

Case Study

Heat stroke and Heat exhaustion

If you have ever tried to do some sort of heavy manual labor on a hot day or competed in a physical competition you may have experienced dizziness and weakness. In some cases when it is severe enough you may have even gone as far as to collapsing and loss of consciousness. This is known as heat exhaustion. Heat exhaust happens when your body is trying to get rid of excessive heat and keep its temperature at a optimal place. When the body is trying to get rid of a lot of heat you will start to sweat in large amounts which will lead to a significant reduction of blood volume. The body also diverts the blood to the skin from other areas of the body. With both of these changes the body produces a reduction in blood pressure which will reduce the blood flow to the brain and give you the symptoms described above. heat stroke is a far more serious condition. This happens when the body's temperature rises out of control due to the failure of the thermoregulating system. If the body is unable to reduce its temperature due to outside or physical influences the brain will start to malfunction. Delirium and loss of consciences set in. The center of the brain controlling the sweat glands will stop functioning halting the production of sweat. This causes the body's temperature to rise even faster. furthermore with the increase of the body's temperature the metabolic process will speed up causing even more heat in the body. If left untreated this will result in death. One of the easiest ways to spot heat stroke is the skin. If it is flushed due to the increase of blood flow but dry because the sweat glands have stopped secreting the individual will need medical attention fast.

Other Examples

- Thermoregulation
 - The skeletal muscles can shiver to produce heat if the body temperature is too low.
 - Non-shivering thermogenesis involves the decomposition of fat to produce heat.
 - Sweating cools the body with the use of evaporation.
- Chemical regulation
 - The pancreas produces insulin and glucagon to control blood-sugar concentration.
- The lungs take in oxygen and give off carbon dioxide, which regulates pH in the blood.
- The kidneys remove urea, and adjust the concentrations of water and a wide variety of ions.

Main examples of homeostasis in mammals are as follows:

- The regulation of the amounts of water and minerals in the body. This is known as osmoregulation. This happens primarily in the kidneys.
- The removal of metabolic waste. This is known as excretion. This is done by the excretory organs such as the kidneys and lungs.
- The regulation of body temperature. This is mainly done by the skin.
- The regulation of blood glucose level. This is mainly done by the liver and the insulin and glucagon secreted by the pancreas in the body.

Most of these organs are controlled by hormones secreted from the pituitary gland, which in turn is directed by the hypothalamus.

D) You get cut and platelets form a clot. This in turn activates the fibrin clotting system and more blood forms clots

7. Where is the body's "thermostat" found?

- A) Within the nervous system, in the Hypothalamus
- B) Within the integumentary system, in the skin
- C) Within the brain, in the corpus callosum
- D) Within the Urinary system, in the kidneys

Glossary

Control Center or Integration Center: receives and processes information from the receptor

Effector: responds to the commands of the control center by either opposing or enhancing the stimulus

Homeostasis: refers to stability, balance or equilibrium

Negative Feedback: a reaction in which the system responds in such a way as to reverse the direction of change

Positive Feedback: a response is to amplify the change in the variable

Receptor: receives information that something in the environment is changing

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lining the trachea and bronchi, and ciliated epithelial cells that move the mucus ever-upward. In this manner mold spores, bacteria, and debris are caught in the mucus, removed from the trachea, and pushed into the esophagus (to be swallowed into a pit of acid). In the oviducts cilia move the ovum from the ovary to the uterus, a journey which takes a few days.



A magnified view of several cells, with visible cilia.

Cell Junctions

The plasma membranes of adjacent cells are usually separated by extracellular fluids that allow transport of nutrients and wastes to and from the bloodstream. In certain tissues, however, the membranes of adjacent cells may join and form a junction. Three kinds of cell junctions are recognized:

- **Desmosomes** are protein attachments between adjacent cells. Inside the plasma membrane, a desmosome bears a disk shaped structure from which protein fibers extend into the cytoplasm. Desmosomes act like spot welds to hold together tissues that undergo considerable stress, such as our skin or heart muscle.
- **Tight junctions** are tightly stitched seals between cells. The junction completely encircles each cell, preventing the movement of material between the cell. Tight junctions are characteristic of cells lining the digestive tract, where materials are required to pass through cells, rather than intercellular spaces, to penetrate the bloodstream.
- **Gap junctions** are narrow tunnels between cells that consist of proteins called connexons. The proteins allow only the passage of ions and small molecules. In this manner, gap junctions allow communication between cells through the exchange of materials or the transmission of electrical impulses.

Cell Metabolism

Cell metabolism is the total energy released and consumed by a cell. Metabolism describes all of the chemical reactions that are happening in the body. Some reactions, called anabolic reactions, create needed products. Other reactions, called catabolic reactions, break down products. Your body is performing both anabolic and catabolic reactions at the same time and around the clock, twenty four hours a day, to keep your body alive and functioning. Even while you sleep, your cells are busy metabolizing.

- **Catabolism:** The energy releasing process in which a chemical or food is used (broken down) by degradation or decomposition, into smaller pieces.
- **Anabolism:** Anabolism is just the opposite of catabolism. In this portion of metabolism, the

cell consumes energy to produce larger molecules via smaller ones.

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Hair

Types of hair

Humans have three different types of hair:

- Lanugo, the fine hair that covers nearly the entire body of embryos
- Vellus hair, the short, fine, "peach fuzz" body hair that grows in most places on the human body in both sexes
- Terminal hair, the fully developed hair, which is generally longer, coarser, thicker, and darker than vellus hair

Pathological impacts on hair

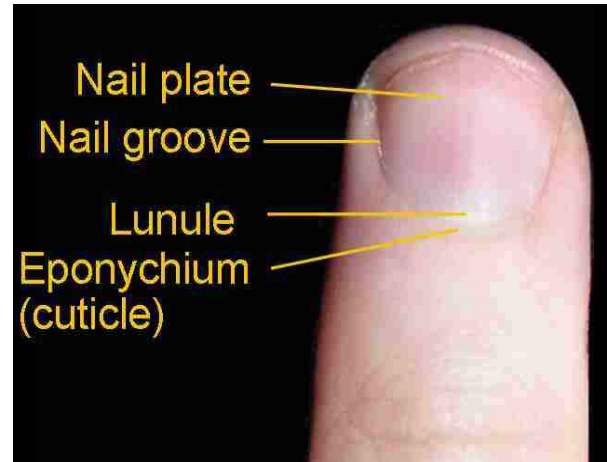
Drugs used in cancer chemotherapy frequently cause a temporary loss of hair, noticeable on the head and eyebrows, because they kill all rapidly dividing cells, not just the cancerous ones. Other diseases and traumas can cause temporary or permanent loss of hair, either generally or in patches.

The hair shafts may also store certain poisons for years, even decades after death. In the case of Col. Lafayette Baker, who died July 3, 1868, use of an atomic absorption spectrophotometer showed the man was killed by white arsenic. The prime suspect was Wallace Pollock, Baker's brother-in-law. According to Dr. Ray A. Neff, Pollack had laced Baker's beer with it over a period of months, and a century or so later minute traces of arsenic showed up in the dead man's hair. Mrs. Baker's diary seems to confirm that it was indeed arsenic, as she writes of how she found some vials of it inside her brother's suit coat one day.

Nails

Parts of the fingernail

The fingernail is an important structure made of keratin. The fingernail generally serve two purposes. It serves as a protective plate and enhances sensation of the fingertip. The protection function of the fingernail is commonly known, but the sensation function is equally important. The fingertip has many nerve endings in it allowing us to receive volumes of information about objects we touch. The nail acts as a counterforce to the fingertip providing even more sensory input when an object is touched.



The parts of a finger nail

Nail Structure

The structure we know of as the nail is divided into six specific parts - the root, nail bed, nail plate, eponychium (cuticle), perionychium, and hyponychium.

Root The root of the fingernail is also known as the germinal matrix. This portion of the nail is actually beneath the skin behind the fingernail and extends several millimeters into the finger. The fingernail root produces most of the volume of the nail and the nail bed. This portion of the nail does not have any melanocytes, or melanin producing cells. The edge of the germinal matrix is seen as a white, crescent shaped structure called the lunula.

Nail Bed The nail bed is part of the nail matrix called the sterile matrix. It extends from the edge of the germinal matrix, or lunula, to the hyponychium. The nail bed contains the blood vessels, nerves, and melanocytes, or melanin-producing cells. As the nail is produced by the root, it streams down along the nail bed, which adds material to the undersurface of the nail making it thicker. It is important for normal nail growth that the nail bed be smooth. If it is not, the nail may split or develop grooves that can be cosmetically unappealing.

Nail Plate The nail plate is the actual fingernail, made of translucent keratin. The pink appearance of the nail comes from the blood vessels underneath the nail. The underneath surface of the nail plate has grooves along the length of the nail that help anchor it to the nail bed.

Eponychium The cuticle of the fingernail is also called the eponychium. The cuticle is situated between the skin of the finger and the nail plate fusing these structures together and providing a waterproof barrier.

Perionychium The perionychium is the skin that overlies the nail plate on its sides. It is also known as the paronychial edge. The perionychium is the site of hangnails, ingrown nails, and an infection of the skin called paronychia.

Hyponychium The hyponychium is the area between the nail plate and the fingertip. It is the junction between the free edge of the nail and the skin of the fingertip, also providing a waterproof

barrier.

Nail Diseases

Nail diseases are in a separate category from diseases of the skin. Although nails are a skin appendage, they have their own signs and symptoms which may relate to other medical conditions. Nail conditions that show signs of infection or inflammation require medical assistance and cannot be treated at a beauty parlor. Deformity or disease of the nails may be referred to as **onychosis**.



Nails: left hand, adult human male

There are many disease that can occur with the fingernails and toenails. The most common of these diseases are ingrown nails and fungal infections.

Ingrown Nails

Onychocryptosis, commonly known as "ingrown nails" (*unguis incarnatus*), can affect either the fingers or the toes. In this condition, the nail cuts into one or both sides of the nail bed, resulting in inflammation and possibly infection. The relative rarity of this condition in the fingers suggests that pressure from the ground or shoe against the toe is a prime factor. The movements involved in walking or other physical disturbances can contribute to the problem. Mild onychocryptosis, particularly in the absence of infection, can be treated by trimming and rounding the nail. More advanced cases, which usually include infection, are treated by surgically excising the ingrowing portion of the nail down to its bony origin and curtailing the matrix, or 'root', to prevent recurrence. This surgery is called **matricectomy**. The best results are achieved by cauterizing the matrix with phenol. Another method, which is much less effective, is excision of the matrix, sometimes called a 'cold steel procedure'.

Nail Fungus

An infection of nail fungus (*onychomycosis*) occurs when fungi infect one or more of your nails. **Onychomycosis** generally begins as a white or yellow spot under the tip of the fingernail or toenail. As the nail fungus spreads deeper into the nail, it may cause the nail to discolor, thicken and develop crumbling edges — an unsightly and potentially painful problem.

Infections of nail fungus account for about half of all nail disorders. These infections usually develop on nails continually exposed to warm, moist environments, such as sweaty shoes or shower floors. Nail fungus isn't the same as athlete's foot, which primarily affects the skin of the feet, but at times the two may coexist and can be caused by the same type of fungus.

An infection with nail fungus may be difficult to treat, and infections may recur. But medications are available to help clear up nail fungus permanently.

into the inner layer. They are distributed over almost the entire surface of the body in humans and many other species, but are lacking in some marine and fur-bearing species. The sweat glands are controlled by sympathetic cholinergic nerves which are controlled by a center in the hypothalamus. The hypothalamus senses core temperature directly, and also has input from temperature receptors in the skin and modifies the sweat output, along with other thermoregulatory processes.

Human eccrine sweat is composed chiefly of water with various salts and organic compounds in solution. It contains minute amounts of fatty materials, urea, and other wastes. The concentration of sodium varies from 35–65 mmol/l and is lower in people acclimatised to a hot environment. The sweat of other species generally differ in composition.

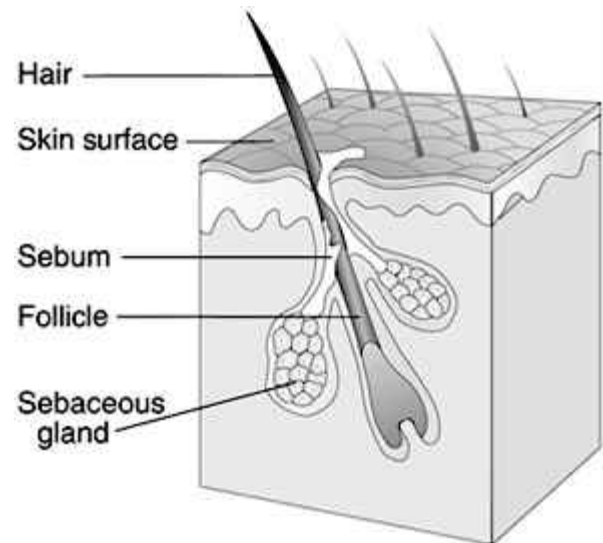
Apocrine

Apocrine glands occur during the early to mid puberty ages approximately around the age of 15 and release more than normal amounts of sweat for approximately a month and subsequently regulate and release normal amounts of sweat after a certain period of time. **Apocrine sweat glands** produce sweat that contains fatty materials. These glands are mainly present in the armpits and around the genital area and their activity is the main cause of sweat odor, due to the bacteria that break down the organic compounds in the sweat from these glands. Emotional stress increases the production of sweat from the apocrine glands, or more precisely: the sweat already present in the tubule is squeezed out. Apocrine sweat glands essentially serve as scent glands.

In some areas of the body, these sweat glands are modified to produce wholly different secretions, however, including the cerumen ("wax") in the outer ear. Other glands, such as Mammary glands, are greatly enlarged and modified to produce milk.

Sebaceous Glands

The **sebaceous glands** are glands found in the skin of mammals. They secrete an oily substance called **sebum** (Latin, meaning *fat* or *tallow*) that is made of fat (lipids) and the debris of dead fat-producing cells. These glands exist in humans throughout the skin except in the palms of the hands and soles of the feet. Sebum acts to protect and waterproof hair and skin, and keep them from becoming dry, brittle, and cracked. It can also inhibit the growth of microorganisms on skin.

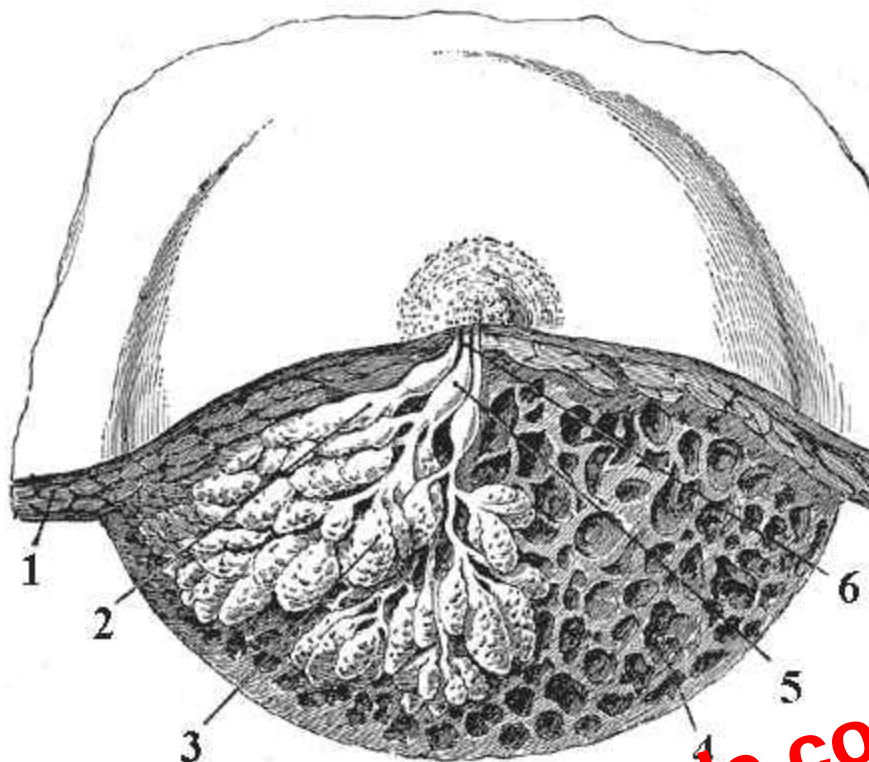


Schematic view of a hair follicle with sebaceous gland.

Sebaceous glands can usually be found in hair-covered areas where they are connected to hair follicles to deposit sebum on the hairs, and bring it to the skin surface along the hair shaft. The structure consisting of hair, hair follicle and sebaceous gland is also known as **pilosebaceous unit**. Sebaceous glands are also found in non haired areas of lips, eyelids, penis, labia minora and nipples; here the sebum reaches the surface through ducts. In the glands, sebum is produced within specialized cells and is released as these cells burst; sebaceous glands are thus classified as holocrine glands.

Sebum is odorless, but its bacterial breakdown can produce odors. Sebum is the cause of some people experiencing "oily" hair if it is not washed for several days. Earwax is partly sebum, as is mucopurulent discharge, the dry substance accumulating in the corner of the eye after sleeping.

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Dissection of a lactating breast. 1 - Fat; 2 - Lactiferous duct; 3 - Lobule; 4 - Connective tissue; 5 - Sinus of lactiferous duct; 6 - Lactiferous duct.

Also, "click" this: ["Breast tissue" anatomy movie visual of the breast.](#)

Development and hormonal control

The development of mammary glands is controlled by hormones. The mammary glands exist in both sexes, but they are rudimentary until puberty when in response to ovarian hormones, they begin to develop in the female. Click this [1] to see what breast tissue does in a female during menstruation. Estrogen promotes formation, while testosterone inhibits it.

At the time of birth, the baby has lactiferous ducts but no alveoli. Little branching occurs before puberty when ovarian estrogens stimulate branching differentiation of the ducts into spherical masses of cells that will become alveoli. True secretory alveoli only develop in pregnancy, where rising levels of estrogen and progesterone cause further branching and differentiation of the duct cells, together with an increase in adipose tissue and a richer blood flow.

