Blood ph and other details

As you may already know, pH is a measure of the concentration of H+ ions in a liquid. When a pH value is lower than 7.0, the concentration of H+ ions is high and the solution is termed acid. Inversely, if the pH value is higher than 7.0, the concentration of H+ ions is low, and the solution is termed basic, or alkaline.

The concentration of H+ ions, hence pH, is a *very* important factor in any enzymatic reaction. One enzyme may work well at pH 4 while another works better at pH 8.

We, however, have evolved from a marine organism that lived in salted water many millions of years ago. This organism was, obviously, alive and had already a lot of enzymes and proteins working to make sure that it could get enough energy from its environment to reproduce and survive.

As this organism comes from the ocean, all of its enzymes were accustomed to work at a pH near that of the ocean (this goes back to bacterias and microscopic algae that live in water near the shore of oceans). This is why some say that blood pH is the same as the ocean (and concentrations of salt and other electrolytes is also highly similar to that of the ocean... explaining the salty taste of blood).

As evolution is a process that keeps the good and scraps the bad, it tried to shape new things while keeping what worked well. In this case the enzymes that did so well for the early organisms were mostly kept and the conditions to make them work dictated which new enzymes were kept and which were not.

Over millions of year of evolution, with the appearance of lizards, Dinosaurs and mammals, blood pH remained somewhat a constant ensuring that every biochemical reactions that has to occur in order to keep you alive at each second can occur. If the blood pH increase or decrease by even a tenth of a pH unit (0.1 pH), the body will immediately try to correct the situation as the homeostasis (which dictates life) of the organism is in critical danger.

The three mechanisms that act if there is a deregulation of pH are:

- The chemical buffers present in the blood (bicarbonate/carbonic acid, monosodium phosphate/bisodium phosphate, proteins/proteinates),

- The respiratory center of the cerbral trunk (which, by increasing or decreasing breathing will alter the concentration of carbonic acid in the blood)

- The regulation of water and ions retention by kidneys.

All those mechanisms ensure that blood pH does not change (or so little) in order to keep *you* alive.

Now if blood pH increase too much (higher than 7.8), the organism will become excited (mainly because the neurons of the brain have too much facility to conduct their signals... even if they should not!) and enter a tetanic and convulsive state which will easily lead to death.

On the opposite side, if the pH drops too much (below 7.0), the organism become catatonic then comatose and then die (mainly because neurons cannot conduct their signals).

Many physiological manifestations occur that will make you know that there is a problem with your blood pH. If you hyperventilate, because of an anxiety attack for example, you will decrease CO_2 concentration in the blood which in turn will cause a direct increase in pH (soluble CO_2 is transformed in carbonic acid in the blood... no more CO_2, no more carbonic acid... hence pH increase!). This drop in pH will be detected by your brain and it will try to shut the blood circulation to your brain in order to try to limit the damages... the result? You faint! After fainting, you will resume normal breathing because the reflex breathing will kick in so that CO2 concentration and pH in the blood will return to normal. You then wake up feeling better.

There are many more examples on how blood pH variations can have direct physiological effects in order to try to return things to normal (ie. keeping homeostasis).

The body's balance between acidity and alkalinity is referred to as acid-base balance. The acidity or alkalinity of any solution, including blood, is indicated on the pH scale.

The blood's acid-base balance is precisely controlled, because even a minor deviation from the normal range can severely affect many organs. The body uses different mechanisms to control the blood's acid-base balance.

Role of the Lungs

One mechanism the body uses to control blood pH involves the release of carbon dioxide from the lungs. Carbon dioxide, which is mildly acidic, is a waste product of the metabolism of oxygen (which all cells need) and, as such, is constantly produced by cells. As with all waste products, carbon dioxide gets excreted into the blood. The blood carries carbon dioxide to the lungs, where it is exhaled. As carbon dioxide accumulates in the blood, the pH of the blood decreases (acidity increases). The brain regulates the amount of carbon dioxide that is exhaled by controlling the speed and depth of breathing. The amount of carbon dioxide exhaled, and consequently the pH of the blood, increases as breathing becomes faster and deeper. By adjusting the speed and depth of breathing, the brain and lungs are able to regulate the blood pH minute by minute.

