Transport of gases by blood.

Reading - Chapter 13 in “Animal Physiology”, pages 525-538.

Architecture of the circulatory system.

Reading - Chapter 12

Oxygen-hemoglobin dissociation curve of a pigeon.

The important property of respiratory pigments is that they combine reversibly with oxygen over the range of partial pressures encountered by the animal.

Bohr shift - Dumping of oxygen at the tissues is enhanced by reduced pH.
Tadpole hemoglobin

Effect of body size on Bohr shift in mammals

Solution:

1. Unloading pressure is higher in smaller animals.

2. Capillary density is higher in smaller animals.

3. Bohr shift is greater in smaller mammals.
The mechanism of CO\textsubscript{2} transport is fundamentally different from O\textsubscript{2} transport. CO\textsubscript{2} is 30 times more soluble than O\textsubscript{2}. CO\textsubscript{2} can be eliminated without a giant specialized respiratory surface.
At the tissues.

The combination of O\(_2\) with Hb in the lung causes Hb to become a stronger acid. This displaces CO\(_2\) from the blood.

1. Reduces tendency of CO\(_2\) to combine with -NH\(_2\) groups

2. Drives HCO\(_3^-\) to CO\(_2\) + H\(_2\)O

At the lung.

Arterial-venous change in CO\(_2\)

Bohr effect

Haldane effect
Ventilation, CO₂ and pH

Consider the problems for an animal running in a hot environment.

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

**FIGURE 15–33** Relationship between pCO₂ and pH for blood of normal (closed circles) and panting (open circles) birds and mammals. Dotted lines indicate the uncompensated relationship between pCO₂ and pH for the indicated HCO₃⁻ concentration.

Davenport diagram for a terrestrial vertebrate

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

**FIGURE 15–28** The pH-bicarbonate relationship (Davenport diagram) for human blood. The normal acid–base balance (position N; 1.2 mmol L⁻¹ CO₂, pH 7.4; 5.44 kPa pCO₂) can be disturbed by respiratory acidosis (RAC) or alkalosis (RAL), or metabolic acidosis (MAC) or alkalosis (MAL).

RAC - Respiratory acidosis
RAL - Respiratory alkalosis
MAC - Metabolic acidosis
MAL - Metabolic alkalosis
High rate of ventilation leads to low PCO₂ in blood of aquatic animals.

Concentrations of CO₂ and HCO₃⁻ are an order of magnitude less in aquatic animals.
Aquatic animals regulate respiration by monitoring $O_2$ levels.

Terrestrial animals regulate ventilation by monitoring $CO_2$ levels.

Davenport diagram for a terrestrial vertebrate

We regulate ventilation by monitoring $CO_2$ and we regulate pH by breathing.
Architecture of the circulatory system

From chapter 12 of Eckert
read pages 473-476, 481-495, and 499-511.

Most invertebrates have open circulation.
Mammalian and avian system:
Two circuits - systemic and pulmonary
Lymphatic system

Note - most of the blood resides in the veins in a resting vertebrate.

Control of flow.

See Fig. 12-35
Mammalian and avian heart - a double pump

Why is there a difference in pressure in the left and right ventricles during systole?
Basal vertebrate heart (fish) is/was composed primarily of spongy myocardium.
Controversy -
Did lungs evolve so fish could live in hypoxic water?

or

Did lungs evolve to provide $O_2$ to the heart, allowing increased activity metabolism?

Basal tetrapod heart (frog heart)

Reptile heart