Colostrum is secreted in late pregnancy and for the first few days after giving birth. True milk secretion (lactation) begins a few days later due to a reduction in circulating progesterone and the presence of the hormone prolactin. The suckling of the baby causes the release of the hormone oxytocin which stimulates contraction of the myoepithelial cells.

Breast cancer

As described above, the cells of mammary glands can easily be induced to grow and multiply by

2. Semantic Memory

Episodic memory represents our memory of events and experiences in a serial form. It is from this memory that we can reconstruct the actual events that took place at a given point in our lives. Semantic memory, on the other hand, is a structured record of facts, concepts, and skills that we have acquired. The information in the semantic memory is derived from our own episode memory, such as that we can learn new facts or concepts from experiences.

There are three main activities that are related to long term memory:

1. Storage
2. Deletion
3. Retrieval

Information for short term memory is stored in long term memory by rehearsal. The repeated exposure to a stimulus or the rehearsal of a piece of information transfers it into long term memory. Experiments also suggest that learning is most effective if it is distributed over time. Deletion is mainly caused by decay and interference. Emotional factors also affect long term memory. However, it is debatable whether we actually ever forget anything or whether it just sometimes becomes increasingly difficult to retrieve it. Information may not be recalled sometimes but may be recognized, or may be recalled only with prompting. This leads us to the third operation of memory, information retrieval.

There are two types of information retrieval:

1. Recall
2. Recognition

In recall, the information is reproduced from memory. In recognition the presentation of the information provides the knowledge that the information has been seen before. Recognition is of lesser complexity, as the information is provided as a cue. However, the recall may be assisted by the provision of retrieval cues which enable the subject to quickly access the information in memory.

Language and Speech

Language depends on semantic memory so some of the same areas in the brain are involved in both memory and language. Articulation, the forming of speech, is represented bilaterally in the motor areas. However, language analysis and speech formation take place in most individuals in regions of the left hemisphere only. The two regions involved are:

1. Broca's Area
2. Wernicke's Area

Broca's area is located just in front of the voice control area of the left motor cortex. This region assembles the motor of speech and writing. For example, patients with lesions in this area:

1. Understand language perfectly
2. May be able to write perfectly
3. Seldom speak spontaneously

In the SNS and other components of the peripheral nervous system, these synapses are made at sites called ganglia. The cell that sends its fiber is called a preganglionic cell, while the cell whose fiber leaves the ganglion is called a postganglionic cell. As mentioned previously, the preganglionic cells of the SNS are located between the first thoracic segment and the second or third lumbar segments of the spinal cord. Postganglionic cells have their cell bodies in the ganglia and send their axons to target organs or glands.

The ganglia include not just the sympathetic trunks but also the superior cervical ganglion (which sends sympathetic nerve fibers to the head), and the celiac and mesenteric ganglia (which send sympathetic fibers to the gut).

Information transmission

Messages travel through the SNS in a bidirectional flow. Efferent messages can trigger changes in different parts of the body simultaneously. For example, the sympathetic nervous system can accelerate heart rate; widen bronchial passages; decrease motility (movement) of the large intestine; constrict blood vessels; increase peristalsis in the esophagus; cause pupil dilation, piloerection (goose bumps) and perspiration (sweating); and raise blood pressure. Afferent messages carry sensations such as heat, cold, or pain.

The first synapse (in the sympathetic chain) is mediated by nicotinic receptors physiologically activated by acetylcholine, and the target synapse is mediated by adrenergic receptors physiologically activated by either noradrenaline or adrenaline. An exception is with sweat glands which receive sympathetic innervation but have muscarinic acetylcholine receptors which are normally characteristic of PNS. Another exception is with certain deep muscle blood vessels, which have acetylcholine receptors and which dilate (rather than constrict) with an increase in sympathetic tone. The sympathetic system cell bodies are located on the spinal cord excluding the cranial and sacral regions. The preganglionic neurons exit from the vertebral column and synapse with the postganglionic neurons in the sympathetic trunk.

The parasympathetic nervous system is one of three divisions of the autonomic nervous system. Sometimes called the rest and digest system, the parasympathetic system conserves energy as it slows the heart rate, increases intestinal and gland activity, and relaxes sphincter muscles in the gastrointestinal tract.

Relationship to sympathetic

While an oversimplification, it is said that the parasympathetic system acts in a reciprocal manner to the effects of the sympathetic nervous system; in fact, in some tissues innervated by both systems, the effects are synergistic.

Receptors

The parasympathetic nervous system uses only acetylcholine (ACh) as its neurotransmitter. The ACh acts on two types of receptors, the muscarinic and nicotinic cholinergic receptors. Most transmissions occur in two stages: When stimulated, the preganglionic nerve releases ACh at the

Methamphetamine

In the US, medically prescribed **methamphetamine** is distributed in tablet form under the brand name Desoxyn®.

Illicit methamphetamine comes in a variety of forms. Most commonly it is found as a colorless crystalline solid, sold on the street under a variety of names, such as: crystal meth or crystal. Crystal methamphetamine may also be referred to as shards, rock, P, upside-down b, pony, crissie, crystal, glass, ice, devil's dandruff, chimichanga, Jib, critter, Tina, Crawford, Working Man's Cocaine, Pook, tik, or "broken glass". People may confuse crack cocaine with methamphetamine.



Illegal methlab.

It is also sold as a less-pure crystalline powder called crank or speed, or in crystalline rock form called dope, shit, tina, or tweak; both "dope" and "speed" are often used to refer to other drugs. Colorful flavored pills containing methamphetamine and caffeine are known as yaba (Thai for "crazy medicine"). At its most impure, it is sold as a crumbly brown or off-white rock commonly referred to as peanut butter crank. See the list of street names for a more comprehensive list of common street names for methamphetamine.

Methamphetamine found on the street may be pure, or adulterated with chemicals that were used to synthesize it. In some instances, it may be diluted or cut with non-psychoactive substances like inositol. In other instances, it may be mixed with other psychoactive drugs.

Marijuana

The drug cannabis is produced from parts of the cannabis plant, primarily the cured flowers and gathered trichomes of the female plant. The major active chemical compound tetrahydrocannabinol, commonly referred to as THC, has psychoactive and medicinal effects when consumed, usually by smoking or ingestion. Cannabis has been consumed by humans for thousands of years; in the 20th century there was an upswing in the use of cannabis for recreational and religious purposes.

The possession, use, or sale of psychoactive cannabis products became illegal in many parts of the world in the early 20th century. Since then, while some countries have intensified the enforcement of cannabis prohibition, others have reduced the priority of enforcement to the point of de facto legality. Cannabis remains illegal in the vast majority of the world's countries.

The nature and intensity of the immediate effects of cannabis consumption vary according to the dose, the species or hybridization of the source plant, the method of consumption, the user's mental and physical characteristics (such as possible tolerance), and the environment of consumption. This is sometimes referred to as set and setting. Smoking the same cannabis either in a different frame of mind (set) or in a different location (setting) can alter the effects or perception of the effects by the individual. Effects of cannabis consumption may be loosely classified as cognitive and physical. Anecdotal evidence suggests that the Cannabis sativa species tends to produce more of the cognitive or perceptual effects, while Cannabis indica tends to produce more of the physical effects.

extraocular muscles have their origin in the back of the orbit in a fibrous ring called the **annulus of Zinn**. Four of these then course forward through the orbit and insert onto the globe on its anterior half (i.e., in front of the eye's equator). These muscles are named after their straight paths, and are called the four rectus muscles, or four recti. They insert on the globe at 12, 3, 6, and 9 o'clock, and are called the superior, lateral, inferior and medial rectus muscles. (Note that lateral and medial are relative to the subject, with lateral toward the side and medial toward the midline, thus the medial rectus is the muscle closest to the nose).

Eye Movement

The visual system in the brain is too slow to process that information if the images are slipping across the retina at more than a few degrees per second, thus, for humans to be able to see while moving, the brain must compensate for the motion of the head by turning the eyes. To get a clear view of the world, the brain must turn the eyes so that the image of the object of regard falls on the fovea. Eye movements are thus very important for visual perception, and any failure to make them correctly can lead to serious visual disabilities. Having two eyes is an added complication, because the brain must point both of them accurately enough that the object of regard falls on corresponding points of the two retinas; otherwise, double vision would occur. The movements of different body parts are controlled by striated muscles acting around joints. The movements of the eye are no exception, but they have special advantages not shared by skeletal muscles and joints, and so are considerably different.

Try This Experiment

Hold your hand up, about one foot (30 cm) in front of your nose. Keep your head still, and shake your hand from side to side, slowly at first, and then faster and faster. At first you will be able to see your fingers quite clearly. But as the frequency of shaking passes about one hertz, the fingers will become a blur. Now, keep your hand still, and shake your head (up and down or left and right). No matter how fast you shake your head, the image of your fingers remains clear. This demonstrates that the brain can move the eyes opposite to head motion much better than it can follow, or pursue, a hand movement. When your pursuit system fails to keep up with the moving hand, images slip on the retina and you see a blurred hand.

How we see an object

- The light rays enter the eye through the cornea (transparent front portion of eye to focus the light rays)
- Then, light rays move through the pupil, which is surrounded by Iris to keep out extra light
- Then, light rays move through the crystalline lens (Clear lens to further focus the light rays)
- Then, light rays move through the vitreous humor (clear jelly like substance)
- Then, light rays fall on the retina, which processes and converts incident light to neuron signals using special pigments in rod and cone cells.
- These neuron signals are transmitted through the optic nerve,
- Then, the neuron signals move through the visual pathway - Optic nerve > Optic Chiasm > Optic Tract > Optic Radiations > Cortex
- Then, the neuron signals reach the occipital (visual) cortex and its radiations for the brain's processing.

- The visual cortex interprets the signals as images and along with other parts of the brain, interpret the images to extract form, meaning, memory and context of the images.

Depth Perception

Depth perception is the visual ability to perceive the world in three dimensions. It is a trait common to many higher animals. Depth perception allows the beholder to accurately gauge the distance to an object.

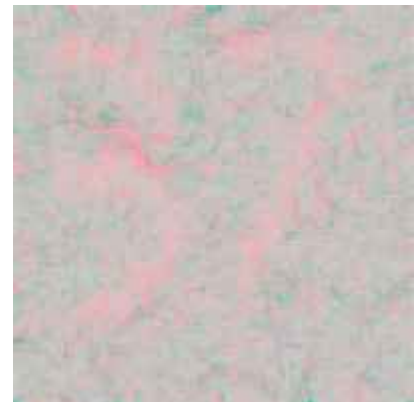
Depth perception is often confused with binocular vision, also known as Stereopsis. Depth perception does rely on binocular vision, but it also uses many other monocular cues.

Diseases, disorders, and age-related changes

There are many diseases, disorders, and age-related changes that may affect the eyes and surrounding structures. As the eye ages certain changes occur that can be attributed solely to the aging process. Most of these anatomic and physiologic processes follow a gradual decline. With aging, the quality of vision worsens due to reasons independent of aging eye diseases. While there are many changes of significance in the non-diseased eye, the most functionally important changes seem to be a reduction in pupil size and the loss of accommodation or focusing capability (presbyopia). The area of the pupil governs the amount of light that can reach the retina. The extent to which the pupil dilates also decreases with age. Because of the smaller pupil size, older eyes receive much less light at the retina. In comparison to younger people, it is as though older persons wear medium-density sunglasses in bright light and extremely dark glasses in dim light. Therefore, for any detailed visually guided tasks on which performance varies with illumination, older persons require extra lighting.

Color Blindness

Color Blindness or color vision deficiency, in humans is the inability to perceive differences between some or all colors that other people can distinguish. It is most often of genetic nature, but may also occur because of eye, nerve, or brain damage, or due to exposure to certain chemicals. There are many types of color blindness. The most common variety are hereditary (genetic) photoreceptor disorders, but it is also possible to acquire color blindness through damage to the retina, optic nerve, or higher brain areas. There is generally no treatment to cure color deficiencies, however, certain types of tinted filters and contact lenses may help an individual to distinguish different colors better.



This image contains a two digit number similar to the sample above. Someone who is protanopic might not see this number. (GFDL - Zxc, Cyp)

Night Blindness

Also known as Nyctalopia, is a condition making it difficult or impossible to see in the dark. It is a symptom of several eye diseases. Night blindness may exist from birth, or be caused by injury or malnutrition (for example, a lack of vitamin A). The most common cause of nyctalopia is retinitis pigmentosa, a disorder in which the rod cells in the retina gradually lose their ability to respond to the light. Patients suffering from this genetic condition have progressive nyctalopia

decrease and eventually cease

C) Ruffini corpuscles is a class of slowly adapting mechanoreceptor

D) Pacinian corpuscles allow sodium ions to influx in, creating a receptor potential

4. When eating a piece of candy, I will use the following to sense that it is sweet

A) Fungiform papillae

B) Filiform papillae

C) Foliate papillae

D) Circumvallate papillae

E) All of the above

5. If I have a cold, food may not taste as good to me because

A) The nerve fibrils are not functioning properly

B) My food will taste the same; taste and smell have nothing in common

C) Papilla become blocked by mucus and are unable to function

D) Olfaction, taste and trigeminal receptors together contribute to the flavor of my food

6. Walking from a well lit room into a dark room would cause the following to occur

A) The sclera in the eye to open and eventually allow me to see in the dark

B) The extraocular muscles in the eye to open and eventually allow me to see in the dark

C) The cones in the eye to open and eventually allow me to see in the dark

D) the rods in the eye to open and eventually allow me to see in the dark

7. Hair cells in the ear

A) Are the actual sensory receptors that will fire off action potentials when they are disturbed

B) Show a graded response, instead of the spikes typical of other neurons

C) "Rub" against the overhanging tectorial membrane

D) All of the above

8. Eyesight decreases with age because

A) Older eyes receive much less light at the retina

B) There are numerous eye diseases that can affect an older eye

C) The extent to which the pupil dilates decreases with age

D) all of the above

9. Teens walking off of a roller coaster in Magic Mountain seem to have vertigo because

A) The fluid in the auricle has not stopped moving causing conflicts with the information coming from your vision

B) the fluid in the cochlea has not stopped moving causing conflicts with the information coming from your vision

C) The fluid in the tympanic membrane has not stopped moving causing conflicts with the information coming from your vision

D) The fluid in the stirrup has not stopped moving causing conflicts with the information coming

from your vision

10. These receptors react to foods treated with monosodium glutamate

- A) Salt
- B) Sour
- C) Bitter
- D) Sweet
- E) Umami

Glossary

Anosmia: Lack of olfaction, or a loss of the sense of smell

Auditory Canal: Tube from the auditory meatus or opening of the ear to the tympanic membrane

Auditory Tube: Either of the paired tubes connecting the middle ears to the nasopharynx; equalizes air pressure on the two sides of the eardrum

Chemoreception: Physiological response of a sense organ to a chemical stimulus

Choroid: Vascular layer of the eye lying between the retina and the sclera

Circumvallate papillae: Papillae that are present on the back of the oral part of the tongue

Cochlea: Is concerned with hearing, resembling a shell of a snail

Dysosmia: When things smell differently than they should

Equilibrium: Sense of balance

Extraocular muscles: Six muscles that control eye movements: lateral rectus, medial rectus, inferior rectus, superior rectus, inferior oblique and superior oblique

Filiform papillae: Thin, longer papillae that don't contain taste buds but are the most numerous

Foliate papillae: Ridges and grooves towards the posterior part of the tongue

Fungiform papillae: These are present mostly at the apex (tip) of the tongue- slightly mushroom shaped

Gustation: The sense of taste

Hair Cell: Mechanosensors for hearing, columnar cells each with a bundle of 100-200 specialized cilia at the top

Haptic: From the Greek Haphe, means pertaining to the sense of touch

Hyposmia: Decreased ability to smell

Inner Ear: Innermost part of the ear, contains the cochlea, vestibule and semi-circular canals

Mechanoreceptor: Sensory receptor that responds to mechanical pressure or distortion

Meissner's Corpuscle: Encapsulated unmyelinated nerve endings, usually found in areas sensitive to light touch

Middle Ear: Air Filled Cavity behind the Ear Drum, includes most of the ear Drum and ear Bones

Nasopharynx: Nasal part of the pharynx that lies behind the nose and above the level of the soft palate

Nociception: The perception of pain

Olfaction: The sense of smell

Otitis Media: An inflammation of the middle ear

Outer Ear: External portion of the ear, includes the auricle, ear canal and surface of the ear drum

Oval Window: Fenestra that has the base of the stapes attached to it

Pacinian Corpuscles: Detect gross pressure changes and vibrations

Papilla: Specialized epithelial cells that are small projections on the top of the tongue

Perception: The brain's interpretation of a sensation

Phantosmia: Phenomenon of smelling odors that aren't really present (AKA Phantom odors)

neuromuscular junction. There is one neuromuscular junction for each fiber.

- The acetylcholine diffuses across the cleft and binds to nicotinic receptors on the motor end plate, opening channels in the membrane for sodium and potassium. Sodium rushes in, and potassium rushes out. However, because sodium is more permeable, the muscle fiber membrane becomes more positively charged, triggering an action potential.
- The action potential on the muscle fiber causes the sarcoplasmic reticulum to release calcium ions (Ca^{++}).
- The calcium binds to the troponin present on the thin filaments of the myofibrils. The troponin then allosterically modulates the tropomyosin. Normally the tropomyosin physically obstructs binding sites for cross-bridge; once calcium binds to the troponin, the troponin forces the tropomyosin to move out of the way, unblocking the binding sites.
- The cross-bridge (which is already in a ready-state) binds to the newly uncovered binding sites. It then delivers a power stroke.
- ATP binds the cross-bridge, forcing it to conform in such a way as to break the actin-myosin bond. Another ATP is split to energize the cross bridge again.
- Steps 7 and 8 repeat as long as calcium is present on thin filament.
- Throughout this process, the calcium is actively pumped back into the sarcoplasmic reticulum. When no longer present on the thin filament, the tropomyosin changes back to its previous state, so as to block the binding sites again. The cross-bridge then ceases binding to the thin filament, and the contractions cease as well.
- Muscle contraction remains as long as Ca^{++} is abundant in sarcomere.