Role of the Kidneys

The kidneys are also able to affect blood pH by excreting excess acids or bases. The kidneys have some ability to alter the amount of acid or base that is excreted, but because the kidneys make these adjustments more slowly than the lungs do, this compensation generally takes several days.

Buffer Systems

Yet another mechanism for controlling blood pH involves the use of buffer systems, which guard against sudden shifts in acidity and alkalinity. The pH buffer systems are combinations of the body's own naturally occurring weak acids and weak bases. These weak acids and bases exist in balance under normal pH conditions. The pH buffer systems work chemically to minimize changes in the pH of a solution by adjusting the proportion of acid and base. The most important pH buffer system in the blood involves carbonic acid (a weak acid formed from the carbon dioxide dissolved in blood) and bicarbonate ions (the corresponding weak base).

Acidosis and Alkalosis

There are two abnormalities of acid-base balance.

- Acidosis: The blood has too much acid (or too little base), resulting in a decrease in blood pH.
- Alkalosis: The blood has too much base (or too little acid), resulting in an increase in blood pH.

Acidosis and alkalosis are not diseases but rather are the result of a wide variety of disorders. The presence of acidosis or alkalosis provides an important clue to doctors that a serious problem exists.

Acidosis and alkalosis are categorized as metabolic or respiratory, depending on their primary cause. Metabolic acidosis and metabolic alkalosis are caused by an imbalance in the production of acids or bases and their excretion by the kidneys. Respiratory acidosis and respiratory alkalosis are caused primarily by changes in carbon dioxide exhalation due to lung or breathing disorders.

Blood is normally slightly basic, with a pH range of 7.35 to 7.45. To function properly, the body maintains the pH of blood close to 7.40.

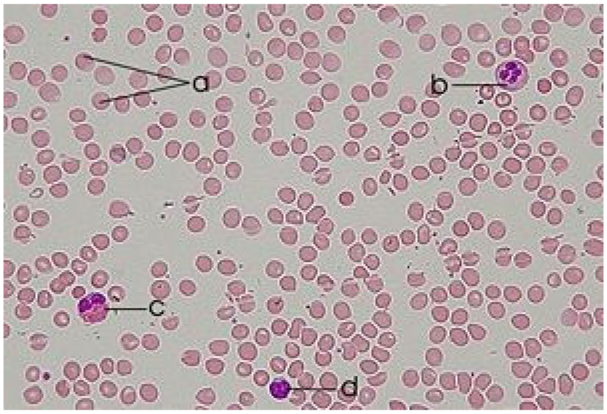
Phagolysosomal pH of human neutrophils

The normal range for pH of blood for sustaining human life is 7.35-7.45. If pH is below 7.35, it is considered acidosis; if it is above 7.45, it is alkalosis. The cause is respiratory or metabolic and the entire Arterial Blood Gas Sample is analyzed to determine whether it is respiratory acidosis, respiratory alkalosis, metabolic acidosis, or metabolic alkalosis--compensated or uncompensated.

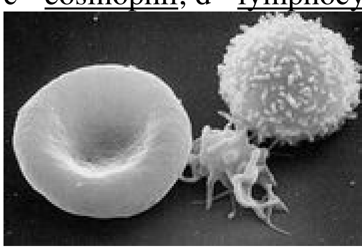
pH of 7.0, as defined by the 'concentration of $H3O+$ equaling the concentration of $OH-$ in pure water', is a standard to determine how other solutions compare. Blood is not a solution, but it is really technically more like a liquid matrix of cells, ions, crystals, and debris. If you ask a biologist, he will state blood acts like a tissue with a function of it's own to support the body equilibrium.

In order for the human body to survive, it can only handle a small range of pH deviation. Depending on what type of acidosis or alkalosis, the body will compensate or try to recover. If no medical attention, it will go into as state of shock and will be unresponsive to resuscitation.

Blood



Human blood smear:
a - erythrocytes; b - neutrophil;
c - eosinophil; d - lymphocyte.



A scanning electron microscope (SEM) image of a normal red blood cell, a platelet, and a white blood cell.

