

DIFFUSION

1. Entropy is a measure of disorder.
2. The (empirical) Second Principle of Thermodynamics says that the entropy of the universe, or of any isolated system, always increases.
3. A non-zero concentration gradient is a low-entropy situation.
4. The drive to higher entropy requires that the solute have the same concentration on both sides of the membrane. Thus, material diffuses from the high concentration side to the low concentration side.

BIOLOGICAL MEMBRANES

1. Cell membranes are about 10 nm thick.
2. The thin outer surface of the membrane is water-soluble protein and the bulk of the interior is water-insoluble protein and lipid (fat).
3. Material can move across the membrane by the passive mechanisms of simple diffusion and protein-facilitated transfer. The former is non-selective and the latter is highly selective, but both require a concentration gradient.
4. Material can move across the membrane by an active mechanism - which requires energy and which can move material against a concentration gradient.

GAS TRANSPORT IN BLOOD

1. Inhaled oxygen is carried from the lungs to the metabolizing tissues by hemoglobin (Hb) in red blood cells:



This reaction is reversed at the metabolizing tissues.

2. Most CO₂ is carried from the metabolizing tissues back to the lungs as HCO₃⁻, the bicarbonate ion, dissolved in the aqueous part of the blood:



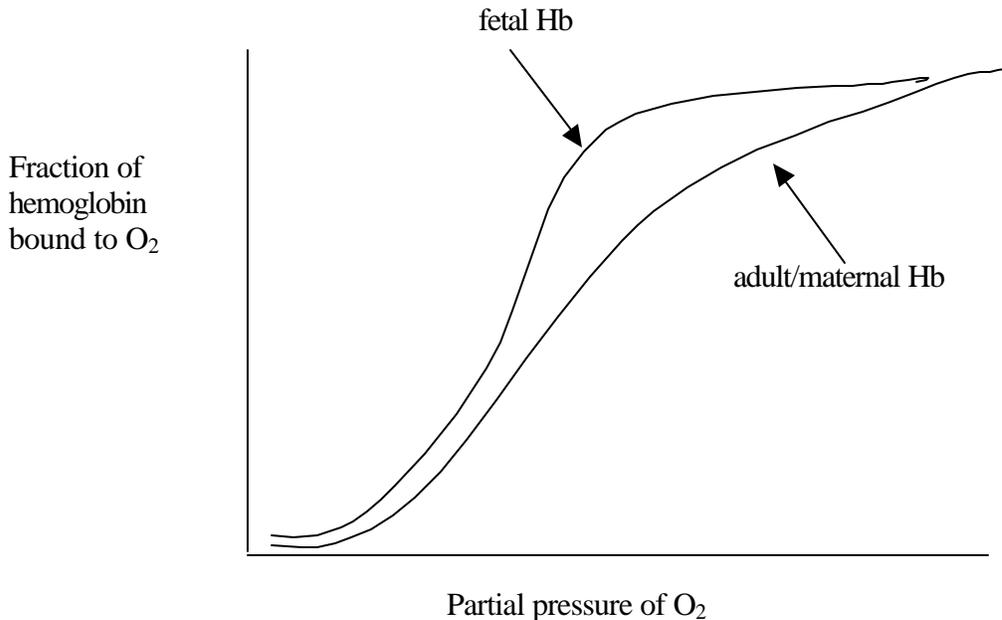
This reaction is reversed at the lungs and the CO₂ is exhaled.

SITES OF GAS EXCHANGE

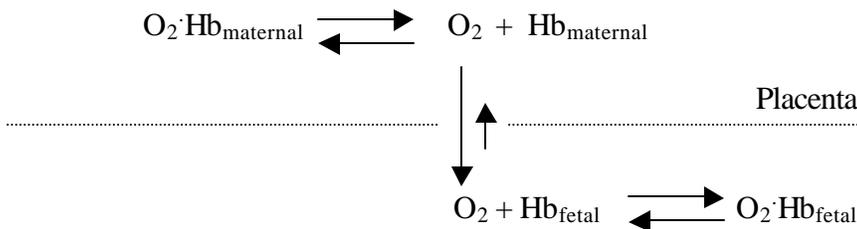
1. Arteries branch into capillaries about the diameter of blood cells. This generates high resistance to blood flow. Heart must be very strong to overcome this
2. The large surface area of capillaries allows high gas exchange rates.
3. Gas exchange surfaces of lungs, kidneys and placenta are extensively folded to give large surface areas.

INTERPLACENTAL TRANSFER OF O₂

- Fetal hemoglobin has a different structure than does adult/maternal hemoglobin. A greater fraction of fetal hemoglobin (Hb_{fetal}) than maternal hemoglobin (Hb_{maternal}) is bound to oxygen for a given partial pressure of oxygen. Thus, Hb_{fetal} has a *higher affinity* for O₂ than does Hb_{maternal}.



- Oxygenated (and nutrient-rich) blood from the mother goes to her side of the placenta.
- O₂ diffuses across the placenta. The net movement of O₂ is toward the fetal side of the membranes because of the higher O₂ concentration on the maternal side and because of the higher O₂ affinity of Hb_{fetal}, compared to Hb_{maternal}.



- Fetal blood and maternal blood do not mix. Fetal blood is shunted past the fetal lungs because the fetus gets its O₂ from its mother, not from its own lungs.
- Most fetal CO₂ is carried in a dissolved form as the bicarbonate ion and thus hemoglobin is less involved than for oxygen movement. However, the exchange of CO₂ is also across the placental membranes and, as expected, is driven by the greater partial pressure of CO₂ on the fetal side.