Types of Contractions:

- Isometric contraction--muscle does not shorten during contraction and does not require the sliding of myofibrils but muscles are stiff.
- Isotonic contraction--inertia is used to move or work. More energy is used by the muscle and contraction lasts longer than isometric contraction.
- Twitch--exciting the nerve to a muscle or by passing electrical stimulus through muscle itself. Some fibers contract quickly while others contract slowly.

The Efficiency of Muscle Contraction:

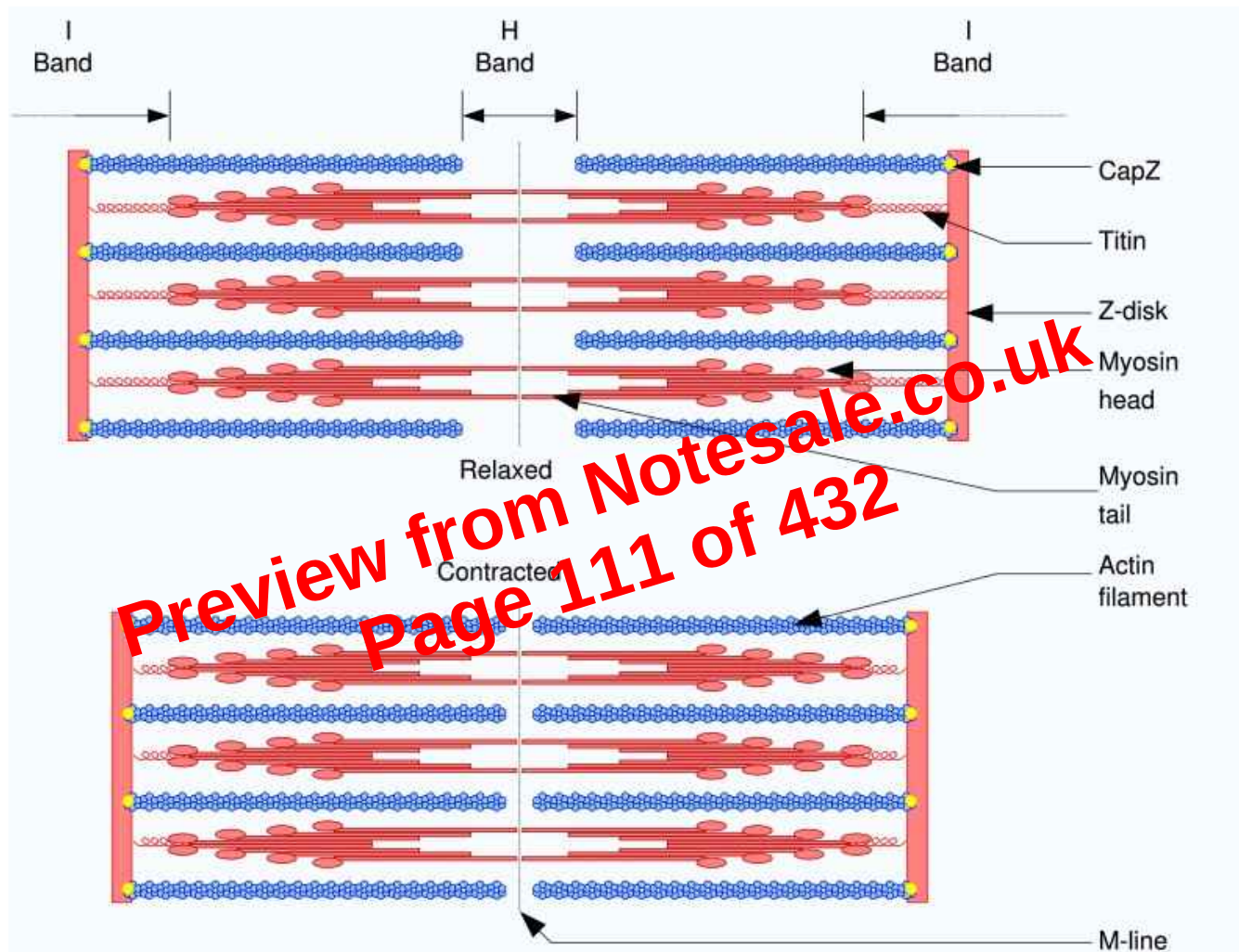
- Only about 20% of input energy converts into muscular work. The rest of the energy is heat.
- 50% of energy from food is used in ATP formation.
- If a muscle contraction is slow or without movement, energy is lost as maintenance heat.
- If muscle contraction is rapid, energy is used to reduce friction.

Summation of Muscle Contraction: It is the adding together of individual muscle twitches to make strong muscle movements.

- Multiple motor unit summation--increasing number of motor units contracting simultaneously.
- Wave summation--increasing rapidity of contraction of individual motor units.
- Tetanization--higher frequency successive contractions fuse together and cannot be distinguished from one another.

Sliding Filament theory

When a muscle contracts, the actin is pulled along myosin toward the center of the sarcomere until the actin and myosin filaments are completely overlapped. The H zone becomes smaller and smaller due to the increasing overlap of actin and myosin filaments, and the muscle shortens. Thus when the muscle is fully contracted, the H zone is no longer visible (as in the bottom diagram, left). Note that the actin and myosin filaments themselves do not change length, but instead slide past each other.



Sliding myofibril (GFDL - Slashme)

Cellular Action of Skeletal Muscles

During cellular respiration the mitochondria, within skeletal muscle cells, convert glucose from the blood to carbon dioxide and water in the process of producing ATP (see [cell physiology](#)). ATP is needed for all muscular movement. When the need of ATP in the muscle is higher than the cells can produce with aerobic respiration, the cells will produce extra ATP in a process called anaerobic respiration. The first step of aerobic respiration (glycolysis) produces two ATP per glucose molecule. When the rest of the aerobic respiration pathway is occupied the pyruvate molecule can be converted to lactic acid. This method produces much less ATP than the aerobic method, but it does it faster and allows the muscles to do a bit more than if they relied solely on ATP production from aerobic

then water). A drop in pH is called **Acidic**. This condition is also called **Acidosis**. A jump in pH higher than 7.45 is called "Alkalis". To maintain the homeostasis (or balance,) the blood has tiny molecules within the RBC that help prevent drops or increases from happening.

Destruction

Red blood cells are broken down and hemoglobin is released. The globin part of the hemoglobin is broken down into amino acid components, which in turn is recycled by the body. The iron is recovered and returned to the bone marrow to be reused. The heme portion of the molecule experiences a chemical change and then gets excreted as bile pigment (bilirubin) by the liver. Heme portion after being broken down contributes to the color of feces and your skin color changing after being bruised.

White Blood Cells

Shape

White blood cells are different from red cells in the fact that they are usually larger in size 10-14 micrometers in diameter. White blood cells do not contain hemoglobin which in turn makes them translucent. Many times in diagrams or pictures white blood cells are represented in a blue color, mainly because blue is the color of the stain used to see the cells. White blood cells also have nuclei, that are some what segmented and are surrounded by electrons inside the membrane.



from left to right diagram of Erythrocyte, Thrombocyte, and Leukocyte

Functions

White blood cells (leukocytes) are also known as "WBC's". White blood cells are made in the bone marrow but they also divide in the blood and lymphatic systems. They are commonly amoeboid (cells that move or feed by means of temporary projections, called pseudopods (false feet), and escape the circulatory system through the capillary beds. The different types of WBC's are Basophils, Eosinophils, Eutrophils, Monocytes, B- and T-cell lymphocytes. Neutrophils, Eosinophils, and Basophils are all granular leukocytes. Lymphocytes and Monocytes are agranular leukocytes. Basophils store and synthesize histamine which is important in allergic reactions. They enter the tissues and become "mass cells" which help blood flow to injured tissues by the release of histamine. Eosinophils are chemotaxic and kill parasites. Neutrophils are the first to act when there is an infection and are also the most abundant white blood cells. Neutrophils fight bacteria and viruses by *phagocytosis* which mean they engulf pathogens that may cause infection. The life span of a of Neutrophil is only about 12-48 hours. Monocytes are the biggest of the white blood cells and are responsible for rallying the cells to defend the body. Monocytes carry out phagocytosis and are also called macrophages. Lymphocytes help with our immune response. There are two Lymphocytes: the B- and T- cell. B-Lymphocytes produce antibodies that find and mark pathogens for destruction. T-Lymphocytes kill anything that they deem abnormal to the body.

When the lining of a blood vessel breaks and endothelial cells are damaged, revealing collagen proteins in the vessel wall, platelets swell, grow spikey extensions, and start clumping together. They start to stick to each other and the walls of the vessel. This continues as more platelets congregate and undergo these same transformations. This process results in a platelet plug that seals the injured area. If the injury is small, a platelet plug may be able to form and close it within several seconds. If the damage is more serious, the next step of blood clotting will take place. Platelets contain secretory granules. When they stick to the proteins in the vessel walls, they *degranulate*, thus releasing their products, which include ADP (adenosine diphosphate), serotonin, and thromboxane A₂.

A Blood Clot Forms: If the platelet plug is not enough to stop the bleeding, the third stage of hemostasis begins: the formation of a blood clot. First, blood changes from a liquid to a gel. At least 12 substances called *clotting factors* take part in a series of chemical reactions that eventually create a mesh of protein fibers within the blood. Each of the *clotting factors* has a very specific function. We will discuss just three of the substances here: prothrombin, thrombin, and fibrinogen. Prothrombin and fibrinogen are proteins that are produced and deposited in the blood by the liver.

- *Prothrombin:* When blood vessels are damaged, vessels and nearby platelets are stimulated to release a substance called *prothrombin activator*, which in turn activates the conversion of *prothrombin*, a plasma protein, into an enzyme called *thrombin*. This reaction requires calcium ions.
- *Thrombin:* *Thrombin* facilitates the conversion of a soluble plasma protein called *fibrinogen* into long insoluble fibers or threads of the protein *fibrin*.
- *Fibrin:* Fibrin threads wind around the platelet plug at the damaged area of the blood vessel, forming an interlocking network of fibers and a framework for the clot. This net of fibers traps and helps hold platelets, blood cells and other molecules tight to the site of injury, functioning as the initial clot. This temporary fibrin clot can form in less than a minute, and usually does a good job of reducing the blood flow. Next, platelets in the clot begin to shrink, tightening the clot and drawing together the vessel walls. Usually, this whole process of clot formation and tightening takes less than a half hour.

The use of adsorbent chemicals, such as zeolites, and other hemostatic agents, are also being explored for use in sealing severe injuries quickly.

ABO Group System

The **ABO blood group** is represented by substances on the surface of red blood cells (RBCs). These substances are important because they contain specific sequences of amino acid and carbohydrates which are antigenic. As well as being on the surface of RBCs, some of these antigens are also present on the cells of other tissues. A complete blood type describes the set of 29 substances on the surface of RBCs, and an individual's blood type is one of the many possible combinations of blood group antigens. Usually only the ABO blood group system and the presence or absence of the Rhesus D antigen (also known as the Rhesus factor or RH factor) are determined and used to describe the blood type. Over 400 different blood group antigens have been found, many of these being very rare. If an individual is exposed to a blood group antigen that is not recognized as self, the individual can become sensitized to that antigen; the immune system makes specific antibodies which binds specifically to a particular blood group antigen and an immunological memory against that particular

controlled by a single gene with three alleles: *i*, *I^A*, and *I^B*. The gene encodes an enzyme that modifies the carbohydrate content of the red blood cell antigens.

I^A gives type A,
I^B gives type B,
i give types O

I^A and *I^B* are dominant over *i*, so *ii* people have type O, *I^AI^A* or *I^Ai* have A, and *I^BI^B* or *I^Bi* have type B. *I^AI^B* people have both phenotypes because A and B are codominant, which means that type A and B parents can have an AB child. Thus, it is extremely unlikely for a type AB parent to have a type O child (it is not, however, direct proof of illegitimacy): the cis-AB phenotype has a single enzyme that creates both A and B antigens. The resulting red blood cells do not usually express A or B antigen at the same level that would be expected on common group A or B red blood cells, which can help solve the problem of an apparently genetically impossible blood group.

Rh Factor

Many people have the Rh Factor on the red blood cell. Rh carriers do not have the antibodies for the Rh Factor, but can make them if exposed to Rh. Most commonly Rh is seen when anti-Rh antibodies cross from the mother's placenta into the child before birth. The Rh Factor enters the child destroying the child's red blood cells. This is called Hemolytic Disease.

Compatibility in Blood Transfusions

Blood transfusions between donor and recipient of incompatible blood types can cause severe acute immunological reactions, hemolysis (RBC destruction), renal failure, shock, and sometimes death. Antibodies can be highly active and can attack RBCs and bind components of the complement system to cause massive hemolysis of the transfused blood.

A patient should ideally receive their own blood or type-specific blood products to minimize the chance of a transfusion reaction. If time allows, the risk will further be reduced by cross-matching blood, in addition to blood typing both recipient and donor. Cross-matching involves mixing a sample of the recipient's blood with a sample of the donor's blood and checking to see if the mixture agglutinates, or forms clumps. Blood bank technicians usually check for agglutination with a microscope, and if it occurs, that particular donor's blood cannot be transfused to that particular recipient. Blood transfusion is a potentially risky medical procedure and it is vital that all blood specimens are correctly identified, so in cross-matching labeling is standardized using a barcode system known as ISBT 128.

Hemolytic Disease of the Newborn

Often a pregnant woman carries a fetus with a different blood type to herself, and sometimes the mother forms antibodies against the red blood cells of the fetus, leading to low fetal blood counts, a condition known as hemolytic disease of the newborn.

Hemolytic disease of the newborn, (also known as HDN) is an alloimmune condition that develops in a fetus when the IgG antibodies produced by the mother and passing through the placenta include

royal family. Alexandra, granddaughter to Queen Victoria, married Nicholas (Tsar of Russia in the 1900s). Alexandra was a carrier of the disease and passed the disease to their first son, Tsarevich Alexi, who was heir to the throne of Russia. The family tried to keep their son's secret from the people, but Alexi suffered with serious bruises and extreme pain. The family found help from a monk named Rasputin. He kept their secret and gained a great deal of power over the family, making them think he was their only hope. During this time of great turmoil in Russia, Nicholas and Alexandra spent most of their attentions on their son, and not on the people. It wasn't long before the Bolshevik Revolution of 1917 began.

Factor V Leiden

The opposite of Hemophilia, Factor V Leiden is the name given to a variant of human factor V that causes a hypercoagulability disorder. In this disorder the Leiden variant of factor V, cannot be inactivated by activated protein C. Factor V Leiden is the most common hereditary hypercoagulability disorder amongst Eurasians. It is named after the city Leiden (The Netherlands), where it was first identified in 1994 by Prof R. Bertina et al. Those that have it are at a slightly higher risk of developing blood clots than those without. Those that test positive for factor V should avoid (oral contraceptives, obesity, smoking, and high blood pressure.)

Anemia

Anemia (AmE) or anaemia (BrE), from the Greek (*ἀναμία*) meaning "without blood", refers to a deficiency of red blood cells (RBCs) and/or hemoglobin. This results in a reduced ability of blood to transfer oxygen to the tissues causing hypoxia. Since all human cells depend on oxygen for survival, varying degrees of anemia can have a wide range of clinical consequences. Hemoglobin (the oxygen-carrying protein in the red blood cells) has to be present to ensure adequate oxygenation of all body tissues and organs.

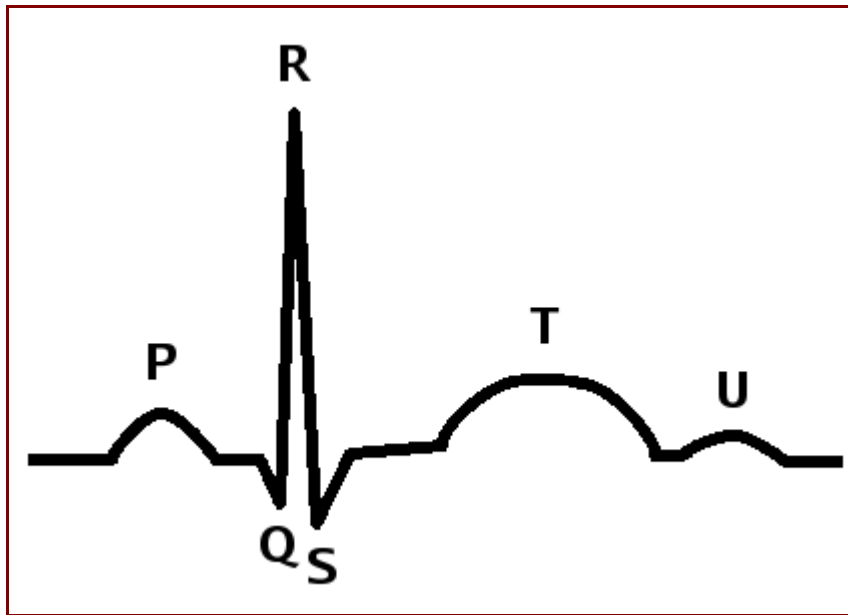
The three main classes of anemia include excessive blood loss (acutely such as a hemorrhage or chronically through low-volume loss), excessive blood cell destruction (hemolysis) or deficient red blood cell production (ineffective hematopoiesis). In menstruating women, dietary iron deficiency is a common cause of deficient red blood cell production.

Sickle cell

Sickle-cell disease is a general term for a group of genetic disorders caused by sickle hemoglobin (Hgb S or Hb S). In many forms of the disease, the red blood cells change shape upon deoxygenation because of polymerization of the abnormal sickle hemoglobin. This process damages the red blood cell membrane, and can cause the cells to become stuck in blood vessels. This deprives the downstream tissues of oxygen and causes ischemia and infarction. The disease is chronic and lifelong. Individuals are most often well, but their lives are punctuated by periodic painful attacks. In addition to periodic pain, there may be damage of internal organs, and/or stroke. Lifespan is often shortened with sufferers living to an average of 40 years. It is common in people from parts of the world where malaria is or was common, especially in sub-Saharan Africa or in descendants of those



*Image of RBC's with
Sickle Cell mutations.*



P

P wave- indicates that the atria are electrically stimulated to pump blood into the ventricles.