Blood is a specialized bodily fluid that delivers necessary substances to the body's cells—such as nutrients and oxygen—and transports waste products away from those same cells.

In vertebrates it is composed of blood cells suspended in a liquid called blood plasma. Plasma, which comprises 55% of blood fluid, is mostly water (90% by volume), and contains dissolved proteins, glucose, mineral ions, hormones, carbon dioxide (plasma being the main medium for excretory product transportation), platelets and blood cells themselves. The blood cells present in blood are mainly red blood cells (also called RBCs or erythrocytes) and white blood cells, including leukocytes and platelets (also called thrombocytes).

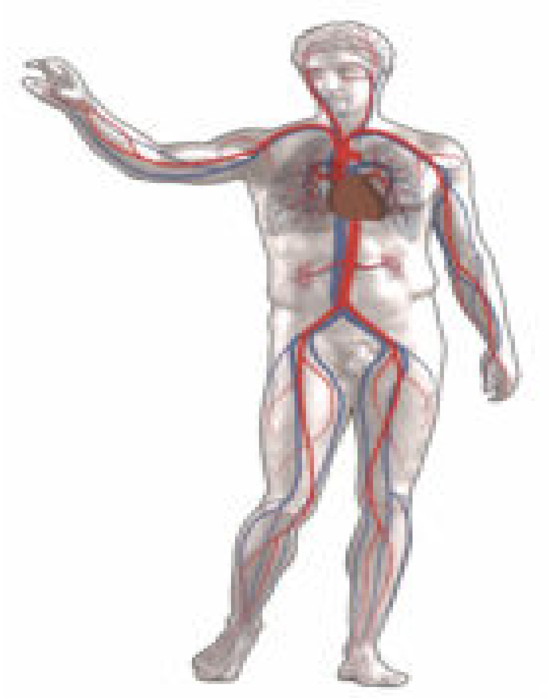
The most abundant cells in vertebrate blood are red blood cells. These contain hemoglobin, an iron-containing protein, which facilitates transportation of oxygen by reversibly binding to this respiratory gas and greatly increasing its solubility in blood. In contrast, carbon dioxide is almost entirely transported extracellularly dissolved in plasma as bicarbonate ion.

Vertebrate blood is bright red when its hemoglobin is oxygenated. Some animals, such as crustaceans and mollusks, use hemocyanin to carry oxygen, instead of hemoglobin. Insects and some molluscs use a fluid called hemolymph instead of blood, the difference being that hemolymph is not contained in a closed circulatory system. In most insects, this 'blood' does not contain oxygen-carrying molecules such as hemoglobin because their bodies are small enough that their tracheal system suffices for supplying oxygen.

Jawed vertebrates have an adaptive immune system, based largely on white blood cells. White blood cells help to resist infections and parasites. Platelets are important in the clotting of blood. Arthropods, using hemolymph, have hemocytes as part of their immune system.

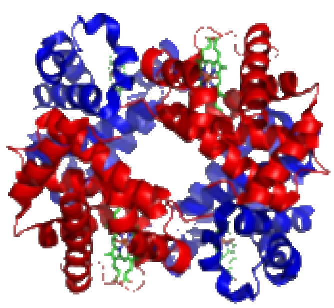
Blood is circulated around the body through blood vessels by the pumping action of the heart. In animals having lungs, arterial blood carries oxygen from inhaled air to the tissues of the body, and venous blood carries carbon dioxide, a waste product of metabolism produced by cells, from the tissues to the lungs to be exhaled.

Medical terms related to blood often begin with ***hemo-*** or ***hemato-*** (BrE: *haemo-* and *haemato-*) from the Greek word '*α□ μα*' for 'blood.' Anatomically and histologically, blood is considered a specialized form of connective tissue, given its origin in the bones and the presence of potential molecular fibers in the form of fibrinogen.

