Hemoglobin Encyclopedia Article

Hemoglobin

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Contents

Hemoglobin Encyclopedia Article.....1

Contents.....2

Hemoglobin.....3

Hemoglobin

Hemoglobin is a protein found in red **blood** cells that functions in transporting oxygen to peripheral tissues of the body. Each red blood cell (RBC) has about 280 million hemoglobin molecules and roughly 2.5 million new RBCs are produced every second. Adult hemoglobin (HbA) is composed of four highly folded polypeptide chains including two alpha globin subunits and two beta globin subunits. Fetal hemoglobin (HbF), however, is made up of two alpha and two gamma globin subunits. The globin genes are expressed in a tissue-specific and developmentally regulated manner. Molecular cues cause a neonatal switch in the production of HbF to HbA. Normally, globin subunits are produced in equal amounts and permanently join together for the life of a RBC. Each polypeptide chain has an iron containing heme group that reversibly binds oxygen. Up to four molecules of oxygen can bind to one molecule of hemoglobin. Hemoglobinopathies (defects in hemoglobin) such as **sickle cell anemia** and thalassemia, represent genetic diseases that involve abnormal hemoglobin.

The ability of hemoglobin to bind to oxygen is a function of the partial pressure of oxygen (pO_2). Oxygen loading onto hemoglobin in the **lungs** is cooperative in that when the first oxygen molecule binds, it induces conformational changes in the structure of hemoglobin that allows other molecules of oxygen to bind more readily. Fully oxygenated hemoglobin, as it arrives at peripheral tissues, gives up approximately 25% of the oxygen bound to hemoglobin under normal resting conditions (where the pO_2 is typically 40 mm Hg). The other 75% represents an oxygen reserve that is only utilized during reduced pO_2 (below 40 mm Hg, such as during exercise). The allosteric interactions of the four polypeptide subunits results in an oxygen-equilibrium curve that is S-shaped, or sigmoidal.

Many factors can shift the oxygen-hemoglobin dissociation curve, such as pH, temperature, byproducts of cellular respiration, or CO_2. Lower pH levels decrease the affinity of hemoglobin for oxygen, a phenomenon known as the Bohr effect. For example, when muscle **tissue** contracts repeatedly, the cells utilize the oxygen reserves to produce more **ATP**. ATP production releases heat leading to an increase in temperature surrounding the active tissues. Byproducts of cellular respiration such as CO_2 and 2,3-diphosphoglycerate are also released, contributing to a reduction in the pH of the tissues (CO_2 reacts with water to produce carbonic acid). All these factors cause a shift to the right in the oxygen-hemoglobin dissociation curve.