QRS

QRS complex- indicates that the ventricles are electrically stimulated to pump blood out.

ST

ST segment- indicates the amount of time from the end of the contraction of the ventricles to the beginning of the T wave.

T

T wave- indicates the recovery period of the ventricles.

Cardiac Muscle Contraction

After an action potential excites the plasma membrane of the cardiac muscle cell the contraction is due to an increase in the cytoplasmic concentration of calcium ions. Similar to skeletal muscle, the release of Ca^{2+} ions from the sarcoplasmic reticulum binds to troponin which allows actin to bind with myosin. The difference between skeletal muscle and cardiac muscle is that when the action potential opens voltage gated calcium ion channels in the T-tubules. The increase in cytosolic calcium causes calcium ions to bind to receptors on the surface of the sarcoplasmic reticulum. The binding of calcium ions to these receptors causes the opening of more calcium ion channels in the SR membrane. Calcium ions then rush out of the SR and bind to troponin and allow the myosin and actin to bind together which causes contraction. This sequence is called calcium-induced calcium release. Contraction ends when the level of cytosolic calcium returns to normal resting levels.

Blood Pressure

Blood pressure is the pressure exerted by the blood on the walls of the blood vessels. Unless indicated otherwise, blood pressure refers to systemic arterial blood pressure, i.e., the pressure in the large arteries delivering blood to body parts other than the lungs, such as the brachial artery (in the arm). The pressure of the blood in other vessels is lower than the arterial pressure. Blood pressure values are universally stated in millimeters of mercury (mm Hg). The systolic pressure is defined as the peak pressure in the arteries during the cardiac cycle; the diastolic pressure is the lowest pressure (at the resting phase of the cardiac cycle). The mean arterial pressure and pulse pressure are other important quantities. Typical values for a resting, healthy adult are approximately 120 mm Hg systolic and 80 mm Hg diastolic (written as 120/80 mm Hg), with large individual variations. These measures of blood pressure are not static, but undergo natural variations from one heartbeat to another or throughout the day (in a circadian rhythm); they also change in response to stress, nutritional factors,

Fibrous Pericardium: a dense connective tissue that protects the heart, anchoring it to the surrounding walls, and preventing it from overfilling with blood

Heart Rate: term used to describe the frequency of the cardiac cycle

Hepatic Veins: blood vessels that drain de-oxygenated blood from the liver and blood cleaned by the liver (from the stomach, pancreas, small intestine and colon) into the inferior vena cava

Hypertension or High Blood Pressure: medical condition wherein the blood pressure is chronically elevated

Inferior Vena Cava (or IVC): a large vein that carries de-oxygenated blood from the lower half of the body into the heart

Intraventricular Septum: the stout wall separating the lower chambers (the ventricles) of the heart from one another

Left Atrium: receives oxygenated blood from the left and right pulmonary veins

Lub-Dub: first heart tone, or S1; caused by the closure of the atrioventricular valves, mitral and tricuspid, at the beginning of ventricular contraction, or systole

Lumen: hollow internal cavity in which the blood flows

Lymph: originates as blood plasma that leaks from the capillaries of the circulatory system, becoming interstitial fluid, filling the space between individual cells of tissue

Mitral valve: also known as the bicuspid valve; prevents blood flowing from the left ventricle into the left atrium

Myocardium: the muscular tissue of the heart.

Norepinephrine: Produced in the adrenal medulla of the adrenal glands, major function is a strong vasoconstrictor that will in turn increase respiratory rate.

Pacemaker Cells: cells that create these rhythmical impulses of the heart

Plaque: an abnormal inflammatory accumulation of macrophage white blood cells within the walls of arteries

Pulmonary Valve: lies between the right ventricle and the pulmonary artery; prevents back-flow of blood into the ventricle

Pulse: the number of heartbeats per minute

Purkinje fibers (or Purkinje tissue): located in the inner ventricular walls of the heart, just beneath the endocardium; specialized myocardial fibers that conduct an electrical stimulus or impulse that enables the heart to contract in a coordinated fashion

Renin-Angiotension system:

Right Atrium: receives de-oxygenated blood from the superior vena cava and inferior vena cava

Serous Pericardium: functions in lubricating the heart to prevent friction from occurring during heart activity

Semilunar Valves: positioned on the pulmonary artery and the aorta

Sinoatrial Node: (abbreviated SA node or SAN, also called the sinus node): the impulse generating (pacemaker) tissue located in the right atrium of the heart

Sinusoidal Capillaries: special forms of fenestrated capillaries that have larger opening allowing RBCs and serum proteins to enter

Systole: contraction of the heart

Systolic Pressure: the highest point in blood pressure when the blood is being pumped out of the left ventricle into the aorta during ventricular systole

Superior Vena Cava (SVC): a large but short vein that carries de-oxygenated blood from the upper half of the body to the heart's right atrium

Thrombus: a blood clot in an intact blood vessel

Tricuspid Valve: on the right side of the heart, between the right atrium and the right ventricle; allows blood to flow from the right atrium into the right ventricle when the heart is relaxed during diastole

Vasoconstriction: the constriction of blood vessels

Vasodilation: the dilation of blood vessels

Veins: carry de-oxygenated blood from the capillary blood vessels to the right part of the heart

Ventricle: a heart chamber which collects blood from an atrium

Venule: a small blood vessel that allows deoxygenated blood to return from the capillary beds to the larger blood vessels called

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lymph nodes due to a radical mastectomy). Edema is common in the lower extremities when people spend a lot of time sitting, because the fluid return is based largely on the massaging action of skeletal muscles.

Lymphatic Vessels and Ducts

The lymphatic vessels are similar in structure to the cardiovascular veins, meaning they also have valves. They are dependent upon the contraction of skeletal muscle, respiratory movements and valves that do not allow backward flow. The vessels merge before entering one of two ducts.

- **Thoracic Duct:** This duct is much larger than the lymphatic duct. It serves the abdomen, lower extremities and the left side of the upper body (head, neck, and arm)
- **Right Lymphatic Duct:** This duct serves all of the right side of the upper body and thoracic area (head, neck).

Organs, Tissues and Cells of the Immune System

The immune system consists of a network of lymphatic organs, tissues, and cells. These structures are supported by the reticuloendothelial system: loose connective tissue with a network of reticular fibers. Phagocytic cells, including monocytes and macrophages, are located in the reticular connective tissue. When micro-organisms invade the body, or the body encounters antigens (such as pollen), antigens are transported to the lymph. Lymph is carried through the lymph vessels to regional lymph nodes. In the lymph nodes, the macrophages and dendritic cells phagocytose the antigens, process them, and present the antigens to lymphocytes, which can then start producing antibodies or serve as memory cells. The function of memory cells is to recognize specific antigens in the future.

Primary Lymphatic Organs The primary lymphatic organs are the red bone marrow and the thymus. They are the site of production and maturation of lymphocytes, the type of white blood cell that carries out the most important work of the immune system.

- **Red Bone Marrow** Red bone marrow, the soft, spongy, nutrient rich tissue in the cavities of certain long bones, is the organ that is the site of blood cell production.

Some of the white blood cells produced in the marrow are: neutrophils, basophils, eosinophils, monocytes, and lymphocytes. Lymphocytes differentiate into B lymphocytes and T lymphocytes. Red bone marrow is also the site of maturation of B lymphocytes. T lymphocytes mature in the thymus.

- **Thymus Gland** The thymus gland is located in the upper thoracic cavity posterior to the sternum and anterior to the ascending aorta. The thymus is an organ that is more active in children, and shrinks as we get older. Connective tissue separates the thymus into lobules, which contain lymphocytes. Thymic hormones such as thymosin are produced in the thymus gland. Thymosin is thought to aid in the maturation of T lymphocytes. **The Thymus** is critical to the immune system. Without a thymus, a person has no ability to reject foreign substances, blood lymphocyte level is very poor, and the body's response to most antigens is either absent or very weak

Immature T lymphocytes travel from the bone marrow through the bloodstream to reach the

There are different classes of antibodies, or immunoglobulins (Ig), such as IgA, IgG, IgE, and IgM. They can attach to the surface of a microbe and make it more easily phagocytized by neutrophils, monocytes and macrophages. Anything that simplifies phagocytosis is called an *opsonin*. The process of antibodies attaching to invaders can be termed 'opsonization.' Some antibodies can bind and inactivate certain poisons or toxins and are called *antitoxins* (tetanus immunizations stimulate your body to produce antibodies against the tetanus toxin rather than against the bacteria that produces the toxin). Still other antibodies can bind to the surface of microbes and prevent their attachment to the body's cells (thus preventing viruses from entering host cells). Also, some of them can stimulate nine proteins found in plasma, called *complement*.

Memory B cells

At the time of activation some of the clones become memory B cells. These cells are long lived and have recorded the information about the foreign antigen so antibodies can be made more quickly, and in greater amount, in case a second exposure should occur. Since the second response is much stronger than the first and puts more antibodies into circulation, we often receive "booster shots" for immunizations.

T Cells Attack Infected Cells

Defending the body against intracellular pathogens is the role of T lymphocytes, which carry out *cell-mediated immunity* (CMI). Macrophages phagocytize invading microbes and present parts of the microbe (antigens) to the T cell lymphocytes. The appropriate T cell is *turned on* or stimulated. The activated T cell rapidly multiplies into a large homogenous group (clone) of *cytotoxic T cells* (Tc cells).

- (a) Attack organisms directly, Also kill infected cells

These cytotoxic T cells migrate to the site of infection (or disease) and produce chemicals which directly kill the invader. Cytotoxic T cells release "perforin" that causes pores to form in the plasma membrane of the target cell, resulting in lysis.

- (b) T cells develop in the thymus gland from immature precursor cells that migrate there from the bone marrow.
- (c) Killer and helper T cells
- (d) Memory T Cells

A portion of these activated T cells become *memory* T cells (Tm). These cells record the information about the foreign antigen so T cells can respond more quickly, and more strongly, if a second exposure occurs. A portion of the T cells become *T helper cells* (TH) or *T suppressor cells* (Ts). TH cells stimulate other T cells and B cells by releasing *cytokines* and other stimulatory chemicals. Ts cells suppress the immune response. Experience has shown that cell mediated immunity is most useful to the body by: Protecting against microbes which exist inside of our body's cells (intracellular bacteria and intracellular viruses). Protecting against fungal infections. Protecting against protozoan parasites. Protecting against cancer cells.

Immunization

While some infectious diseases are common and can occur many times in the same person, others can only occur once in a lifetime thanks to the immune system and its ability to remember the organism and prevent following infections. To avoid an epidemic of a grave disease such as polio, before the disease can be acquired, an immunization can create a man-made "memory".

- Active immunization

A person receives an injection (vaccine) that contains dead or harmless living forms of an organism. The vaccine stimulates the immune system to produce antibodies and memorize the organism. If there is a later exposure to this organism and subsequent infection, the antibodies will stop the infection.

- Passive immunization

Blood containing antibodies is taken from animals or humans who have recently had an infection. Blood serum is made that contains the antibodies, and then injected into the person. The antibodies either attack an infection that is present or provide short-term protection.

- Genetically engineered viruses

Genetic engineering is a technique that alters or changes the DNA of a plant or animal by inserting new genetic information from another organism. After these organisms replicate, vaccines and hormones are made that can help fight disease.

- Hepatitis B vaccine

The gene of the surface antigen of Hepatitis B virus is implanted into the DNA of a single bacterium. The bacteria produces viral antigens which are then implanted to stimulate the immune system.

IMMUNE SYSTEM DISORDERS

The immune system is a very complex and highly developed system, yet it has a very simple mission, seek and destroy invaders. When the immune system does not function properly it leaves the body open for attacks from an array of diseases. We classify these into three broad categories; autoimmunity, immunodeficiencies, and hypersensitivities.

Anything that can trigger the immune response is called an antigen. An antigen can be a microbe such as a virus, or even a part of a microbe. Tissues of cells from another person also carry nonself markers and act as antigens. This explains why tissue transplants can be rejected. In abnormal situations, the immune system can mistake self for nonself and launch an attack against the body's own cells or tissues. The result is called an autoimmune disease. Some forms of arthritis and diabetes are autoimmune diseases. In other cases, the immune system responds to a seemingly harmless foreign substance such as a dust mite. The result is allergy, and this kind of antigen is called an allergen.

It is in the mitochondria of the cells where oxygen is actually consumed and carbon dioxide produced. Oxygen is produced as it combines with hydrogen ions to form water at the end of the electron transport chain (see chapter on cells). As cells take apart the carbon molecules from glucose, these get released as carbon dioxide. Each body cell releases carbon dioxide into nearby capillaries by diffusion, because the level of carbon dioxide is higher in the body cells than in the blood. In the capillaries, some of the carbon dioxide is dissolved in plasma and some is taken by the hemoglobin, but most enters the red blood cells where it binds with water to form carbonic acid. It travels to the capillaries surrounding the lung where a water molecule leaves, causing it to turn back into carbon dioxide. It then enters the lungs where it is exhaled into the atmosphere.

Lung Capacity

The normal volume moved in or out of the lungs during quiet breathing is called **tidal volume**. When we are in a relaxed state, only a small amount of air is brought in and out, about 500 mL. You can increase both the amount you inhale, and the amount you exhale, by breathing deeply. Breathing in very deeply is **Inspiratory Reserve Volume** and can increase lung volume by 2900 mL, which is quite a bit more than the tidal volume of 500 mL. We can also increase expiration by contracting our thoracic and abdominal muscles. This is called **expiratory reserve volume** and is about 1400 mL of air. **Vital capacity** is the total of tidal, inspiratory reserve and expiratory reserve volumes; it is called vital capacity because it is vital for life, and the more air you can move, the better off you are. There are a number of illnesses that we will discuss later in the chapter that decrease vital capacity. Vital Capacity can vary a little depending on how much we can increase inspiration by expanding our chest and lungs. Some air that we breathe never even reaches the lungs! Instead it fills our nasal cavities, trachea, bronchi, and bronchioles. These passages aren't used in gas exchange so they are considered to be **dead air space**. To make sure that the inhaled air gets to the lungs, we need to breathe slowly and deeply. Even when we exhale deeply some air is still in the lungs (about 1000 mL) and is called **residual volume**. This air isn't useful for gas exchange. There are certain types of diseases of the lung where residual volume builds up because the person cannot fully empty the lungs. This means that the vital capacity is also reduced because their lungs are filled with useless air.

Stimulation of Breathing

There are two pathways of motor neuron stimulation of the respiratory muscles. The first is the control of voluntary breathing by the cerebral cortex. The second is involuntary breathing controlled by the medulla oblongata.

There are chemoreceptors in the aorta, the carotid arteries, and in the medulla oblongata of the brainstem that are sensitive to pH. As carbon dioxide levels increase there is a buildup of carbonic acid, which releases hydrogen ions and lowers pH. Thus, the chemoreceptors do not respond to changes in oxygen levels (which actually change much more slowly), but to pH, which is an indirect measure of carbon dioxide levels. **In other words, CO₂ is the driving force for breathing.** The receptors in the aorta and the carotid arteries stimulate an immediate increase in breathing rate and the receptors in the medulla stimulate a sustained increase in breathing until blood pH returns to normal.

This response can be experienced by running a 100 meter dash. During this exertion (or any other sustained exercise) your muscle cells must metabolize ATP at a much faster rate than usual, and thus will produce much higher quantities of CO₂. The blood pH drops as CO₂ levels increase, and you will

smaller tubes as they run throughout the lungs

Cellular Respiration: takes place at the mitochondria of the cells where the oxygen is actually consumed and carbon dioxide produced

Chronic Bronchitis: an obstructive pulmonary disease characterized by inflammation of the bronchi of the lungs

COPD: Chronic Obstructive Pulmonary Disease.

Cystic Fibrosis (CF): disease that causes the formation of a thick mucus substance that affects the lungs, intestines, pancreas and liver. It can be test for with a sweat test.

Emphysema: a chronic lung disease, often caused by exposure to toxic chemicals or long-term exposure to tobacco smoke

External Respiration: the exchange of gases between the air in the alveoli and the blood within the pulmonary capillaries

Hyperventilation: excessive rate and depth of breathing causing the blood pH to increase

Laryngitis: inflammation of the larynx. It causes hoarse voice or the complete loss of the voice because of irritation to the vocal folds (vocal cords)

Lung Cancer: cancer of the tissue of the lung, often caused by smoking

Nasal Cavities: hollow spaces within the bones of the skull that warm, moisten, and filter the air

Otitis Media: infection of the middle ear, it is often a complication seen in children who have a nasal infection

Pneumonia: bacterial or viral infection in the lungs where the bronchi and the alveoli fill with a thick fluid

Pulmonary Alveoli: microscopic membranous air sacs within the lungs, they are units of respiration and the site of gas exchange between the respiratory and circulatory systems

Pulmonary Embolism Pulmonary embolism is blockage of the pulmonary artery (or one of its branches) by a blood clot, fat, air or clumped tumor cells.

Pulmonary Fibrosis: a condition where fibrous tissue builds up in the lungs

Pulmonary Tuberculosis (TB): infectious disease caused by the bacterium mycobacterium tuberculosis

Respiratory Illnesses: the result of bacterial or viral infection of the lungs

Sinusitis: an infection of the cranial sinuses "sinus infection", develops when nasal congestion blocks off the tiny openings that lead to the sinuses

obstruction is in the liver) or "extrahepatic" (outside the liver). It can lead to jaundice, and is identified by the presence of elevated bilirubin level that is mainly conjugated.

Biliary colic

This is when a gallstone blocks either the common bile duct or the duct leading into it from the gallbladder. This condition causes severe pain in the right upper abdomen and sometimes through to the upper back. It is described by many doctors as the most severe pain in existence, between childbirth and a heart attack. Other symptoms are nausea and vomiting and diarrhea, bleeding caused by continual vomiting, and dehydration caused by the nausea and diarrhea. Another more serious complication is total blockage of the bile duct which leads to jaundice, which if it is not corrected naturally or by surgical procedure can be fatal as it causes liver damage. The only long term solution is the removal of the gallbladder.