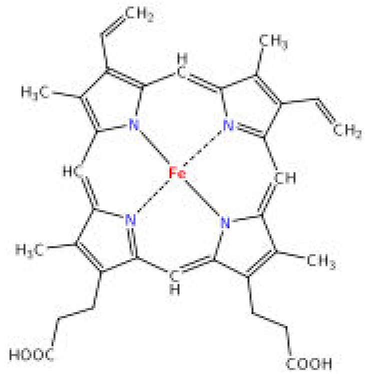


Blood circulation:
Red = oxygenated
Blue = deoxygenated

Functions



Hemoglobin
green = heme groups
red & blue = protein subunits



Heme

Blood performs many important functions within the body including:

- Supply of oxygen to tissues (bound to hemoglobin which is carried in red cells)
- Supply of nutrients such as glucose, amino acids and fatty acids (dissolved in the blood or bound to plasma proteins (eg blood lipids)
- Removal of waste such as carbon dioxide, urea and lactic acid
- Immunological functions, including circulation of white cells, and detection of foreign material by antibodies.
- Coagulation, which is one part of the body's self-repair mechanism
- Messenger functions, including the transport of hormones and the signaling of tissue damage
- Regulation of body pH (the normal pH of blood is in the range of 7.35 - 7.45)
- Regulation of core body temperature
- Hydraulic functions

Constituents of human blood

Blood accounts for 7% of the human body weight, with an average density of approximately 1060 kg/m^3, very close to pure water's density of 1000 kg/m^3. The average adult has a blood volume of roughly 5 litres, composed of plasma and several kinds of cells (occasionally called *corpuscles*); these formed elements of the blood are erythrocytes (red blood cells), leukocytes (white blood cells) and thrombocytes (platelets). By volume the red blood cells constitute about 45% of whole blood, the plasma constitutes about 55%, and white cells constitute a minute volume.

Whole blood (plasma and cells) exhibits non-Newtonian fluid dynamics; its flow properties are adapted to flow effectively through tiny capillary blood vessels with less resistance than plasma by itself. In addition, if all human hemoglobin was free in the plasma rather than being contained in RBCs, the circulatory fluid would be too viscous for the cardiovascular system to function effectively.

Cells

One microliter of blood contains:

- **4.7 to 6.1 million (for male), 4.2 to 5.4 million (for female) erythrocytes:** In mammals, mature red blood cells lack a nucleus and organelles. They contain the blood's hemoglobin and distribute oxygen. The red blood cells (together with endothelial vessel cells and other cells) are also marked by glycoproteins that define the different blood types. The proportion of blood occupied by red blood cells is referred to as the hematocrit, and is normally about 45%. The combined surface area of all the red cells in the human body would be roughly 2,000 times as great as the body's exterior surface.
- **4,000-11,000 leukocytes:** White blood cells are part of the immune system; they destroy and remove old or aberrant cells and cellular debris, as well as attack infectious agents (pathogens) and foreign substances. The cancer of leukocytes is called leukemia.
- **200,000-500,000 thrombocytes:** thrombocytes, also called platelets, are responsible for blood clotting (coagulation). They change fibrinogen into fibrin. This fibrin creates a mesh onto which red blood cells collect and clot, which then stops more

blood from leaving the body and also helps to prevent bacteria from entering the body.

Plasma

Constitution of normal blood	
Parameter	**Value**
Hematocrit	45 ± 7 (38-52%) for males 42 ± 5 (37-47%) for females
pH	7.35-7.45
base excess	-3 to +3
PO_2	10-13kPa (80-100 mmHg)
PCO_2	4.8kPa - 5.8kPa (35-45 mmHg)
HCO_3^-	21mM - 27mM
Oxygen saturation	Oxygenated: 98-99% Deoxygenated: 75%

About 55% of whole blood is blood plasma, a fluid that is the blood's liquid medium, which by itself is straw-yellow in color. The blood plasma volume totals of 2.7-3.0 litres in an average human. It is essentially an aqueous solution containing 92% water, 8% blood plasma proteins, and trace amounts of other materials. Plasma circulates dissolved nutrients, such as, glucose, amino acids and fatty acids (dissolved in the blood or bound to plasma proteins), and removes waste products, such as, carbon dioxide, urea and lactic acid.

