Body Systems II
Biology 110 Lecture Notes -- Dr. S. Bryant

CIRCULATORY SYSTEM

The respiratory and circulatory systems work together as a unit to exchange gases between body cells and the environment. There are two major types of circulatory systems in animals, called open & closed. In a closed circulatory system, as in humans, the blood is always supposed to flow in one direction through blood vessels. [In an open circulatory system, blood flows into sinuses. In these spaces, blood simply bathes the tissues, and is then collected into ducts for return to the tubular part of the circulatory system. In humans, the mother's part of the placenta, for instance, has open circulation.]

The heart consists of 2 halves, left and right, each with two parts. The right heart has a blood-receiving chamber called an atrium, and a blood pumping chamber, called a ventricle. The right atrium receives deoxygenated blood from the body, pumps the blood the right ventricle, from which it is pumped to the lungs. The left atrium receives the oxygenated blood, pumps it to the left ventricle, from which it is pumped to body tissues. Arteries are the thick-walled blood vessels which carry high-pressure blood away from the heart; veins are the thin-walled vessels which carry low-pressure blood from the body back to the lungs. Blood pressure is lost as the collective diameter of the very small blood vessels in the body is much greater than the diameter of the aorta, the main artery leaving the left ventricle. Arteries are generally buried deep in the body, running along bones for protection. If you cut a vein, blood oozes or flows out: you don't lose all that much blood from a vein cut. An arterial cut squirts blood out under high pressure, and one can bleed to death from such a cut quite quickly.

Other organisms have different types of hearts: in fish, blood goes from the 2-chambered heart to the gills for oxygenation, then to the body, then back to heart. Amphibians have 3 chambers: 2 atria & 1 ventricle. blood from ventricle goes to both lungs and body, but body & lungs have separate returns. Birds & mammals keep left & right hearts separate, one heart for oxygenation (pulmonary circuit), and one heart for body circulation (systemic circuit).

A heart attack occurs when heart muscle dies due lack of oxygen. This is most commonly caused by the blood flow to a heart artery being shut off by a blood clot forming in an already narrowed artery. Arteries can get narrowed by the formation of plaques, cholesterol-rich deposits that may form when the internal lining of an artery is injured (due to infection, for instance). The medical term for a heart attack is a "myocardial infarct". "Myo" means muscle, "cardial" means muscle, and "infarct" means death. Exercise can increase the size of the heart, just like exercise can increase the size of other muscles. When muscles increase in size, they must also increase their blood flow to supply the new muscle tissue. Some people develop "collateral arteries", which connect the normal arteries supplying the heart muscle. If one has a collateral artery, the heart muscle can be supplied with blood in two directions, so if one direction is blocked, the muscle doesn't die (though it doesn't receive the full oxygenation it did before). "Sudden death" is usually caused by a part of the heart not getting enough oxygen, and then by the electrical system of the heart becoming desynchronized. For the heart to squeeze blood, each muscle fiber in a chamber must contract with the other muscle fibers. If the muscles contract out of sync, the heart just quivers, and doesn't pump blood. This condition is known as fibrillation. If the atria fibrillate, it isn't life-endangering, because when the ventricles expand, they create enough of a vacuum that they can suck in the blood from the atria. However, if the ventricles fibrillate, blood isn't pumped

(to lungs and/or body), and the person will die. A defibrillator is a device that gives an electrical shock to the chest with enough power to (sometimes) resynchronize the heart muscle fibers to they begin beating together again.

When, say, the left ventricle of the heart contracts, blood is simply pushed: it could either go out to the body, or back into the left atrium. However, there are sets of one-way valves that make sure the blood goes into the aorta, rather than back into the atrium. Some of these valves are connected to the inside of the heart by tendon-like cords that prevent the valve from collapsing like an upside-down umbrella in a strong updraft. The common name for these valve cords is "heart strings," popularized in some songs. The sounds of the beating heart are made by the heart valves slamming shut after a contraction.

Blood pressure is a measure of the force exerted against blood vessel walls by the blood under pressure from the beating heart. The first number, called the systolic blood pressure, is the pressure exerted at the heart's maximum contraction. The second number, the diastolic blood pressure, is the pressure exerted when the left ventricle is at maximum relaxation. The actual sounds one hears when taking blood pressure are the artery walls slamming shut after a spurt of blood pass

The body also has what is in effect a second circulatory system, called the lymph system. Fluid from the blood leaks out of the capillaries and bathes the surrounding cells. This fluid is eventually collected into ducts, which come together in swollen "nodes". In the nodes reside white blood cells, which, if they detect foreign invaders in the fluid (called "lymph"), multiply to fight the infection. This gives one "swollen glands" (really swollen lymph nodes) when one has certain infective diseases. You may have had a relative or physician feel under the sides of your jaw when you were sick to check whether the lymph nodes were swollen.

DIGESTIVE SYSTEM

The digestive system consists of several parts, which listed below with their major functions. The digestive system is topologically on the outside of the body; only the materials actually absorbed into the bloodstream become part of the inside of the body. (The body is really a doughnut, with the digestive system as the "hole").

Mouth: this part of the system is used to mechanically break food into smaller chunks, coat it with saliva to make passage to the stomach easy, and to begin the breakdown of starches with an enzyme called salivary amylase (which is part of saliva).

