Please note – These are extracts from one student's response

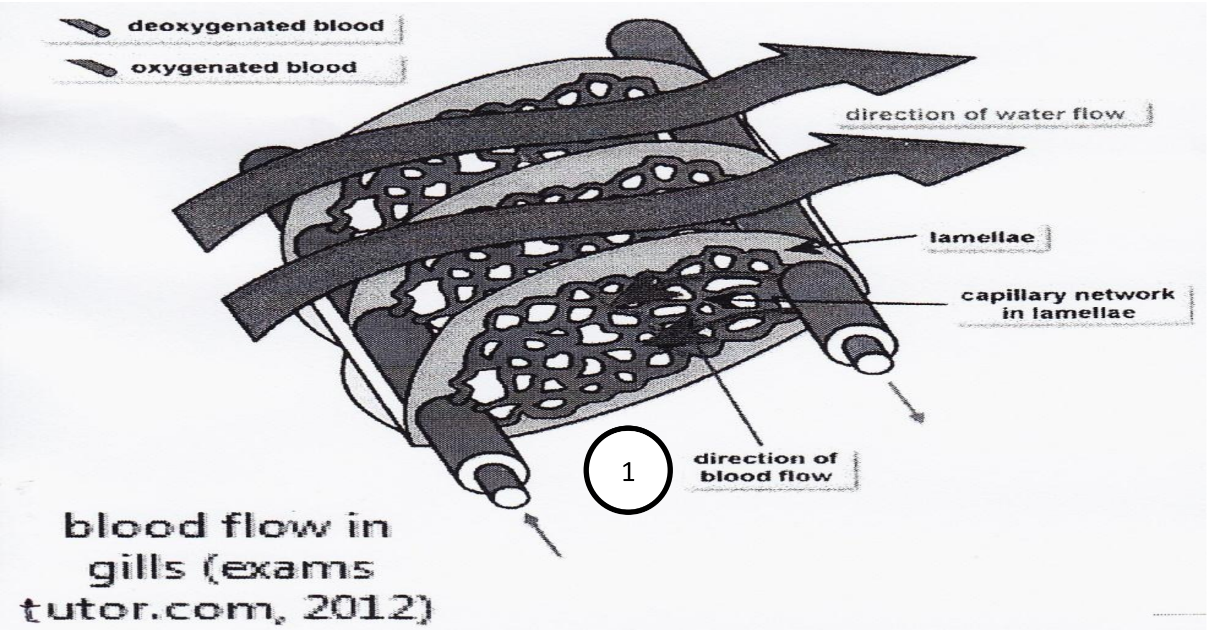
4 All living organisms respire. Cells need and use the energy that is formed through this process to assist with life processes in order for organisms to survive and reproduce. Oxygen and carbon dioxide are the main gases involved in aerobic respiration. Gas exchange is a physical process by which oxygen is extracted from the air and into the bloodstream, while carbon dioxide is simultaneously released. Gas exchange is the diffusion of these gases into and out of cells, and this is essential for respiration to occur.

For diffusion and therefore gas exchange to occur quickly there must be a large surface area 2
to volume ratio for the gas exchange to take place, a partial pressure gradient for the gases to diffuse down, a thin surface that gases can diffuse rapidly across and a moist surface that gases can dissolve and diffuse into and out of. These conditions are called gas exchange surfaces.

Reptiles, mammals and fish are vertebrates which all require oxygen (O_2) to survive, and all carry out gas exchange. They have different ways of carrying this out, related to their habitat in order to occupy a specific ecological niche.

3 Fish live in water. They carry out gas exchange in a different way to mammals. They use gills and the flow of water over their gills to take O_2 and to remove CO_2. A fish breathes as it swims by opening its mouth and allowing water to flow over the gills. When the fish opens its mouth the opercula close, meaning that water can flow over the gills and O_2 can be
extracted and CO_2 can be removed. Then the fish closes the mouth and the opercula open, 2
allowing the water to flow out of the fish.