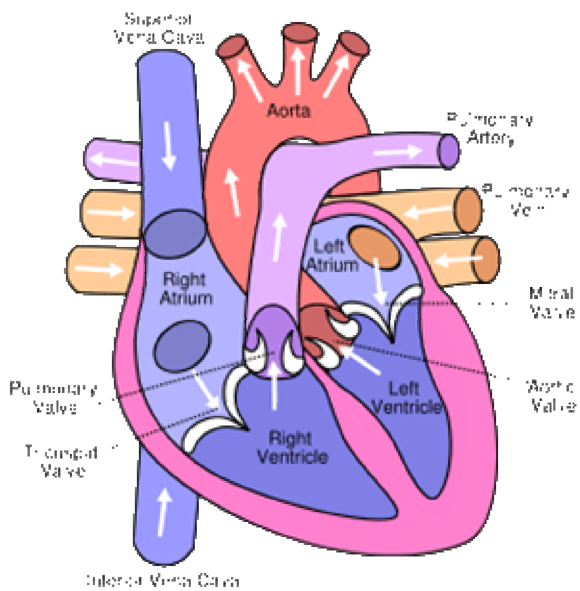
Other important components include:

- Serum albumin
- Blood clotting factors (to facilitate coagulation)
- Immunoglobulins (antibodies)
- lipoprotein particles
- Various other proteins
- Various electrolytes (mainly sodium and chloride)

The term *serum* refers to plasma from which the clotting proteins have been removed. Most of the proteins remaining are albumin and immunoglobulins.

The normal pH of human arterial blood is approximately 7.40 (normal range is 7.36-7.44), a weak alkaline solution. Blood that has a pH below 7.35 is too acidic, while blood pH above 7.45 is too alkaline. Blood pH, partial pressure of oxygen (PaO_2), partial pressure of carbon dioxide($PaCO_2$) and HCO_3 are carefully regulated by a number of homeostatic mechanisms, which principally exert their influence through influence the respiratory system and the urinary system in the control the acid-base balance and respiration. Plasma also circulates hormones transmitting their messages to various tissues. The list of normal reference ranges for various blood electrolytes is extensive.

Physiology



Cardiovascular system

The circulation of blood through the human heart: Circulatory system

Blood is circulated around the body through blood vessels by the pumping action of the heart. In humans, blood is pumped from the strong left ventricle of the heart through arteries to peripheral tissues and returns to the right atrium of the heart through veins. It then enters the right ventricle and is pumped through the pulmonary artery to the lungs and returns to the left atrium through the pulmonary veins. Blood then enters the left ventricle to be circulated again. Arterial blood carries oxygen from inhaled air to all of the cells of the body, and venous blood carries carbon dioxide, a waste product of metabolism by cells, to the lungs to be exhaled.

However, one exception includes pulmonary arteries which contains the most deoxygenated blood in the body, while the pulmonary veins contain oxygenated blood.

Additional return flow may be generated by the movement of skeletal muscles which can compress veins and push blood through the valves in veins towards the right atrium.

The blood circulation was famously described by William Harvey in 1628.

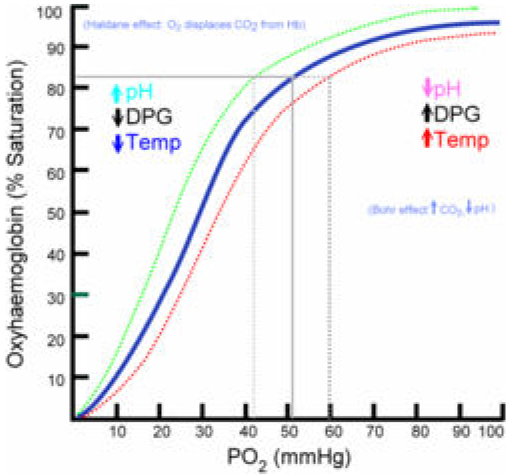
Production and degradation of blood cells

In vertebrates, the various cells of blood are made in the bone marrow in a process called hematopoiesis, which includes erythropoiesis, the production of red blood cells; and myelopoiesis, the production of white blood cells and platelets.

