances enter and leave the blood (and where)
- the role of blood cells, platelets
- the role of the blood vessels.

 ISBN 978-0-947504-91-5

For *each* group, reasons for *differences* between the groups need to be *explained*, e.g.:

- why open systems meet the needs of insects, but not the needs of vertebrates
- why a single circulation system meets the needs of fish, but mammals need a double system
- why some groups have haemocyanin as their oxygen-carrying pigment, while others have haemoglobin
- differences in the role of the blood in carrying O_2 and CO_2 (e.g. insects compared with mammals). The differences need to be related to differences in habitat (e.g. aquatic or terrestrial); gas exchange requirements (e.g. aquatic or air, site of gas exchange, O_2 transport, activity levels of the animals (high or low), size of the animals (large or small), ecological niches (specific adaptations to their habitat and lifestyle).

ESA PUBLICATIONS ISBN 978-0-947504-91-5