Gastrointestinal Dysfunctions

As we age, the amount of digestive enzymes produced by the body drops way down. This leads to decreased and slower digestion, slower absorption of nutrients and increased accumulation of fecal matter in the intestinal tract. Undigested food material and metabolic waste can also build up due to slow elimination, starting of a series of health problems.

When digestion slows, it turns the intestines into a toxic environment. Helpful organisms cannot live in toxic environments. When the beneficial organisms die they are replaced by harmful organisms, such as yeasts and parasites, the most common being *Candida albicans*. This leads to changes in the intestinal wall which produces *leaky gut syndrome* which allows many toxic chemicals to be introduced into the blood stream. As a result the entire toxic load of the body is increased, which causes a bigger burden on the liver, kidneys and other body organs. When this happens the organs that are normally used for eliminating waste and supplying nutrients the GI tract becomes into a large dump for waste. This problem is made worse by the use of junk food, prescriptions, over the counter medications, antibiotics and a diet that is too low in fiber.

Most people never even think about their GI tract. We are all concerned about what the outside of our body look like, but we completely ignore the inside. Because our bodies are very resilient, deterioration of the digestive system can go on for years with no symptoms or side-effect. When symptoms finally do appear they are usually very non-specific, they include: decreased energy, headaches, diarrhea, constipation, heartburn, and acid reflux. Over the years these symptoms become more serious, they include: asthma, food allergies, arthritis, and cancer.

Poor digestion, poor absorption, and bacterial imbalance can be traced to a lot of chronic conditions. Every organ in the body receives nutrients for the GI tract. If the GI tract is malfunctioning then the whole body suffers.

It is possible to return good health to your GI tract by improving digestion, consuming the right amount of fiber, cutting out junk food and refined sugars.

You can improve the function of the intestines by taking fiber supplements and vitamins (especially B12 and vitamin K). Some doctors suggest herbal or vitamin enemas to cleanse and relieve constipation and to help stimulate *peristaltic movement* which will help to move the bowels.

Food Allergies

Food allergies occur when the immune system thinks that a certain protein in any kind of food is a foreign object and will try to fight against it.

Only about eight percent of children and two percent of adults actually have a food allergy. A person can be allergic to any kind of food, but the most common food allergies are from nuts, cow's milk, eggs, soy, fish, and shellfish. Most people who have a food allergy are allergic to less than four different foods.

The most common signs of food allergies are hives, swelling, itchy skin, itchiness, tingling or swelling in the mouth, coughing, trouble breathing, diarrhea, and vomiting. The two most common chronic illness that are associated with food allergies are eczema and asthma.

Food allergies can be fatal if it causes the reaction called anaphylaxis. This reaction makes it hard for the person to breathe. This can be treated by an epinephrine injection.

GERD, Heartburn, Acid Reflux

GERD, or Gastroesophageal Reflux Disease occurs when the lower esophageal sphincter is not able to close properly. When this happens, contents from the stomach called reflux leak back into the esophagus and the stomach.

When the stomach refluxes, stomach acid touches the lining of the esophagus and causes it to have a burning feeling in the throat or the chest. This is what heartburn is. When you taste the fluid in the back of your throat, it is called acid indigestion. It is common for a person to get occasional heartburn, but when it occurs more than twice a week it can be considered as GERD. GERD can occur in people of all ages including infants.

Some symptoms of GERD include having a pain in your chest, hoarseness, having trouble swallowing, or having the feeling of food being stuck in your throat. The main symptoms are having persistent heartburn and acid regurgitation. GERD can also cause bad breath and a dry cough.

No one knows why people get GERD. Some things that could contribute to GERD are alcohol use, pregnancy, being overweight and smoking. Certain foods might also contribute like citrus fruits, caffeine, spicy, fatty, and dried foods, and also mint flavorings.

Over-the-counter antacids or medications that help stop acid production and help the muscles empty the stomach are commonly used to treat GERD.

Constipation

Not everyone is on the same schedule for having a bowel movement. Depending on the person, a "normal" schedule can range anywhere from three times a day to three times a week. If you start having bowel movements less than your own personal schedule, then you might be getting the signs of constipation.

Constipation is when you have trouble having bowel movements. The stool is very hard making it hard to pass and causing a person to strain. You may even feel like you have to have a bowel

13 NUTRITION

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The Community and Nutrition Programs

Connections between nutrition and health have probably been understood, at least to some degree, among all people of all places and times. For example, around 400 BC Hippocrates said, "Let food be your medicine and medicine be your food." Understanding the physiological needs of our cells helps us understand why it is that food has such an impact on overall health. In this chapter we introduce nutrition by examining how cells use different nutrients and then discuss disease conditions that are tied to nutritional problems.

Nutrition and Health in the Community

The nutritional status of people in our communities is a concern not only for quality of life, but also for economics (treating illness costs far more than preventing it). Various public health agencies are striving to prevent nutritional deficiencies and improve overall health. In the U.S., the government supplies a variety of resources such as state assistance, WIC (Women, Infant and Child), and so forth. In addition, there have been many government agencies and voluntary health and scientific associations, such as the American Heart Association, that focus on the style and dietary factors that prevent chronic and life-threatening diseases. The U.S. Department of Agriculture (USDA) and the U.S. Department of Health and Human Services (USDHHS) developed dietary guidelines in 1977 that were compiled and displayed as the food guide pyramid. The food guide pyramid was revised as "My Pyramid," but this new chart is confusing to most people. Harvard School of Public Health developed an alternative healthy eating pyramid (shown below) based on long-term nutritional studies. This pyramid differs from the old USDA pyramid in several key aspects: for example, exercise is at the bottom to remind us of its important role in our health. Also, not all carbohydrates are at the bottom (white bread, white rice, and potatoes are now at the top with sugars), and not all oils are at the top (plant oils are at the bottom). Other resource, such as the Recommended Daily Allowance (RDA) have helped people become more aware of nutritional needs, yet obesity and chronic health problems continue to rise.

Nutritional Requirements

Our bodies have certain nutritional needs and if they are not met will cause catabolism of its own fats, carbohydrates and proteins. Molecules are continuously broken down, so we must replace them. Food molecules, essential fatty acids and essential amino acids are particularly important in replacing these molecules. Vitamins (Vital Emino acids) and minerals are not used as energy, but are essential in enzyme reactions. Living tissue is kept alive by using the expenditure of ATP, found in the break down of food. Foods energy value is measured in kilocalories. 1 kilocalorie is equal to 1000 calories.

Carbohydrates

Macronutrient

Aspartic acid	D	Asp	Behaves similarly to glutamic acid. Carries a hydrophilic acidic group with strong negative charge. Usually is located on the outer surface of the protein, making it water-soluble. Binds to positively-charged molecules and ions, often used in enzymes to fix the metal ion. When located inside of the protein, aspartate and glutamate are usually paired with arginine and lysine.
Glutamate	E	Glu	Behaves similar to aspartic acid. Has longer, slightly more flexible side chain.
Phenylalanine	F	Phe	Essential for humans. Phenylalanine, tyrosine, and tryptophan contain large rigid aromatic group on the side chain. These are the biggest amino acids. Like isoleucine, leucine and valine, these are hydrophobic and tend to orient towards the interior of the folded protein molecule.
Glycine	G	Gly	Because of the two hydrogen atoms at the α carbon, glycine is not optically active . It is the smallest amino acid, rotates easily, adds flexibility to the protein chain. It is able to fit into the tightest spaces, e.g., the triple helix of collagen . As too much flexibility is usually not desired, as a structural component it is less common than alanine.
Histidine	H	His	In even slightly acidic conditions protonation of the nitrogen occurs, changing the properties of histidine and the polypeptide as a whole. It is used by many proteins as a regulatory mechanism, changing the conformation and behavior of the polypeptide in acidic regions such as the late endosome or lysosome , enforcing conformation change in enzymes. However only a few histidines are needed for this, so it is comparatively scarce.
Isoleucine	I	Ile	Essential for humans. Isoleucine, leucine and valine have large aliphatic hydrophobic side chains. Their molecules are rigid, and their mutual hydrophobic interactions are important for the correct folding of proteins, as these chains tend to be located inside of the protein molecule.
Lysine	K	Lys	Essential for humans. Behaves similarly to arginine. Contains a long flexible side chain with a positively-charged end. The flexibility of the chain makes lysine and arginine suitable for binding to molecules with many negative charges on their surfaces. E.g., DNA -binding proteins have their active regions rich with arginine and lysine. The strong charge makes these two amino acids prone to be located on the outer hydrophilic surfaces of the proteins; when they are found inside, they are usually paired with a corresponding negatively-charged amino acid, e.g., aspartate or glutamate.
Leucine	L	Leu	Essential for humans. Behaves similar to isoleucine and valine. See isoleucine.
Methionine	M	Met	Essential for humans. Always the first amino acid to be incorporated into a protein; sometimes removed after translation. Like cysteine, contains sulfur, but with a methyl group instead of hydrogen. This methyl group can be activated, and is used in many reactions where a new carbon atom is being added to another molecule.
Asparagine	N	Asn	Similar to aspartic acid. Asn contains an amide group where Asp has a carboxyl .
Proline	P	Pro	Contains an unusual ring to the N-end amine group, which forces the CO-NH amide sequence into a fixed conformation. Can disrupt protein folding structures like α helix or β sheet, forcing the desired kink in the protein chain. Common in collagen , where it often undergoes a posttranslational

14 THE ENDOCRINE SYSTEM

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Introduction To The Endocrine System

The endocrine system is a control system of ductless glands that secrete chemical messengers called hormones that circulate within the body via the bloodstream to affect distant cells within specific organs. Endocrine glands secrete their products immediately into the blood or interstitial fluid, without storage of the chemical. Hormones act as "messengers," and are carried by the bloodstream to different cells in the body, which interpret these messages and act on them.

It seems like a far fetched notion or idea that a small chemical can enter the bloodstream and cause an action at a distant location in the body. Yet this occurs in our bodies everyday of our lives. The ability to maintain homeostasis and respond to stimuli is largely due to hormones secreted within the body. Without hormones, you could not grow, maintain a constant temperature, produce offspring, or perform the basic actions and functions that are essential for life.

The endocrine system provides an electrochemical connection from the hypothalamus of the brain to all the organs that control the body metabolism, growth and development and reproduction.

There are two types of hormones secreted in the endocrine system: (1) steroidal and (2) nonsteroidal, or protein based hormones.

The endocrine system regulates its hormones through negative feedback, except in very specific cases like childbirth. Increases in hormone activity decrease the production of that hormone. The immune system and other factors contribute as control factors also, altogether maintaining constant levels of hormones.

Types of Glands

Exocrine Glands are those which release their cellular secretions through a duct which empties to the outside or into the lumen (empty internal space) of an organ. These include certain sweat glands, salivary and pancreatic glands, and mammary glands. They are not considered a part of the endocrine system.

Endocrine Glands are those glands which have no duct and release their secretions directly into the intercellular fluid or into the blood. The collection of endocrine glands make up the endocrine system.

The main endocrine glands are the pituitary (anterior and posterior lobes), thyroid, parathyroids, adrenal (cortex and medulla), pancreas and gonads.

The pituitary gland is attached to the hypothalamus of the lower forebrain.

The thyroid gland consists of two lateral masses, connected by a crossbridge, that are attached to

been repaired, or negated, corrective actions decrease or discontinue. For example, the amount of glucose in the blood controls the secretion of insulin and glucagons via negative feedback.

The production of some hormones is controlled by positive feedback. In such a system, hormones cause a condition to intensify, rather than decrease. As the condition intensifies, hormone production increases. Such positive feedback is uncommon, but does occur during childbirth, where hormone levels build with increasingly intense labor contractions. Also in lactation, hormone levels increase in response to nursing, which causes milk production to increase. The hormone produced by the hypothalamas causing the milk let down and uterine contraction is **oxytocin**.

Endocrine Glands

Pituitary gland

The hypothalamus makes up the lower region of the diencephalons and lies just above the brain stem. The pituitary gland (hypophysis) is attached to the bottom of the hypothalamus by a slender stalk called the infundibulum. The pituitary gland consists of two major regions, the anterior pituitary gland (anterior lobe or adenohypophysis) and the posterior pituitary gland (posterior lobe or neurohypophysis). The hypothalamas also controls the glandular secretion of the pituitary gland.

The hypothalamus oversees many internal body conditions. It receives nervous stimuli from receptors throughout the body and monitors chemical and physical characteristics of the blood, including temperature, blood pressure, and nutrient, hormone, and water content. When deviations from homeostasis occur or when certain developmental changes are required, the hypothalamus stimulates cellular activity in various parts of the body by directing the release of hormones from the anterior and posterior pituitary glands. The hypothalamus communicates directives to these glands by one of the following two pathways.

The Pituitary gland is found in the inferior part of the brain and is connected by the Pituitary Stalk. It can be referred to as the master gland because it is the main place for everything that happens within the endocrine system. It is divided into two sections: the **anterior** lobe (adenohypophysis) and the **posterior** lobe (neurohypophysis). The Posterior pituitary is involved in sending hormones that control all other hormones of the body.

Posterior pituitary

Communication between the hypothalamus and the posterior pituitary occurs through neurosecretory cells that span the short distance between the hypothalamus and the posterior pituitary. Hormones produced by the cell bodies of the neurosecretory cells are packaged in vesicles and transported through the axon and stored in the axon terminals that lie in the posterior pituitary. When the neurosecretory cells are stimulated, the action potential generated triggers the release of the stored hormones from the axon terminals to a capillary network within the posterior pituitary. Two hormones, oxytocin and antidiuretic hormone (ADH), are produced and released this way. If one's not able to produce ADH it can cause Diabetes Insipidus which means a person is producing large amounts of urine, resulting in loss of ions from the blood.

Thyroid gland

The **Thyroid gland** is one of the largest endocrine glands in the body. It is positioned on the neck just below the Larynx and has two lobes with one on either side of the trachea. It is involved in the production of the hormones T3 (triiodothyronine) and T4 (thyroxine). These hormones increase the metabolic activity of the body's cells. The thyroid also produces and releases the hormone calcitonin (thyrocalcitonin) which contributes to the regulation of blood calcium levels. Thyrocalcitonin or calcitonin decreases the concentration of calcium in the blood. Most of the calcium removed from the blood is stored in the bones.

The thyroid hormone consists of two components, thyroxine and iodine. This hormone increases the metabolism of most body cells. A deficiency of iodine in the diet leads to the enlargement of the thyroid gland, known as a simple goiter. Hypothyroidism during early development leads to cretinism. In adults, it produces myxedema, characterized by obesity and lethargy. Hyperthyroidism leads to a condition known as exophthalmic goiter, characterized by weight loss as well as hyperactive and irritable behavior.

The thyroid gland is a two-lobed gland that manifests a remarkably powerful active transport mechanism for uptaking iodide ions from the blood. As blood flows through the gland, iodide is converted to an active form of iodine. This iodine combines with an amino acid called tyrosine. Two molecules of iodinated tyrosine then combine to form thyroxine. Following its formation, the thyroxine becomes bound to a polysaccharide-protein material called thyroglobulin. The normal thyroid gland may store several weeks supply of thyroxine in this bound form. An enzymatic splitting of the thyroxine from the thyroglobulin occurs when a specific hormone is released into the blood. This hormone, produced by the pituitary gland, is known as thyroid-stimulating hormone (TSH). TSH stimulates certain major rate-limiting steps in thyroxine secretion, and thereby alters its rate of release. A variety of bodily defects, either dietary, hereditary, or disease induced, may decrease the amount of thyroxine released into the blood. The most popular of these defects is one that results from dietary iodine deficiency. The thyroid gland enlarges, in the continued presence of TSH from the pituitary, to form a goiter. This is a futile attempt to synthesize thyroid hormones, for iodine levels that are too low. Normally, thyroid hormones act via a negative feedback loop on the pituitary to decrease stimulation of the thyroid. In goiter, the feedback loop cannot be in operation - hence continual stimulation of the thyroid and the inevitable protuberance on the neck. Formerly, the principal source of iodine came from seafood. As a result, goiter was prevalent amongst inland areas far removed from the sea. Today, the incidence of goiter has been drastically reduced by adding iodine to table salt.

Thyroxine serves to stimulate oxidative metabolism in cells; it increases the oxygen consumption and heat production of most body tissues, a notable exception being the brain. Thyroxine is also necessary for normal growth, the most likely explanation being that thyroxine promotes the effects of growth hormone on protein synthesis. The absence of thyroxine significantly reduces the ability of growth hormone to stimulate amino acid uptake and RNA synthesis. Thyroxine also plays a crucial role in the closely related area of organ development, particularly that of the central nervous system.

If there is an insufficient amount of thyroxine, a condition referred to as hypothyroidism results. Symptoms of hypothyroidism stem from the fact that there is a reduction in the rate of oxidative energy-releasing reactions within the body cells. Usually the patient shows puffy skin, sluggishness, and lowered vitality. Other symptoms of hypothyroidism include weight gain, decreased libido, inability to tolerate cold, muscle pain and spasm, insomnia and brittle dry hair. Hypothyroidism in children, a condition known as cretinism, can result in mental retardation, dwarfism, and permanent

No organ except the pancreas makes significant amounts of insulin or glucagon. **Insulin** acts to lower blood sugar levels by allowing the sugar to flow into cells. Glucagon acts to raise blood sugar levels by causing glucose to be released into the circulation from its storage sites. Insulin and glucagon act in an opposite but balanced fashion to keep blood sugar levels stable.

A healthy working pancreas in the human body is important for maintaining good health by preventing malnutrition, and maintaining normal levels of blood sugar. The digestive tract needs the help of the enzymes produced by the pancreas to reduce food particles to their simplest elements, or the nutrients cannot be absorbed. Carbohydrates must be broken down into individual sugar molecules. Proteins must be reduced to simple amino acids. Fats must be broken down into fatty acids. The pancreatic enzymes are important in all these transformations. The basic particles can then easily be transported into the cells that line the intestine, and from there they can be further altered and transported to different tissues in the body as fuel sources and construction materials. Similarly, the body cannot maintain normal blood sugar levels without the balanced action of insulin and glucagon.