During childhood, almost every human bone produces red blood cells; as adults, red blood cell production is limited to the larger bones: the bodies of the vertebrae, the breastbone (sternum), the ribcage, the pelvic bones, and the bones of the upper arms and legs. In addition, during childhood, the thymus gland, found in the mediastinum, is an important source of lymphocytes. The proteinaceous component of blood (including clotting proteins) is produced predominantly by the liver, while hormones are produced by the endocrine glands and the watery fraction is regulated by the hypothalamus and maintained by the kidney.

Healthy erythrocytes have a plasma life of about 120 days before they are degraded by the spleen, and the Kupffer cells in the liver. The liver also clears some proteins, lipids and amino acids. The kidney actively secretes waste products into the urine.

Oxygen transport



Basic hemoglobin saturation curve. It is moved to the right in higher acidity (more dissolved carbon dioxide) and to the left in lower acidity (less dissolved carbon dioxide)

About 98.5% of the oxygen in a sample of arterial blood in a healthy human breathing air at sea-level pressure is chemically combined with the Hgb. About 1.5% is physically dissolved in the other blood liquids and not connected to Hgb. The hemoglobin molecule is the primary transporter of oxygen in mammals and many other species.

With the exception of pulmonary and umbilical arteries and their corresponding veins, arteries carry oxygenated blood away from the heart and deliver it to the body via arterioles and capillaries, where the oxygen is consumed; afterwards, venules and veins carry deoxygenated blood back to the heart.

Under normal conditions in humans at rest, hemoglobin in blood leaving the lungs is about 98-99% saturated with oxygen. In a healthy adult at rest, *deoxygenated* blood returning to the lungs is still approximately 75% saturated.

Increased oxygen consumption during sustained exercise reduces the oxygen saturation of venous blood, which can reach less than 15% in a trained athlete; although breathing rate and blood flow increase to compensate, oxygen saturation in arterial blood can drop to 95% or less under these conditions. Oxygen saturation this low is considered dangerous in an individual at rest (for instance, during surgery under anesthesia. Sustained hypoxia, (oxygenation of less than 90%) is dangerous to health, and severe hypoxia (saturations of less than 30%) may be rapidly fatal.

A fetus, receiving oxygen via the placenta, is exposed to much lower oxygen pressures (about 21% of the level found in an adult's lungs) and so fetuses produce another form of hemoglobin with a much higher affinity for oxygen (hemoglobin F) in order to function under these conditions.

Carbon dioxide transport

When blood flows through capillaries, carbon dioxide diffuses from the tissues into the blood. Some carbon dioxide is dissolved in the blood. Some carbon dioxide reacts with hemoglobin and other proteins to form carbamino compounds. The remaining carbon dioxide is converted to bicarbonate and hydrogen ions through the action of RBC carbonic anhydrase. Most carbon dioxide is transported through the blood in the form of bicarbonate ions.

Carbon dioxide (CO_2), the main cellular waste product is carried in blood mainly dissolved in plasma, in equilibrium with bicarbonate (HCO_3^-) and carbonic acid (H_2CO_3). 86%-90% of CO_2 in the body is converted into carbonic acid, which can quickly turn into bicarbonate, the chemical equilibrium being important in the pH buffering of plasma. Blood pH is kept in a narrow range (pH between 7.35-7.45).

Transport of hydrogen ions

Some oxyhemoglobin loses oxygen and becomes deoxyhemoglobin. Deoxyhemoglobin binds most of the hydrogen ions as it has a much greater affinity for more hydrogen than does oxyhemoglobin.

Lymphatic system

In mammals, blood is in equilibrium with lymph, which is continuously formed in tissues from blood by capillary ultrafiltration. Lymph is collected by a system of small lymphatic vessels and directed to the thoracic duct, which drains into the left subclavian vein where lymph rejoins the systemic blood circulation.

Thermoregulation

Blood circulation transports heat throughout the body, and adjustments to this flow are an important part of thermoregulation. Increasing blood flow to the surface (e.g. during warm weather or strenuous exercise) causes warmer skin, resulting in faster heat loss, while decreasing surface blood flow conserves heat.

Hydraulic functions

The restriction of blood flow can also be used in specialized tissues to cause engorgement resulting in an erection of that tissue; examples are the erectile tissue in the penis, nipples or clitoris.

