Aspects of Vertebrate Respiration

Countercurrent exchange in fish gills
the most efficient respiratory system
Four gill arches on each side of head - each with two rows of gill filaments - divided into thin lamellae that project into flow of water
Movement of water across lamellae occurs in only one direction
Direction of blood circulation runs opposite that of water flow
Countercurrent flow maximizes difference in oxygen concentration between water and blood
Countercurrent exchange results in blood always being exposed to water with a higher oxygen concentration. A diffusion gradient is maintained across the surface of gills, allowing blood to become up to 85% saturated with oxygen.

A concurrent exchange system would allow no greater than 50% saturation.
How Hemoglobin Works

Oxygen concentration of blood depends on oxygen concentration of the air or water from which it comes.

Blood plasma can contain only 3 ml O$_2$/liter.
Whole blood contains nearly 200 ml O$_2$/liter.
Most oxygen bound to hemoglobin inside red blood cells.

Hemoglobin - an O$_2$ carrier protein - found in most animals.

Has 4 polypeptide subunits.
Each subunit has an iron containing heme group.
O$_2$ can be carried by each subunit.
Hemoglobin picks up $O_2$ in lungs - becomes oxyhemoglobin
bright red color
Hemoglobin releases $O_2$ at tissues - becomes deoxyhemoglobin
dark red color - looks blue under skin
Hb has asymptotic loading curve
- completely deoxygenated Hb
will take up the first and second $O_2$ molecules easily but picks
up the third and fourth less easily
- completely oxygenated Hb dumps
the fourth and third $O_2$ molecule
reservedly but dumps the
second and first more readily
- allows low amounts of $O_2$ to be
delivered to resting tissue and
large amounts to active tissue
Hb is sensitive to pH and temperature
low pH or high temperature results in a change in the loading curve - the curve shifts to the right
allows greater O₂ delivery to tissue that have low pH or high temperature

Low pH in tissues is associated with active metabolism - through production of CO₂ and lactic acid

\[ \text{H}_2\text{O} + \text{CO}_2 \leftrightarrow \text{H}_2\text{CO}_3 \leftrightarrow \text{H}^+ + \text{HCO}_3^- \]