

Gaseous exchange in a protozoan, an earthworm and a bony fish essay sample

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All organisms need exchange and transport systems. The gaseous exchange requirements increase as the organism increases in size and complexity.

Demands for water, oxygen and nutrient molecules increase with the size.

Acellular organisms are active in wet conditions only. Their surface is permeable to oxygen, carbon dioxide and water. They have a large surface area to volume ratio, and diffusion distances in their body are small.

Annelida, such as the earthworm, have long, thin, segmented bodies, consisting of three different layers of cells. The surface area to volume ratio is quite large, and diffusion distances are long.

Chordates, such as fish, are also made up of three layers of cells. Their surface area to volume ratio is small, and the diffusion distances are very large. In both earthworms and fish, an efficient transport system, containing haemoglobin, is available to carry oxygen around the body. The surface area to volume ratio is a way of expressing the relationship between these parameters as an organism's size changes. Exchange of materials often occurs through the process of diffusion; in which dissolved molecules or other particles move from areas of higher concentration to areas of lower concentration.

Generally, large organisms use more oxygen and produce more carbon dioxide than smaller organisms of the same species. As the protozoan is very small in size, around 1/10 mm in diameter, it has a very large surface area to volume ratio. It has a large surface area to volume ratio, as it needs to be able to take up all the oxygen it needs by diffusion across the body surface.

The earthworm will also have a relatively large surface area to volume ratio, as the streamlining and shape of their bodies will increase the ratio.

However, larger organisms, like bony fish, will have a much smaller surface area to volume ratio and so will not be able to obtain all of its oxygen needed. Larger organisms like the fish need special respiratory organs to take in the oxygen to keep them alive. Fish have sets of gills that help them take in oxygen from the water they live in. If the layers of thin gill lamellae in the gills are not kept apart by the water, they will stick together and the surface area will be reduced, and it is too small for efficient gas exchange to take place.

This is because surface tension of water clings to the gill, which causes the lamellae to collapse and the effective surface area is reduced to a tiny fraction of what is normal. In order for the fish to stay alive, they need to transfer oxygen from the water into their bloodstream. The gills provide a large surface area, mainly from the filaments and secondary lamellae. Having a large surface area for gaseous exchange means that more oxygen can enter the blood over a given period of time. A single gill of a bony fish consists of a curved gill arch bearing a V-shaped double row of gill filaments.

The protozoa's cell membrane is an external surface that is permeable to gases. The earthworm's skin is also permeable to gases. Fish however, do not have an external surface that is permeable to gases. The thick skin and scales of a fish do not allow gas to diffuse through into their body. Gaseous exchange takes place in the cell membrane of the protozoan, through the

skin of the earthworm, and through gill plates and gill lamellae in bony fish. The protozoan's surface area cannot be increased for gaseous exchange.

Whereas in the earthworms, they are able to increase their size a small bit due to the fact that they have long and very thin bodies. The amount that it increases however is not enough to make a large difference. In fish, the division of the gill surface into lots of gill lamellae, which all carry a number of gill plates, enables the fish to increase the surface area so that more oxygen is allowed to be extracted from the water. In all three organisms being compared, the exchange surface is both thin and moist. In the fish and the earthworm, not only do they have a thin, moist exchange surface, but it also has a good supply of blood.

Large organisms need a circulatory system, as the surface area to volume ratio is small so it cannot keep up with the oxygen demand. Blood flows from an afferent vessel in each gill arch down the inner side of each lamella, across the gill plate, and back to an efferent vessel. Water passes over the gill plates in the opposite direction to the blood supply, so blood meets water with a higher concentration of oxygen than its own. This is known as a counter current mechanism, and it helps to increase the rate of diffusion from water to blood, and it also improves the efficiency in which the fish's gills extract oxygen from the water.

By blood travelling in the opposite direction to the water, it helps to maintain a diffusion gradient all the way along the gill. As this occurs, more oxygen is able to diffuse from the water into the bloodstream. The distance in which

diffusion occurs over affects the rate of gaseous exchange also. A short distance for the oxygen increases the rate of oxygen entry into the blood. In the fish, the blood travelling in the folds of the filaments is very close to the oxygen-containing water, being separated by a very thin membrane only.

Gills have a short diffusion distance that is provided by flattened cells in capillaries and epithelium. This enables oxygen to enter the bloodstream at a much quicker rate. In the single celled organism, the diffusion distance is very short, and so provides a pathway to all parts of its small body. The distance from gas exchange surface to the inside of the organism is short enough for diffusion of gases to be efficient. Earthworms have a large distance in which diffusion needs to occur due to the fact that they have extremely long and thin bodies. Both fish and earthworms have an oxygen carrying pigment in their blood.

This pigment is known as haemoglobin. The gas-carrying capacity of the blood is increased by haemoglobin. Earthworms have haemoglobin dissolved in their blood plasma, whereas bony fish have the haemoglobin in red blood cells. Fish also have a special ventilating mechanism for the gaseous exchange surface. The fish has a positive ventilation mechanism for taking in water and passing it out over their gills. They ventilate using a unidirectional respiration system. This is due to the density of water being too great for the fish to breathe like humans.

The fish expands its buccal cavity, creating a large surface area for the intake of water. Pressure decreases in the cavity, so it is then lower than that

of the external atmospheric pressure, which allows water to enter down a pressure gradient. As the fish closes its mouth, it raises the floor of the cavity, decreasing the volume, but at the same time increasing the pressure. Water is then forced in over the gills. When this occurs, the operculum cavity bulges out, decreasing the pressure, which allows water to be drained over the gills.

Protozoa are small enough to be able to rely on diffusion across their cell membrane and to all parts of its body to let gaseous exchange to occur. Earthworms use diffusion across the cells of their skin, but do also have a blood transport system, containing haemoglobin, which allows oxygen to be transported to and from its cells. Fish have gills to give themselves an enormous internal surface. They are able to take in as much oxygen as they need, with the help of a counter current mechanism, and are also able to actively ventilate this surface.