Another example of a hydraulic function is the jumping spider, in which blood forced into the legs under pressure causes them to straighten for a powerful jump, without the need for bulky muscular legs.

Invertebrates

In insects, the blood (more properly called hemolymph) is not involved in the transport of oxygen. (Openings called tracheae allow oxygen from the air to diffuse directly to the tissues). Insect blood moves nutrients to the tissues and removes waste products in an open system.

Other invertebrates use respiratory proteins to increase the oxygen carrying capacity. Hemoglobin is the most common respiratory protein found in nature. Hemocyanin (blue) contains copper and is found in crustaceans and mollusks. It is thought that tunicates (sea squirts) might use vanabins (proteins containing vanadium) for respiratory pigment (bright green, blue, or orange).

In many invertebrates, these oxygen-carrying proteins are freely soluble in the blood; in vertebrates they are contained in specialized red blood cells, allowing for a higher concentration of respiratory pigments without increasing viscosity or damaging blood filtering organs like the kidneys.

Giant tube worms have unusual hemoglobins that allow them to live in extraordinary environments. These hemoglobins also carry sulfides normally fatal in other animals.

Color

Hemoglobin

A bleeding finger

Hemoglobin is the principal determinant of the color of blood in vertebrates. Each molecule has four heme groups, and their interaction with various molecules alters the exact color. In vertebrates and other hemoglobin-using creatures, arterial blood and capillary blood are bright red as oxygen imparts a strong red color to the heme group. Deoxygenated blood is a darker shade of red; this is present in veins, and can be seen during blood donation and when venous blood samples are taken. Blood in carbon monoxide poisoning is bright red, because carbon monoxide causes the formation of carboxyhemoglobin. In cyanide poisoning, the body cannot utilize oxygen, so the venous blood remains oxygenated, increasing the redness. While hemoglobin containing blood is never blue, there are several conditions and diseases where the color of the heme groups makes the skin appear blue. If the heme is oxidized, methemoglobin, which is more brownish and cannot transport oxygen, is formed. In the rare condition sulfhemoglobinemia, arterial hemoglobin is partially oxygenated, and appears dark-red with a bluish hue (cyanosis).

Veins in the skin appear blue for a variety of reasons only weakly dependent on the color of the blood. Light scattering in the skin, and the visual processing of color play roles as well.

Skinks in the genus *Prasinohaema* have green blood due to a buildup of the waste product biliverdin.

Hemocyanin

The blood of most molluscs - including cephalopods and gastropods - as well as some arthropods, such as horseshoe crabs, is blue, as it contains the copper-containing protein hemocyanin at concentrations of about 50 grams per litre. Hemocyanin is colourless when deoxygenated and dark blue when oxygenated. The blood in the circulation of these creatures, which generally live in cold environments with low oxygen tensions, is grey-white to pale yellow, and it turns dark blue when exposed to the oxygen in the air, as seen when they bleed. This is due to change in color of hemocyanin when is it oxidized. Hemocyanin carries oxygen in extracellular fluid, which is in contrast to the intracellular oxygen transport in mammals by hemoglobin in RBCs.

Vacuum

If human blood was exposed to vacuum, it would lose all oxygen (bound to the hemoglobin molecules in its red cells) as it does in part when it supplies oxygen to various organs as it passes through the body. This state of deoxyhemoglobin has a purplish colour.

Pathology

General medical disorders

- Disorders of volume
  - Injury can cause blood loss through bleeding. A healthy adult can lose almost 20% of blood volume (1L) before the first symptom, restlessness, begins, and 40% of volume (2L) before shock sets in.
  - Thrombocytes are important for blood coagulation and the formation of blood clots which can stop bleeding.
  - Trauma to the internal organs or bones can cause internal bleeding, which can sometimes be severe.
  - Dehydration can reduce the blood volume by reducing the water content of the blood. This would rarely result in shock (apart from the very severe cases) but may result in orthostatic hypotension and fainting.