The pancreas contains exocrine and endocrine cells. Groups of endocrine cells, the **islets of Langerhans**, secrete two hormones. The beta cells secrete **insulin**; the alpha cells secrete **glucagon**. The level of sugar in the blood depends on the opposing action of these two hormones.

Insulin decreases the concentration of glucose in the blood. Most of the glucose enters the cells of the liver and skeletal muscles. In these cells, this **monosaccharide** is converted to the polysaccharide glycogen. Therefore, insulin promotes **glycogenesis** (glycogen formation), stimulating the breakdown of glycogen into glucose for release into the blood.

Insulin deficiency leads to the development of **diabetes mellitus**, specifically **type I**, juvenile diabetes. As the pancreas does not produce sufficient insulin, it is treated by insulin injections. In **type II** or maturity-onset diabetes, the pancreas does produce enough insulin, but the target cells do not respond to it.

As already stated, the pancreas is a mixed gland having both endocrine and exocrine functions. The exocrine portion secretes digestive enzymes into the duodenum via the pancreatic duct. The endocrine portion secretes two hormones, insulin and glucagon, into the blood.

Insulin is a hormone that acts directly or indirectly on most tissues of the body, with the exception of the brain. The most important action of insulin is the stimulation of the uptake of glucose by many tissues, particularly the liver, muscle and fat. The uptake of glucose by the cells decreases blood glucose and increases the availability of glucose for the cellular reactions in which glucose participates. Thus, glucose oxidation, fat synthesis, and glycogen synthesis are all accentuated by an uptake of glucose. It is important to note that insulin does not alter glucose uptake by the brain, nor does it influence the active transport of glucose across the renal tubules and gastrointestinal epithelium.

As stated, insulin stimulates glycogen synthesis. In addition, it also increases the activity of the enzyme that catalyzes the rate-limiting step in glycogen synthesis. Insulin also increases triglyceride levels by inhibiting triglyceride breakdown, and by stimulating production of triglyceride through fatty acid and glycerophosphate synthesis. The net protein synthesis is also increased by insulin, which stimulates the active membrane transport of amino acids, particularly into muscle cells. Insulin also has effects on other liver enzymes, but the precise mechanisms by which insulin induces these changes are not well understood.

Review Questions

1. My child just fell and was hurt, the anxious feeling that I feel is caused by
 - A) glucagon
 - B) insulin
 - C) epinephrine
 - D) adrenocorticotrophic
 - E) None of these
2. All of Bob's life he has had to take insulin shots, this is caused because
 - A) his beta cells don't function correctly
 - B) his alpha cells don't function correctly
 - C) his DA hormone isn't functioning correctly
 - D) his GHRH hormone isn't functioning correctly
3. The reason iodine is in salt is
 - A) to prevent diabetes
 - B) to prevent simple goiters
 - C) to prevent Addison's disease
 - D) to prevent Cushing's syndrome
4. All hormones react to a negative feedback except
 - A) progesterone
 - B) estrogen
 - C) prolactin
 - D) oxytocin
 - E) none of these
5. If I have a high blood calcium level it may be due to
 - A) calcitonin
 - B) parathyroid
 - C) glucocorticoids
 - D) glucagon
6. Hormones that are lipids that are synthesized from cholesterol
 - A) protein
 - B) amino acid-derived
 - C) polypeptide
 - D) steroids
 - E) eicosanoids
7. This type of hormone must bind to a receptor protein on the plasma membrane of the cell

body temperature. Temperature has to be lower than normal in order for *spermatogenesis* (sperm production) to take place.

A male can become sterile when testes have been exposed too often to high temperatures, such as when frequently in a hot tub.

The two muscles that regulate the temperature of the testes are the dartos and cremaster muscles:

- *Dartos Muscle*

The dartos muscle is a layer of smooth muscle fibers in the subcutaneous tissue of the scrotum (surrounding the scrotum). This muscle is responsible for wrinkling up the scrotum, in conditions of cold weather, in order to maintain the correct temperature for spermatogenesis.

- *Cremaster Muscle*

The cremaster muscle is a thin strand of skeletal muscle associated with the testes and spermatic cord. This muscle is a continuation of the internal oblique muscle of the abdominal wall, from which it is derived. It is responsible for raising or lowering the testes to keep them at the correct temperature. Because it is skeletal muscle, it can also be contracted voluntarily. Some males, such as athletes, have the ability to consciously raise their scrotum up, to protect themselves against injury, while playing sports. However, not all males have this ability.

Seminiferous Tubules

Each testis contains over 100 yards of tightly packed seminiferous tubules. Around 90% of the weight of each testes consists of seminiferous tubules. The seminiferous tubules are the functional units of the testes where spermatogenesis takes place. Once the sperm are produced, they moved from the seminiferous tubules into the rete testis for further maturation.

Interstitial Cells (Cells of Leydig)

In between the seminiferous tubules within the testes, are interstitial cells, or, *Cells of Leydig*. They are responsible for secreting the male sex hormones (i.e., testosterone).

Sertoli Cells

A Sertoli cell (a kind of sustentacular cell) is a 'nurse' cell of the testes which is part of a seminiferous tubule.

It is activated by follicle-stimulating hormone, and has FSH-receptor on its membranes.

Its main function is to nurture the developing sperm cells through the stages of spermatogenesis. Because of this, it has also been called the "mother cell." It provides both secretory and structural support.

The junctions of Sertoli cells form the blood-testis barrier, a structure that partitions the interstitial blood compartment of the testis from the adluminal compartment of the seminiferous tubules. Sertoli cells control the entry and exit of nutrients, hormones and other chemicals into the tubules of the testis

		Leydig in the testicles.
Testicular arteries (Gonadal arteries)	Branch of the abdominal aorta. It is a paired artery. Each passes obliquely downward and laterally behind the peritoneum.	Supplies blood to the testes.
Urethra	Connects bladder to outside body, about 8 inches long.	Tubular structure that receives urine from bladder and carries it to outside of the body. Also passage for sperm.
Vas deferens	Muscular tubes connecting the left and right epididymis to the ejaculatory ducts to move sperm. Each tube is about 30 cm long.	During ejaculation the smooth muscle in the vas deferens wall contracts, propelling sperm forward. Sperm are transferred from the vas deferens into the urethra, collecting fluids from accessory sex glands en route

Composition of human semen

The components of semen come from two sources: sperm, and "seminal plasma". Seminal plasma, in turn, is produced by contributions from the seminal vesicle, prostate, and bulbourethral glands.

Seminal plasma of humans contains a complex range of organic and inorganic constituents.

The seminal plasma provides a nutritive and protective medium for the spermatozoa during their journey through the female reproductive tract. The normal environment of the vagina is a hostile one for sperm cells, as it is very acidic (from the native microflora producing lactic acid), viscous, and patrolled by immune cells. The components in the seminal plasma attempt to compensate for this hostile environment. Basic amines such as putrescine, spermine, spermidine and cadaverine are responsible for the smell and flavor of semen. These alkaline bases counteract the acidic environment of the vaginal canal, and protect DNA inside the sperm from acidic denaturation.

The components and contributions of semen are as follows:

GLAND	APPROXIMATE %	DESCRIPTION
testes	2-5%	Approximately 200- to 500-million spermatozoa (also called sperm or spermatozoans), produced in the testes, are released per ejaculation
seminal vesicle	65-75%	amino acids, citrate, enzymes, flavins, fructose (the main energy source of sperm cells, which rely entirely on sugars from the seminal plasma for energy), phosphorylcholine, prostaglandins (involved in suppressing an immune response by the female against the foreign semen), proteins, vitamin C
prostate	25-30%	acid phosphatase, citric acid, fibrinolysin, prostate specific antigen, proteolytic enzymes, zinc (serves to help to stabilize the DNA-containing chromatin in the sperm cells. A zinc deficiency may result in lowered fertility because of increased sperm fragility. Zinc deficiency can also adversely affect spermatogenesis.)
bulbourethral glands	< 1%	galactose, mucus (serve to increase the mobility of sperm cells in the vagina and cervix by creating a less viscous channel for the

sperm cells to swim through, and preventing their diffusion out of the semen. Contributes to the cohesive jelly-like texture of semen.), pre-ejaculate, sialic acid

A 1992 World Health Organization report described normal human semen as having a volume of 2 ml or greater, pH of 7.2 to 8.0, sperm concentration of 20×10^6 spermatozoa/ml or more, sperm count of 40×10^6 spermatozoa per ejaculate or more and motility of 50% or more with forward progression (categories a and b) of 25% or more with rapid progression (category a) within 60 minutes of ejaculation.[2]

Functions

Hormone Regulation

Hormones which control reproduction in males are:

Gonadotropin-Releasing Hormone (GnRH):

- The hypothalamus secretes this hormone into the pituitary gland in the brain.
- There are two gonadotropic hormones, FSH and LH.

Luteinizing Hormone (LH):

- The pituitary gland secretes this hormone after receiving a GnRH signal from the hypothalamus.
- LH stimulates Leydig cells in the testes, telling them to produce testosterone.

Follicle-Stimulating Hormone (FSH):

- The pituitary gland also secretes this hormone.
- Testosterone helps FSH run through the bloodstream to make Sertoli cells, located in the seminiferous tubules of the testes, to make immature sperm to mature sperm.

Testosterone:

- Also known as "the male hormone" and "androgen".
- Testosterone is vital for the production of sperm.

Erection

The erection of the penis is its enlarged and firm state. It depends on a complex interaction of psychological, neural, vascular and endocrine factors. The term is also applied to the process that leads to this state.

A penile erection occurs when two tubular structures that run the length of the penis, the corpora cavernosa, become engorged with venous blood. This is a result of parasympathetic nerve induced

puberty, averaging about 2–3 cc in volume and about 1.5-2 cm in length. Testicular size continues to increase throughout puberty, reaching maximal adult size about 6 years later. While 18-20 cc is reportedly an average adult size, there is wide variation in the normal population.

The testes have two primary functions: to produce hormones and to produce sperm. The Leydig cells produce testosterone (as described below), which in turn produces most of the changes of male puberty. However, most of the increasing bulk of testicular tissue is spermatogenic tissue (primarily Sertoli and interstitial cells). The development of sperm production and fertility in males is not as well researched. Sperm can be detected in the morning urine of most boys after the first year of pubertal changes (and occasionally earlier).

Genitalia

A boy's penis grows little from the fourth year of life until puberty. Average prepubertal penile length is 4 cm. The prepubertal genitalia are described as stage 1. Within months after growth of the testes begins, rising levels of testosterone promote growth of the penis and scrotum. This earliest discernible beginning of pubertal growth of the genitalia is referred to as stage 2. The penis continues to grow until about 18 years of age, reaching an average adult size of about 10-16 cm.

Although erections and orgasm can occur in prepubertal boys, they become much more common during puberty, accompanied by development of *libido* (sexual desire). Ejaculation becomes possible early in puberty; prior to this boys may experience dry dreams. Emission of seminal fluid may occur due to masturbation or spontaneously during sleep (commonly termed a *wet dream*, and more clinically called a *nocturnal emission*). The ability to ejaculate is a fairly early event in puberty compared to the other characteristics, and can occur even before reproductive capacity itself. In parallel to the irregularity of the first few periods of a girl, for the first one or two years after a boy's first ejaculation, his seminal fluid may contain few or no sperm.

If the foreskin of a boy does not become retractable during childhood, it normally begins to retract during puberty. This occurs as a result of the increased production of testosterone and other hormones in the body.

Genital Erection

The penis contains two chambers called the corpora cavernosa, which run the length of the organ. A spongy tissue, full of muscle, veins, arteries, etc. fills these chambers. The corpora cavernosa are surrounded by a membrane, called the tunica albuginea.

Erection begins with sensory or mental stimulation, or both. Impulses from the brain and local nerves cause the muscles of the corpora cavernosa to relax, allowing blood to flow in and fill the spaces. The blood creates pressure in the corpora cavernosa, making the penis expand. The tunica albuginea helps trap the blood in the corpora cavernosa, thereby sustaining erection. When muscles in the penis contract to stop the inflow of blood and open outflow channels, erection is reversed.

lean body mass of an average female, and about 50% of the body fat.

This muscle develops mainly during the later stages of puberty, and muscle growth can continue even after a male is biologically adult. The peak of the so-called "strength spurt," the rate of muscle growth, is attained about one year after a male experiences his peak growth rate.

Body odor, skin changes, acne

Rising levels of androgens can change the fatty acid composition of perspiration, resulting in a more "adult" body odor. As in girls, another androgen effect is increased secretion of oil (sebum) from the skin and the resultant variable amounts of acne.

Sexual Homology

In short, this is a known list of sex organs that evolve from the same tissue in a human life.

Indifferent	Male	Female
Gonad	Testis	Ovary
Mullerian duct	Appendix testis	Fallopian tubes
Mullerian duct	Prostatic utricle	Uterus, proximal vagina
Wolffian duct	Rete testis	Rete ovarii
Mesonephric tubules	Efferent ducts	Epididymis
Wolffian duct	Epididymis	Gartner's duct
Wolffian duct	Vas deferens	
Wolffian duct	Seminal vesicle	
Wolffian duct	Prostate	Skene's glands
Urogenital sinus	Bladder, urethra	Bladder, urethra, distal vagina
Urogenital sinus	Bulbourethral gland	Bartholin's gland
Genital swelling	Scrotum	Labia majora
Urogenital folds	Distal urethra	Labia minora
Genital tubercle	Penis	Clitoris
Prepuce	Foreskin	Clitoral hood
	Bulb of penis	Vestibular bulbs
	Glans penis	Clitoral glans
	Crus of penis	Clitoral crura

- A) the sperm are introduced into the urethra
 - B) the sperm are ejaculated into the vaginal canal
 - C) the sperm begin to interact with the fertilizing layer of an egg cell
 - D) the sperm reach the cervix
6. It takes sperm _____ weeks to travel through the epididymis
- A) 6-8
 - B) 1-3
 - C) 2-4
 - D) 4-6
7. While singing in the choir, Ben suddenly notices his voice is constantly cracking. This is caused by
- A) androgens
 - B) LH
 - C) FSH
 - D) Ben's inability to sing
8. In sexual homology, the glans penis in the male is equal to _____ in the female
- A) clitoral hood
 - B) clitoris
 - C) clitoral glans
 - D) clitoral crura
9. In sexual homology, the _____ in the male is equal to the fallopian tubes in the female
- A) testis
 - B) appendix testis
 - C) vas deferens
 - D) seminal vesicle
 - E) efferent ducts
10. Joe has a bulge in the groin area that seems to get worse when he lifts things. This most likely is
- A) epididymitis
 - B) testicular cancer
 - C) varicocele
 - D) hydrocele
 - E) inguinal hernia

Glossary

Androgen: The generic term for any natural or synthetic compound, usually a steroid hormone, that stimulates or controls the development and maintenance of masculine characteristics in vertebrates by binding to androgen receptors. This includes the activity of the accessory male sex organs and development of male secondary sex characteristics. They are also the precursor of all estrogens, the

During sexual excitement, the clitoris erects and extends, the hood retracts, making the clitoral glans more accessible. The size of the clitoris is variable between women. On some, the clitoral glans is very small; on others, it is large and the hood does not completely cover it.

Urethra

The opening to the urethra is just below the clitoris. Although it is not related to sex or reproduction, it is included in the vulva. The **urethra** is actually used for the passage of urine. The urethra is connected to the bladder. In females the urethra is 1.5 inches long, compared to males whose urethra is 8 inches long. Because the urethra is so close to the anus, women should always wipe themselves from front to back to avoid infecting the vagina and urethra with bacteria. This location issue is the reason for bladder infections being more common among females.

Hymen

The hymen is a thin fold of mucous membrane that separates the lumen of the vagina from the urethral sinus. Sometimes it may partially cover the vaginal orifice. The hymen is usually perforated during later fetal development.

Because of the belief that first vaginal penetration would usually tear this membrane and cause bleeding, its "intactness" has been considered a guarantor of virginity. However, the hymen is a poor indicator of whether a woman has actually engaged in sexual intercourse because a normal hymen does not completely block the vaginal opening. The normal hymen is never actually "intact" since there is always an opening in it. Furthermore, there is not always bleeding at first vaginal penetration. The blood that is sometimes, but not always, observed after first penetration can be due to tearing of the hymen, but it can also be from injury to nearby tissue.

A tear in the hymen, medically referred to as a "transection," can be seen in a small percentage of women or girls after first penetration. A transection is caused by penetrating trauma. Masturbation and tampon insertion can, but generally are not forceful enough to cause penetrating trauma to the hymen. Therefore, the appearance of the hymen is not a reliable indicator of virginity or chastity.

Perineum

The perineum is the short stretch of skin starting at the bottom of the vulva and extending to the anus. It is a diamond shaped area between the symphysis pubis and the coccyx. This area forms the floor of the pelvis and contains the external sex organs and the anal opening. It can be further divided into the urogenital triangle in front and the anal triangle in back.

The perineum in some women may tear during the birth of an infant and this is apparently natural. Some physicians however, may cut the perineum preemptively on the grounds that the "tearing" may be more harmful than a precise cut by a scalpel. If a physician decides the cut is necessary, they will perform it. The cut is called an episiotomy.

Internal Genitals

Vagina

The **vagina** is a muscular, hollow tube that extends from the vaginal opening to the cervix of the uterus. It is situated between the urinary bladder and the rectum. It is about three to five inches long in a grown woman. The muscular wall allows the vagina to expand and contract. The muscular walls are lined with mucous membranes, which keep it protected and moist. A thin sheet of tissue with one or more holes in it, called the hymen, partially covers the opening of the vagina. The vagina receives sperm during sexual intercourse from the penis. The sperm that survive the acidic condition of the vagina continue on through to the fallopian tubes where fertilization may occur.

The vagina is made up of three layers, an inner mucosal layer, a middle muscularis layer, and an outer fibrous layer. The inner layer is made of vaginal rugae that stretch and allow penetration to occur. These also help with stimulation of the penis. The middle layer has glands that secrete an acidic mucus (pH of around 4.0.) that keeps bacterial growth down. The outer muscular layer is especially important with delivery of a fetus and placenta.