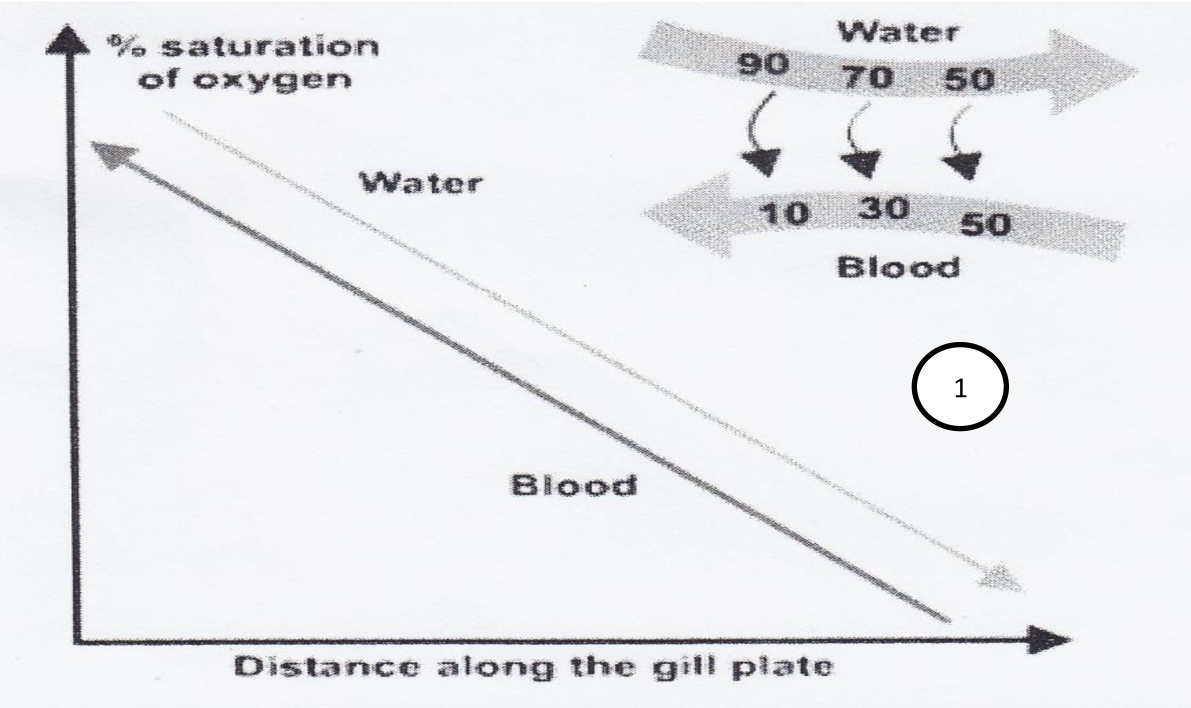
The gills of a fish have filaments, which comb through the water. On the filaments are
1 lamellas. The lamella are shaped like a ladder, so that the O_2 poor blood travels up one side before crossing over to the other side and travelling back down as O_2 rich blood. As the blood travels across, through the capillaries, it takes in O_2 by diffusion.



blood flow in gills (exams tutor.com, 2012)

Oxygenated blood then flows through the body of the fish where mitochondria in cells carry out respiration and ATP is produced to give the fish energy for its life processes. 4

2 A counter current system ensures that the water which meets the blood in the gills always has a greater concentration of oxygen, therefore producing a relatively effective gradient for the diffusion of oxygen into the fish's circulatory system.



(Counter current flow, Google images, 2012)

The diagram shows that water entering the mouth with high oxygen saturation meets the
blood with low oxygen saturation. This allows oxygen to diffuse from the water and across
the lamellae into the capillaries. As the water flows across the lamellae it gradually loses 2
more oxygen but will still allow for diffusion as it flows across incrementally deoxygenated
and unsaturated blood in the capillaries where the concentration and partial pressure of
oxygen is still lower than that of the dwindling concentration in the water. This is more
effective then concurrent flow, in which blood flows the same way as water.

Because there is less oxygen in water it requires fish to use more energy to carry out gas
5 exchange i.e. 20% of its energy. This is much higher than the 1-2% used by terrestrial vertebrates. To accommodate for this, fish are able to remove 80% of the oxygen in water, compared to only the 25% of oxygen removed in air by humans. This is achieved by fish through the counter current flow system, which isn't present or needed in terrestrial animals, as their lower extraction rates provide them with sufficient oxygen due to the drastically higher abundance of oxygen in air.