- Disorders of circulation
  - Shock is the ineffective perfusion of tissues, and can be caused by a variety of conditions including blood loss, infection, and poor cardiac output.
  - Atherosclerosis reduces the flow of blood through arteries, because atheroma lines arteries and narrows them. Atheroma tends to increase with age, and its progression can be compounded by many causes including smoking, high blood pressure, excess circulating lipids (hyperlipidemia), and diabetes mellitus.
  - Coagulation can form a thrombosis which can obstruct vessels.
  - Problems with blood composition, the pumping action of the heart, or narrowing of blood vessels can have many consequences including hypoxia (lack of oxygen) of the tissues supplied. The term *ischemia* refers to tissue which is inadequately perfused with blood, and *infarction* refers to

tissue death (necrosis) which can occur when the blood supply has been blocked (or is very inadequate).

Hematological disorders

- Anemia
    - Insufficient red cell mass (anemia) can be the result of bleeding, blood diseases like thalassemia, or nutritional deficiencies; and may require blood transfusion. Several countries have blood banks to fill the demand for transfusable blood. A person receiving a blood transfusion must have a blood type compatible with that of the donor.
    - Sickle-cell anemia

- Disorders of cell proliferation
    - Leukemia is a group of cancers of the blood-forming tissues.
    - Non-cancerous overproduction of red cells (polycythemia vera) or platelets (essential thrombocytosis) may be premalignant.
    - Myelodysplastic syndromes involve ineffective production of one or more cell lines.

- Disorders of coagulation
    - Hemophilia is a genetic illness that causes dysfunction in one of the blood's clotting mechanisms. This can allow otherwise inconsequential wounds to be life-threatening, but more commonly results in hemarthrosis, or bleeding into joint spaces, which can be crippling.
    - Ineffective or insufficient platelets can also result in coagulopathy (bleeding disorders).
    - Hypercoagulable state (thrombophilia) results from defects in regulation of platelet or clotting factor function, and can cause thrombosis.

- Infectious disorders of blood

- Blood is an important vector of infection. HIV, the virus which causes AIDS, is transmitted through contact with blood, semen or other body secretions of an infected person. Hepatitis B and C are transmitted primarily through blood contact. Owing to blood-borne infections, bloodstained objects are treated as a biohazard.
- Bacterial infection of the blood is bacteremia or sepsis. Viral Infection is viremia. Malaria and trypanosomiasis are blood-borne parasitic infections.

Carbon monoxide poisoning

Substances other than oxygen can bind to hemoglobin; in some cases this can cause irreversible damage to the body. Carbon monoxide, for example, is extremely dangerous when carried to the blood via the lungs by inhalation, because carbon monoxide irreversibly binds to hemoglobin to form carboxyhemoglobin, so that less hemoglobin is free to bind oxygen, and less oxygen can be transported in the blood. This can cause suffocation insidiously. A fire burning in an enclosed room with poor ventilation presents a very dangerous hazard since it can create a build-up of carbon monoxide in the air. Some carbon monoxide binds to hemoglobin when smoking tobacco.

Medical treatments

Blood products

Blood for transfusion is obtained from human donors by blood donation and stored in a blood bank. There are many different blood types in humans, the ABO blood group system, and the Rhesus blood group system being the most important. Transfusion of blood of an incompatible blood group may cause severe, often fatal, complications, so crossmatching is done to ensure that a compatible blood product is transfused.

Other blood products administered intravenously are platelets, blood plasma, cryoprecipitate and specific coagulation factor concentrates.

Intravenous administration

Many forms of medication (from antibiotics to chemotherapy) are administered intravenously, as they are not readily or adequately absorbed by the digestive tract.

After severe acute blood loss, liquid preparations, generically known as plasma expanders, can be given intravenously, either solutions of salts (NaCl, KCl, $CaCl_2$ etc...) at physiological concentrations, or colloidal solutions, such as dextrans, human serum albumin, or fresh frozen plasma. In these emergency situations, a plasma expander is a more effective life saving procedure than a blood transfusion, because the metabolism of transfused red blood cells does not restart immediately after a transfusion.

Bloodletting

In modern evidence-based medicine bloodletting is used in management of a few rare diseases, including hemochromatosis and polycythemia. However, bloodletting and leeching were common unvalidated interventions used until the 19th century, as many diseases were incorrectly thought to be due to an excess of blood, according to Hippocratic medicine.