Purposes of the Vagina

- Receives a males erect penis and semen during sexual intercourse.
- Pathway through a womans body for the baby to take during childbirth.
- Provides the route for the menstrual blood (menses) from the uterus, to leave the body.
- May hold forms of birth control, such as a diaphragm, FemCap, Nuva Ring, or female condom.

Structure

The basic components of the mammary gland are the **alveoli** (hollow cavities, a few millimetres large) lined with milk-secreting epithelial cells and surrounded by myoepithelial cells. These alveoli join up to form groups known as **lobules**, and each lobule has a **lactiferous duct** that drains into openings in the nipple. The **myoepithelial** cells can contract, similar to muscle cells, and thereby push the milk from the alveoli through the lactiferous ducts towards the nipple, where it collects in widenings (sinuses) of the ducts. A suckling baby essentially squeezes the milk out of these sinuses.

The development of mammary glands is controlled by hormones. The mammary glands exist in both sexes, but they are rudimentary until puberty when - in response to ovarian hormones - they begin to develop in the female. Estrogen promotes formation, while testosterone inhibits it.

At the time of birth, the baby has lactiferous ducts but no alveoli. Little branching occurs before puberty when ovarian estrogens stimulate branching differentiation of the ducts into spherical masses of cells that will become alveoli. True secretory alveoli only develop in pregnancy, where rising levels of estrogen and progesterone cause further branching and differentiation of the duct cells, together with an increase in adipose tissue and a richer blood flow.

Colostrum is secreted in late pregnancy and for the first few days after giving birth. True milk secretion (lactation) begins a few days later due to a reduction in circulating progesterone and the presence of the hormone prolactin. The suckling of the baby causes the release of the hormone oxytocin which stimulates contraction of the myoepithelial cells.

The cells of mammary glands can easily be induced to grow and multiply by hormones. If this growth runs out of control, cancer results. Almost all instances of breast cancer originate in the lobules or ducts of the mammary glands.

STRUCTURE	LOCATION & DESCRIPTION	FUNCTION
Breasts	Upper chest one on each side containing alveolar cells (milk production), myoepithelial cells (contract to expel milk), and duct walls (help with extraction of milk).	Lactation milk/nutrition for newborn.
Cervix	The lower narrower portion of the uterus.	During childbirth, contractions of the uterus will dilate the cervix up to 10 cm in diameter to allow the child to pass through. During orgasm, the cervix convulses and the external os dilates
Clitoris	Small erectile organ directly in front of the vestibule.	Sexual excitation, engorged with blood.
Fallopian tubes	Extending upper part of the uterus on either side.	Egg transportation from ovary to uterus (fertilization usually takes place here).
Hymen	Thin membrane that partially covers the vagina in young females.	
Labia majora	Outer skin folds that surround the entrance to the vagina.	Lubrication during mating.
Labia minora	Inner skin folds that surround the	Lubrication during mating.

ability to specialize into endometrial cells. These same cells were responsible for the growth of the woman's reproductive organs when she was an embryo. It is believed that genetic or environmental influences in later life allow these cells to give rise to endometrial tissue outside the uterus.

Experts estimate that up to one in ten American women of childbearing age have endometriosis. There is some thinking that previous damage to cells that line the pelvis can lead to endometriosis. There are several ways to diagnose endometriosis:

1. **Pelvic exam**
2. **Ultrasound**
3. **Laparoscopy** Usually used, most correct diagnosis
4. **Blood test**

Enometriosis can be treated with:

1. **Pain medication**
2. **Hormone therapy**
 1. **Oral contraceptives**
3. **Gonadotropin-releasing hormone(Gn-Rh)agonists and antagonists**
4. **Danazol(Danocrine)**
5. **Medroxyprogesterone(Depo-Provera)**
6. **Conservative surgery** which removes endometrial growth
7. **Hysterectomy**

Check Your Understanding

1. In homology, the _____ in the female is equal to the penis in the male

- A) labia majora
- B) clitoral hood
- C) clitoris
- D) labia minora
- E) none of the above

2. This contains some of the strongest muscles in the human body

- A) uteras
- B) clitoris
- C) cervix
- D) labia majora

3. This protects the vaginal and urethral openings

- A) labia majora
- B) labia minora
- C) clitoris
- D) urethra

10. When the ovaries stop producing estrogen, this occurs

- A) ovulation
- B) implantation
- C) premenstrual syndrome
- D) menopause

Glossary

Adhesions: Abnormal tissue that binds organs together

Alveoli: Basic components of the mammary glands; lined with milk-secreting epithelial cells

Birth Control: regimen of one or more actions, devices, or medications followed in order to deliberately prevent or reduce the likelihood of a woman becoming pregnant

Cervical Mucus: Mucus secreted by the cervix, near ovulation it helps to lower the acidity of the vagina

Cervix: Lower, narrow portion of the uterus where it joins with the top of the vagina

Clitoris: Small body of spongy tissue that functions solely for sexual pleasure

Chromosomes: Structures in the nucleus that contain the genes for genetic expression

Ectocervix: Portion of the cervix projecting into vagina

Endocervical Canal: Passageway between the external os and the uterine cavity

Endometrium: The inner lining of the uterus

Fallopian Tubes: Located at the upper end of the vagina, passage way for the egg from the ovary

Factor V Leiden: This is the name given to a variant of human factor V that causes a hypercoagulability disorder. In this disorder the Leiden variant of factor V, cannot be inactivated by activated protein C. Factor V Leiden is the most common hereditary hypercoagulability disorder amongst Eurasians. It is named after the city Leiden (The Netherlands), where it was first identified in 1994 by Prof R. Bertina et al.

Gamete: A haploid sex cell; either an egg cell or a sperm cell

Gene: That portion of the DNA of a chromosome containing the information needed to synthesize a particular protein molecule

Gonad: A reproductive organ, testis or ovary that produces gametes and sex hormones

Hormone: A chemical substance produced in an endocrine gland and secreted into the bloodstream that acts on target cells to produce a specific effect

17 PREGNANCY AND BIRTH

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Introduction

In this chapter we will discuss the topics covering pregnancy, from conception to birth. The chapter will cover fertilization, implantation of the zygote, to becoming a fetus, the three trimesters, and the progressive development of the fetus through the weeks of pregnancy. It will cover the topic of birth and different birthing methods.

Fertilization

Fertilization is the joining of a sperm and an egg. A sperm is a male gamete that is released into the vagina of a female during intercourse. In order for fertilization to occur there must be a mature ovum present. Every month one of the ovaries releases an egg which will meet one of the 4 million sperm the male ejaculates into the vagina. The sperm swim through the cervix and into the uterus which lead to the fallopian tubes. This is where fertilization is most likely to take place. The high amount of sperm in the ejaculate is needed because only around 100 survive to enter each the fertilization site. In order to penetrate the egg the sperm must first break through 2 barriers surrounding the ovum. The acrosome of sperm comes in contact with the zona radiata and releases digestive enzymes that break down a gelatinous layer around the egg called, the zona pellucida. Once a sperm reaches the plasma membrane of the egg it sets off a reaction that spreads across the membrane of the egg preventing other sperm from breaking through the egg membrane. Once the sperm reaches the inside of the egg it sheds its tail and the two nuclei fuse and now the 23 chromosomes from the egg and the 23 chromosomes of the sperm join and they become a *zygote*. Chromosomes contain all the information needed to determine the genetic structure of the new baby. Normally all human beings have two chromosomes that determine sex: A combination of X and Y makes a male or a combination of X and X makes a female. All ovum have X sex chromosomes where as sperm have both X or Y sex chromosomes. Therefore, the male gametes determine the sex of the baby.

Pre-embryonic Period

After fertilization, the zygote begins a process of dividing by *mitosis* in a process called *cleavage*. It divides until it reaches 16 cells. It is now referred to as a *morula*. As the morula floats freely within the uterus, it starts to bring nutrients into the cells. The morula fills with fluid and the cells inside start to form two separate groups. At this stage it is now a *blastocyte*. The inner layer of cells is called the *embryoblast*, and will become the fetus. The outer layer is called a *trophoblast* which will develop into part of the placenta. At this point the zona pellucida is disintegrating. The trophoblast contains specialized cells that become extensions, like fingers, that grow into the endometrium once in contact with the well thickened endometrium.

Delivery Options

Hospital Births

The chances of having natural, uncomplicated birth are optimized by carefully selecting your obstetrician and hospital. Doctors who work with midwives have lower cesarean section rates because midwives handle less complicated pregnancies. Delivering babies by abdominal surgery has been steadily rising in America over the past two decades, so that now 22-30% of births in American hospitals are cesarean section. The U.S., despite having the most advanced technology and highly trained medical personnel, ranks 23rd in infant mortality and 18th in perinatal mortality.

Medical interventions such as epidural anesthesia, pitocin augmentation of labor, vacuum extraction of fetus, episiotomy and separation of newborn and mother are common in American hospitals. There are circumstances where medical procedures such as these are necessary, but many parents and professionals now question the routine use of such interventions. In some cases, the routine use of these procedures have lead to further complications. For example, the epidural anesthetic, while providing pain relief, has shown to increase the operative vaginal delivery rate (i.e. forceps and vacuum extraction rates slightly) especially in first time mothers. Epidurals have not been shown to increase the cesarean section rate in recent well documented studies.

Freestanding Birth Centers & Water Birth

"Freestanding" Birth Centers are not inside of or affiliated with a hospital. They are run by collaboration of midwives or physicians. This is an alternative choice for the woman who does not wish to birth in a hospital environment yet is not comfortable giving birth at home. Birth centers do not provide any additional measures of safety than most planned home births with qualified midwives. They may provide the expectant couple with the physiological comfort necessary to enable the mother to relax.

Out of hospital birth centers are designed for women having low-risk pregnancies who want drug-free birth with minimal intervention in a home-like environment. Family members may participate in the birth. C-sections rates are lower than most hospitals because the pregnancies are low risk. Freestanding Birth Centers are an alternative choice for a woman who has had a previous cesarean and wishes to maximize her chances of a vaginal delivery. However, vaginal birth attempts after a prior cesarean section have a 1-2% risk of uterine rupture. Health insurance may cover costs. Many birth centers offer birthing tubs where one can give birth in water.

Homebirth

Birth at home provides parents with intimacy, privacy, comfort and family-centered experience. Childbirth at home may be a safe option for healthy women having normal pregnancies. It is for those who have a very strong desire for natural childbirth and who are willing to take high degree of responsibility for their health care and baby's birth. At home, the parents and midwife are in control of the birthing environment, and strict time perimeters for length of labor are not imposed, or routine medical interventions such as IVs done. However, the World Health Organization (WHO) states that "giving birth in a health facility (not necessarily a hospital) with professional staff is safer by far than doing so at home." (The World Health Report 2005). Also, the American College of Obstetricians and Gynecologists (ACOG) opposes out of hospital births. In choosing the comfort of home parents are also choosing to be further away from lifesaving measures should complications arise.

neonate's blood and the symptoms of jaundice (yellowish skin and yellow discoloration of the whites of the eyes) increase within 24 hours after birth. Like any other severe neonatal jaundice, there is the possibility of acute or chronic kernicterus. Profound anemia can cause high-output heart failure, with pallor, enlarged liver and/or spleen, generalized swelling, and respiratory distress. The prenatal manifestations are known as hydrops fetalis; in severe forms this can include petechiae and purpura. The infant may be stillborn or die shortly after birth.

Other Abnormalities

Physical and Genetic Defects: Physical anomalies are present at birth. Examples are; cardiac, facial (such as cleft palate), club foot, etc. These do not always endanger the baby's life. 1-2% of babies are born with a significant congenital abnormality. 4-6% with something relatively minor.

- **Chromosomal Abnormalities:** Occur when there is a problem in the baby's genetic makeup; these include conditions such as Down syndrome. Other genetic defects, such as cystic fibrosis, can be inherited from the parents.

Staying Healthy

Pregnancy and childbirth place great demands, it is important to keep healthy. The more healthy and relaxed the mother is, the better it will be to cope with the demands of pregnancy. A healthy lifestyle combines many factors:

Balanced Diet

A poor diet can cause a low birth weight. Excessive weight gain during pregnancy can cause back problems, varicose veins, or preeclampsia. Advice on diet often includes to eat foods that are high in nutritional content. Sufficient protein, vitamins, carbohydrates, fats, and minerals, as well as fiber. Limit intake of saturated fats and sugar, and salt. Drink plenty of fluids.

Regular Exercise

Mild exercise, such as walking or swimming, is beneficial and will help cope with the workload of pregnancy and the demands of labor. Mother's should listen to her body and stop exercising when it tells her to. Exercise should never be painful.

Baby's Health

Smoking reduces the oxygen and nutrients passing via the placenta to the baby. Avoid alcohol to avoid serious birth defects.

In vitro Fertilization and Artificial Implantation

An alternative when other methods of achieving contraception have failed.

In vitro fertilization (IVF) is a technique in which egg cells are fertilized by sperm outside the woman's womb. IVF is a major treatment in infertility when other methods of achieving conception have failed. The process involves hormonally controlling the ovulatory process, removing ova (eggs) from the woman's ovaries and letting sperm fertilize them in a fluid medium. The fertilized egg (zygote) is then transferred to the patient's uterus with the intent to establish a successful pregnancy.

because, with the present state of technology, starting a stem cell line requires the destruction of a human embryo and/or therapeutic cloning. Opponents of the research argue that this practice is a slippery slope to reproductive cloning and tantamount to the instrumentalization of a human being. Contrarily, some medical researchers in the field argue that it is necessary to pursue embryonic stem cell research because the resultant technologies are expected to have significant medical potential, and that the embryos used for research are only those meant for destruction anyway (as a product of in vitro fertilization). This in turn, conflicts with opponents in the pro-life movement, who argue that an embryo is a human being and therefore entitled to dignity even if legally slated for destruction. The ensuing debate has prompted authorities around the world to seek regulatory frameworks and highlighted the fact that stem cell research represents a social and ethical challenge.

- **Reproductive Cloning**

Reproductive Cloning is a technology used to generate an animal that contains the same nuclear DNA as another currently or previously existing animal. Scientists transfer the genetic material from the nucleus of a donor adult cell to an egg whose nucleus, and thus its genetic material has been removed. The egg containing the DNA, now reconstructed, has to be treated with chemicals or electric current in order to stimulate cell division. Once the cloned embryo reaches a suitable stage, it is transferred to the uterus of a female host to continue development until birth. Currently this is illegal to practice in the United States.

- **Therapeutic Cloning**

Recent research by researchers led by Anthony Atala of Wake Forest University and a team from Harvard University has found that amniotic fluid, in addition to its main functions of cushioning a growing fetus and providing buoyancy, is also a plentiful source of non-embryonic stem cells. These cells have demonstrated the ability to differentiate into a number of different cell-types, including brain, liver and bone.

Therapeutic Cloning refers to a procedure that allows the cloning of specific body parts and organs to be used for medical purposes. Although this has not been realized, much research is being done on the subject.

Pregnancy and Lactation

Mothers milk is ideal because it meets specific needs. Lactation is a neuroendocrine response in *milk production* sucking stimulates the sensory nerve endings in the nipples it sends stimulus to the hypothalamus the hypothalamus stimulates anterior pituitary and prolactin is released. In *milk let-down* the sucking stimulates sensory nerves in the nipples this stimulates the hypothalamus in the hypothalamus this stimulates the posterior pituitary. This goes on to the release of oxytocin, because, when sucking occurs this stimulates contraction of the cells around the alveoli in the mammary cells milk then flows into the milk ducts causing milk let-down.

Breast milk provides almost all the nutrients required for the first 4-6 months. It contains macronutrients like carbohydrates like lactose, fat such as high linoleic acid and protein like readily digest and absorbed alpha-lactalbumin. Breast milk also contains an adequate supply of vitamins and minerals, digestive enzymes, hormones and immunological factors.

cells made by DNA technology. This concentrate is what the hemophiliac is lacking in their own genes. After the injection is given the patients blood becomes "normal" for a couple of hours which gives time for a clot to form at the site of a damaged blood vessel. This treatment is not a permanent cure, within about 3 days there is no trace left in the system. Today's Factor treatments are much more concentrated than they were in the past so very little is required even if the patient is going in for major surgery or has a major injury. Treatments are also very convenient, they can be stored at home in the fridge for up to 6 months. So if the patient is injured they don't need to go to the hospital they can give themselves an injection at home. After the injection it only takes about 15-20 minutes for the clotting process to begin. There is a risk of contracting other disease such as AIDS from Factor VIII that is made from human plasma, but as technology gets better the cases of AIDS has dropped. There is no possibility of contracting diseases from genetic engineering Factor VIII.

Hemophiliacs can live a long life. The most common reason for early death among patients has been from AIDS related complications.