Esophagus: this is basically a passageway for food from the mouth to the stomach. It secretes mucus to coat food, and moves food to the stomach by rippling muscular contractions. It is these muscular contractions that allow you to swallow upside down or in zero gravity. At the stomach end, it has a ring of constricting muscle (called a sphincter), which normally prevents food from coming back up. However, strong contractions of the stomach can cause regurgitation. But, normally, even if you stand on your head, this sphincter prevents food from coming back up. If this muscle is very weak, even small stomach contractions or gas bubbles can push stomach contents back up, and one may have gastroesophogeal reflux disease, or GERD.

Stomach: the stomach churns food, hydrolyzes proteins, and does some fat breakdown. It also mixes food with mucus. It is very acidic, due to the release of hydrochloric acid from the stomach lining.

Small Intestine (small gut): about 20' long, this completes breakdown of fats & other foods using enzymes from the liver (bile from the liver is stored in the gallbladder, and released into the small intestine for fat breakdown, pancreatic enzymes are also released into the small intestine, and so is bicarbonate which helps to neutralize the acid from the stomach. Bile is a complex substance, and has both red and green pigments, which mixed together make brown, and this gives the feces their characteristic color). In the small intestine, fat is emulsified (bound to water) and broken down, and digestion of other foods is completed. The small molecules of the food are then absorbed by the lining of the small intestine, and picked up by the surrounding blood vessels. These blood vessels collect to become the hepatic portal vein, which carries the products of digestion straight to the liver for detoxification and various kinds of chemistry. The liver is a major chemical factory, and makes all sorts of useful stuff out of the digested food. Although the liver can detoxify some chemicals, it can turn some substances into mutation and cancer-causing chemicals. Many chemicals have to pass the "Ames test" before being allowed on the market. This is a test to see whether a certain chemical increases the mutation rate in bacteria. The chemical is mixed with ground rat liver to simulate the chemical processes that occur in the human liver, before being tested on the bacteria.

Large intestine: this part of the digestive system primarily absorbs water and minerals, and prepares the feces. It also houses vitamin-forming bacteria, producing Vitamin K, biotin, and folic acid.. The major portion of the dry weight of feces is actually dead bacteria, mostly of the type known as *E. coli*, which are much used in microbiology and genetics. Gases are produced by the bacteria in the large intestine, and may include nitrogen, methane, and hydrogen sulfide. People normally produce several liters of gas each day. The end of the large intestine is called the rectum, where feces are stored until expelled. Folds in the walls of the rectum help support the weight of the feces so that gravity doesn't produce unpleasant results. The anus is the sphincter at the end of the rectum. This particular sphincter is generally under voluntary control, though if the large gut isn't doing its job of water absorption (often due to a disturbance of the normal bacterial mix), the liquid contents of the large intestine become difficult to hold in the rectum, and one has diarrhea. If the large intestine takes out too much water, one gets hard, dry feces, and has constipation (difficult passage of the feces). In older people, digestion tends to be more inefficient, so there is more material on which bacteria can work. This is one of the reasons older people tend to produce more gas.

Why don't the stomach & other guts digest themselves? It is because the linings of the gastrointestinal (GI) tract actively exclude harmful substances from getting into cells, and are coated with mucus (slime) to protect them. This doesn't always work; then you get an ulcer, which is a digested hole in the lining. If an ulcer goes all the way through, contents can leak out and you can begin to digest your internal organs — this is then very serious.

EXCRETORY SYSTEM

This is the system used to get rid of wastes that are internal to the body. The lungs get rid of CO_2, the skin gets rid of some salt and urea (from breakdown of protein) in sweat, the liver gets rid of some of the breakdown products of red blood cells, which gives bile some of its color and urine some of its color; the large intestine excretes some iron and salt, but the kidney is generally thought of as the major excretory organ. The kidney filters the blood, and takes out

urea, uric acid, and other chemicals, as well as various salts. These are concentrated in a rather intricate process and sent to the bladder as urine. The kidney also plays a large part in maintaining the pH of the blood. The kidney also keeps the water in the blood at a fairly constant concentration. Dialysis is an artificial process used to filter waste from the blood in people whose kidneys are not working properly (renal failure).

NERVOUS SYSTEM

The nervous system consists of the central nervous system (brain and spinal cord) and the peripheral nervous system (everything else). The brain has several major parts: the cerebrum is the "gray matter" of the brain, and is the largest part. This is where conscious thought occurs. The cerebellum is responsibel for posture, muscular contraction and coordination; the medulla or brain stem controls visceral, involuntary functions, such as breathing and digestion. The thalamus is near the bottom of the brain, and controls sense perception; below that is the hypothalamus, which is responsible for homeostasis; below that is the pituitary, the front part of which release hormones to effect the changes commanded by the hypothalamus.

The peripheral nervous system consist of the somatic nervous system and the autonomic nervous system. The somatic nervous system has both receptor nerves, which sense things, and effector nerves, which control muscles. The autonomic nervous system consists of the sympathetic nervous system, which prepares the body for stress, and the parasympathetic nervous system, which brings the body back to normal condition. In some cases, receptor nerves don't have to send signals all the way tot he brain for processing, and then have the brain send signals back to move muscles. If your foot touches something very hot, the spinal cord itself can receive the signal and send a signal to move your foot away; this is a spinal arc.