Genetic disorders

- **EXAMPLES**
- **Huntington's chorea**

- autosomal dominant
- progressive dementia
- uncontrollable movements of the limbs
- symptoms are not apparent until after age 40

- **Marfan's syndrome**

- autosomal dominant
- occurs equally in genders
- occurs each generation
- occurs in approximately 1/2 of children but may be all or none
- expression usually seen later in life
- In the punnett square risk H = Huntigton's gene / h = normal gene

	H	h
H	Hh	h
h	Hh	h

- 50% chance of contracting Huntington's gene/50% chance of no disease

- **EXAMPLE**
- **PKU**

- inherited metabolic disorder
- inability for body to convert phenylalanine to tyrosine

- brain damage
- behavioral disturbances
- phenotype blond hair, blue eyes, fair skin

- **Sickle cell**

- autosomal recessive
- occurs equally in genders
- increased evidence with both parents carriers
- occurs in approximately $\frac{1}{4}$ of children but may occur more if one parent has the disease
- expression usually seen early in infancy or childhood
- In the punnett square to predict risk P = Phenylketonuria gene / p = normal gene

	P	p
P	PP	Pp
p	Pp	Pp

- 25% chance contracting PKU
- 50% chance of being a carrier of the trait
- 25% chance of having normal genes

- **EXAMPLE**

- **Hemophilia**

- X-linked recessive gene
- affects mostly males
- spontaneous hemorrhage

- **Duschenne's muscular dystrophy**

- sex-linked (X-linked) recessive
- usually seen in males
- females are usually carriers
- affected father, yields a carrier daughter
- In the punnett square to predict risk D = Duschenne's gene / d = normal gene

	Xd	Y
XD	XD Xd	XD Y
Xd	Xd Xd	Xd Y

- Females = 50% chance of being a carrier/ 50% chance of having normal genes
- Males = 50% chance of having Duschenne's/ 50% chance of having normal genes

Withdrawal	Stick sole of foot with stimulus like a pin	This cause the foot to withdraw, this occurs with the use of flexing of the knee to hip	Decreases after the 10th day of birth	This is a protection for the infant in a instance of unpleasant tactile stimulation
Rooting	Touch cheek near the corner of the mouth	The infants head will turn towards the site of stimulation	3 weeks (due to the voluntary response that is now capable for infant to do at this time)	This reflex helps baby to find the mothers nipple
Sucking	Place fingers in infant's mouth	The infant will suck finger rhythmically	4 months (voluntary sucking will come about)	This helps with feeding
Swimming	Place the baby in pool of water face down	The baby paddles and kicks in swimming movements	4 to 6 month	This helps baby to survive if dropped into the water
Moro	Hold infant in a cradling horizontal position and slightly lower the baby in a fast motion toward the ground while making a loud sound supporting the baby	The baby will make a embracing motion and arch its back extending its legs throwing its arms outward and finally it will bring arms in toward its body	6 months	In the evolutionary past this may have helped the baby cling to the mother
Palmar grasp	Place the finger in baby's palm and press against the palm	The baby will immediately grasp the finger	3 to 4 months	This prepares infant for when voluntary grasping comes about
Tonic neck	Turn the baby's head to one side while the baby is awake	This will cause the baby to extend one are in front of its eye on one are on the side to which the head has been turned	4 months	This may prepare for voluntary reaching
Stepping/marching	When you hold the baby under the arm and permit the bare feet of the baby to touch a flat surface	The baby will lift one foot after the other in a stepping fashion	2 months (this applies to a baby who has gained weight a baby who is not as heavy this reflex may be submissive)	This prepares the baby for voluntary walking

Changes in body Proportions

Cephalocaudal trend means that growth occurs from head to tail. The head develops more rapidly than the lower part of the body. At birth the head takes up to one fourth of the total body length and legs only one third. The lower body catches up by age 2 and the head accounts for only one fifth and legs for nearly one half of the body length.

Proximodistal trend means that head growth proceeds literally from near to far or from center of the body outward.

At birth the brain is nearer its adult shape and size than any other physical structure. The brain continues to develop at an astounding pace throughout infancy and toddlerhood.

The Brain Development

The neurons of infants and adults differ in 2 significant ways: Growth of neural fibers and synapses increases connective structures. When synapses are formed, many surrounding neurons die. This occurs in 20 to 80 percent of the brain region.

Dendrites synapses: Synapses are tiny gaps between neurons where fibers from different neurons come close together but do not touch. Neurons release chemicals that cross the synapses sending messages to one another. During the prenatal period the neural tube produces far more neurons than the brain will ever need. **Myelination:** The coating of neural fibers with a fatty sheath called myelin that improves the efficiency of message transfer. Multi-layered lipid cholesterol and protein covering produced by neuroglia causes a rapid gain in overall size of brain due to neural fibers and myelination.

Synaptic pruning: Neurons seldom stimulated soon lose their synapses. Neurons not needed at the moment return to an uncommitted state so they can support future development. However, if synaptic pruning occurs in old age neurons do lose their synapses. If neurons are stimulated at young age even though neurons where pruning they will be stimulated again.

Cerebral Cortex: Surrounding the brain, it is the largest most complex brain structure. The cortex is divided into four major lobes: occipital lobe, parietal lobe, temporal lobe, and frontal lobe which is the last to develop.

Brain plasticity: The brain is highly plastic. Many areas are not yet committed to specific functions. If a part of the brain is damaged, other parts can take over tasks that they would not normally have handled.

Changing states of Arousal

How children develop more regular “sleep patterns” around 4 to 6 months of age: Sleep patterns are more developed as the brain develops. It is not until the first year of life that the secretion of *melatonin*, a hormone produced in the brain, affects more drowsiness in the night than in the day. In addition, REM is decreased.

than in males, especially in the typical female distribution of breasts, hips, and thighs. This produces the typical female body shape. Also, the fat goes to the buttocks of a girl, giving their buttocks more shape and curve.

Body and facial hair in girls

In the months and years following the appearance of pubic hair, other areas of skin which respond to androgens develop heavier hair (androgenic hair) in roughly the following sequence: underarm (axillary) hair, perianal hair, upper lip hair, sideburn (preauricular) hair, and periareolar hair. Arm and leg hair becomes heavier more gradually over 10 years or more. Although in Western culture, hair in some of these areas is unwanted, it rarely indicates a hormone imbalance unless it occurs elsewhere as well (such as under the chin and in the midline of the chest).

Height growth in girls

The estrogen-induced pubertal growth spurt in girls begins at the same time the earliest breast changes begin, or even a few months before, making it one of the earliest manifestations of puberty in girls. Growth of the legs and feet accelerates first, so that many girls have longer legs in proportion to their torso in the first year of puberty. The rate of growth tends to reach a peak velocity (as much as 7.5-10 cm or 3-4 inches per year) midway between thelarche and menarche and is already declining by the time menarche occurs. In the 2 years following menarche most girls grow about 5 cm (2 inches) before growth ceases at maximal adult height. This last growth primarily involves the spine rather than the limbs.

Body odor, skin changes, and acne

Rising levels of androgens can change the fatty acid composition of perspiration, resulting in a more "adult" body odor. This often precedes thelarche and pubarche by 1 or more years. Another androgen effect is increased secretion of oil (sebum) from the skin. This change increases the susceptibility to acne vulgaris, a characteristic affliction of puberty greatly variable in its severity.

Male

The onset of puberty for males is similar to that of females. GnRH secretion from the hypothalamus results in an increase in pituitary gonadatropins secretion LH / ICSH and FSH. The pituitary gonadatropins stimulate the seminiferous tubules and testosterone secretion. Testosterone causes changes in the accessory reproductive organs, secondary sex characteristics and male sex drive.

Testicular size, function, and fertility

In boys, testicular enlargement is the first physical manifestation of puberty (and is termed gonadarche). Testes in prepubertal boys change little in size from about 1 year of age to the onset of puberty, averaging about 2–3 cc in volume and about 1.5-2 cm in length. Testicular size continues to increase throughout puberty, reaching maximal adult size about 6 years later. While 18-20 cc is reportedly an average adult size, there is wide variation in the normal population.

The testes have two primary functions: to produce hormones and to produce sperm. The Leydig cells produce testosterone (as described below), which in turn produces most of the changes of male

Congestive Heart Failure

Congestive heart failure (CHF), also called congestive cardiac failure (CCF) or just heart failure, is a condition that can result from any structural or functional cardiac disorder that impairs the ability of the heart to fill with or pump a sufficient amount of blood throughout the body. It is not to be confused with "cessation of heartbeat", which is known as asystole, or with cardiac arrest, which is the cessation of normal cardiac function in the face of heart disease. Because not all patients have volume overload at the time of initial or subsequent evaluation, the term "heart failure" is preferred over the older term "congestive heart failure". Congestive heart failure is often undiagnosed due to a lack of a universally agreed definition and difficulties in diagnosis, particularly when the condition is considered "mild".

Stroke

A stroke, also known as cerebrovascular accident (CVA), is an acute neurologic injury whereby the blood supply to a part of the brain is interrupted. Stroke can also be said to be a syndrome of sudden loss of neuronal function due to disturbance in cerebral perfusion. This disturbance in perfusion is commonly on the arterial side of the circulation, but can be on the venous side.

The part of the brain with disturbed perfusion can no longer receive adequate oxygen carried by the blood; brain cells are therefore damaged or die, impairing function from that part of the brain. Stroke is a medical emergency and can cause permanent neurologic damage or even death if not promptly diagnosed and treated. It is the third leading cause of death and adult disability in the US and industrialized European nations. On average, a stroke occurs every 45 seconds and someone dies every 3 minutes. Of every 5 deaths from stroke, 4 occur in men and 1 in women.

Progeria

The term Progeria narrowly refers to Hutchinson-Gilford Progeria syndrome, but the term is also used more generally to describe any of the so-called "accelerated aging diseases". The word progeria is derived from the Greek for "prematurely old". Because the "accelerated aging" diseases display different aspects of aging, but never every aspect, they are often called "segmental progerias" by biogerontologists. Hutchinson-Gilford Progeria syndrome is an extremely rare genetic condition which causes physical changes that resemble greatly accelerated aging in sufferers. The disease affects between 1 in 4 million (estimated actual) and 1 in 8 million (reported) newborns. Currently, there are approximately 40-45 known cases in the world. There is no known cure. Most people with progeria die around 13 years of age. Progeria is of interest to scientists because the disease may reveal clues about the process of aging. Unlike most other "accelerated aging diseases" (such as Werner's syndrome, Cockayne's syndrome or xeroderma pigmentosum), progeria is not caused by defective DNA repair. It is caused by mutations in a LMNA (Lamin A protein) gene on chromosome 1. Nuclear lamina is a protein scaffold around the edge of the nucleus that helps organize nuclear processes such as RNA and DNA synthesis.

Senses

Vision

Changes in vision begin at an early age. The cornea becomes thicker and less curved. The anterior chamber decreases in size and volume. The lens becomes thicker and more opaque, and also increases rigidity and loses elasticity. The ciliary muscles atrophy and the pupil constricts. There is also a reduction of rods and nerve cells of the retina.

Hearing

Approximately one third of people over the age of 65 have hearing loss. The ability to distinguish between high and low frequency diminishes with age. Loss of hearing for sounds of high-frequency (presbycusis) is the most common, although the ability to distinguish sound localization also decreases.

Taste and Smell

Sensitivity to odors and taste decline with age. The sense of smell begins to degenerate with the loss of olfactory sensory neurons and loss of cells from the olfactory bulb. The decline in taste sensation is more gradual than that of smell. The elderly have trouble differentiating between flavors. The number of fungiform papillae of the tongue declines by 50% by the age of 50. Taste could also be affected by the loss of salivary gland secretions, notably amylase.

Cellular Aging

As people age, oxygen intake decreases as well as the basal metabolic rate. The decrease in the metabolic rate, delayed shivering response, sedentary lifestyle, decreased vasoconstrictor response, diminished sweating, and undernutrition are reasons why the elderly cannot maintain body temperature. There is also a decrease in total body water (TBW). In newborns, TBW is 75% to 80%. TBW continues to decline in childhood to 60% to 65%, to less than 60% in adults.

Organism Aging

Aging is generally characterized by the declining ability to respond to stress, increasing homeostatic imbalance and increased risk of disease. Because of this, death is the ultimate consequence of aging. Differences in maximum life span between species correspond to different "rates of aging". For example, inherited differences in the rate of aging make a mouse elderly at 3 years and a human elderly at 90 years. These genetic differences affect a variety of physiological processes, probably including the efficiency of DNA repair, antioxidant enzymes, and rates of free radical production.

Aubrey de Grey

Aubrey David Nicholas Jasper de Grey, Ph.D., (born 20 April 1963 in London, England) is a

- **Albert Bandura** Social learning theory
- **Jean Piaget's** Cognitive-developmental theory

Review Questions

1. Which of the following is a characteristic of Deciduous teeth.
 - A) The 32 teeth that erupt after in the place of primary teeth.
 - B) Is the common name for teeth belonging to humans.
 - C) The first set of 20 teeth in the growth development.
 - D) Are teeth that have decayed to the pulp.
 - E) Consist of the first and second premolars and the third molar.
2. It is widely believed that which of the following causes puberty?
 - A) Alterations in brain functions that result in an increase in the secretion of Gonadotropin-releasing hormone (GnRH) from the hypothalamus
 - B) The release of testosterone and estrogen from the gonads.
 - C) Endochondral ossification and an increase in bone mass.
 - D) Environmental exposure to UVA and UVB radiation from the sun.
3. Which of the following factors does not contribute to osteoporosis?
 - A) A history of fractures as an adult, and family history of fractures.
 - B) The age of menarche (first menstrual bleeding)
 - C) Lack of a regular weight-bearing exercise plan.
 - D) Inadequate dietary calcium and vitamin D intake throughout ones life
 - E) Tobacco smoking intake of soft drinks containing phosphoric acid.
4. What is Apoptosis and what cells does it affect?
 - A) Apoptosis is the death of skin cell due to UVA exposure.
 - B) Apoptosis is the death of skin cell due to UVB exposure.
 - C) Apoptosis is the death of skin cell due to UVA and UVB exposure.
 - D) Apoptosis is regulated cell death that affects most cells in the body.
 - E) Apoptosis is the unregulated death of cells due to acute cellular injury.
5. Which of the following statements is true about the Epiphyseal plate / line?
 - A) The epiphyseal line allows lengthwise growth of a bone.
 - B) The ossification of epiphyseal plate controls the stoppage of growth after puberty.
 - C) A fracture at the epiphyseal line during puberty can result in stunted bone growth.
 - D) The epiphyseal line is composed of cartilage.
 - E) All of the above are true.
6. Why are women more prone to osteoporosis than men?

Intramembranous ossification

The type of bone formation responsible for the development of flat bones, especially those found in the skull. In intramembranous ossification mesenchymal cells develop into bone without first going through a cartilage stage.

lacunae

spaces between bone lamellae.

lamellae

concentric layers of bone matrix.

Menopause

The permanent cessation of menstrual cycles.

Menarche

The first menstrual bleeding, usually occurs at about 12.7 years of age.

Mongolian spots

are common among darker-skinned races, such as Asian, East Indian, and African. They are flat, pigmented lesions with unclear borders and irregular shape. They appear commonly at the base of the spine, on the buttocks and back. They may also appear as high as the shoulders and elsewhere. Mongolian spots are benign skin markings and are not associated with any conditions or illnesses.

Necrosis

A form of cell death that results from acute cellular injury.

Osteoporosis

A condition that is characterized by a decrease in bone mass and density, causing bones to become fragile.

Puberty

The process of physical changes by which a child's body becomes an adult body capable of reproduction

Pyloric Stenosis

Narrowing of the pyloric sphincter that reduces or eliminates the passage of food from the stomach to the small intestine, often causing projectile vomiting in infants.

Trabeculae

spongy bones that make plates or bars instead of concentric layers.

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The Urinary System

1. While reading a blood test I notice a high level of creatinine, I could assume from this that

- A) There is a possibility of a UTI
- B) There is a possibility of diabetes
 - C) There is a possibility of kidney failure
- D) There is nothing wrong, this is normal

2. Direct control of water excretion in the kidneys is controlled by

- A) Anti-diuretic hormone
- B) The medulla oblongata
- C) Blood plasma
- D) Sodium amounts in the blood

3. Nephrons

- A) Eliminate wastes from the body
- B) Regulate blood volume and pressure
- C) Control levels of electrolytes and metabolites
- D) Regulate blood pH
 - E) All of the above

4. If I am dehydrated, my body will increase

- A) ATP
- B) ADP
- C) Diluted urine
 - D) ADH

5. Which part of the nephron removes water, ions and nutrients from the blood?

- A) vasa recta
- B) loop of henle
- C) proximal convoluted tubule
 - D) peritubular capillaries
- E) glomerulus

6. Kidneys have a direct effect on which of the following

- A) Blood pressure
- B) How much water a person excretes
- C) Total blood volume
- D) pH
 - E) all of the above

7. Why do substances in the glomerulus enter the Bowman's capsule?

- B) she is old and just clumsy
- C) she has a vitamin K deficiency
- D) she has scurvy
- E) she has rickets
9. As a pirate I may get scurvy because
- A) I am not getting enough vegetables on the ship
- B) I am not getting enough fruit on the ship
- C) I am eating too much fish on the ship
- D) I am getting too much sun on the ship
- E) I am drinking too much rum on the ship
10. I am taking anticoagulant medication and it doesn't seem to be working, this could be because
- A) I have too much vitamin A
- B) I have too much B12
- C) I have too much sodium
- D) I have too much vitamin E
- E) I have too much vitamin K

The Endocrine System

1. My child just fell and was hurt, the anxious feeling that I feel is caused by
- A) glucagon
- B) insulin
- C) epinephrine
- D) adrenocorticotrophic
- E) None of these
2. All of Bob's life he has had to take insulin shots, this is caused because
- A) his beta cells don't function correctly
- B) his alpha cells don't function correctly
- C) his DA hormone isn't functioning correctly
- D) his GHRH hormone isn't functioning correctly
3. The reason iodine is in salt is
- A) to prevent diabetes
- B) to prevent simple goiters
- C) to prevent Addison's disease
- D) to prevent Cushing syndrome
4. All hormones react to a negative feedback except
- A) progesterone

- B) estrogen
 - C) prolactin
 - D) oxytocin
 - E) none of these
5. If I have a high blood calcium level it may be due to
- A) calcitonin
 - B) parathyroid
 - C) glucocorticoids
 - D) glucagon
6. Hormones that are lipids that are synthesized from cholesterol
- A) protien
 - B) amino acid-derived
 - C) polypeptide
 - D) steroids
 - E) eicosanoids
7. This type of hormone must bind to a receptor protein on the plasma membrane of the cell
- A) water soluble
 - B) lipid soluble
 - C) steroid
 - D) polypeptide
 - E) a and c
 - F) lipid soluble
8. Endocrine glands release hormones in response to
- A) Hormones from other endocrine glands
 - B) Chemical characteristics of the blood
 - C) Neural stimulation
 - D) All of the above
9. The anterior pituitary secretes
- A) oxytocin
 - B) endorphins
 - C) ADH
 - D) TRH
10. Chief cells produce
- A) epinephrine
 - B) glucagon
 - C) insulin
 - D) mineralocorticoids

- E) parathyroid hormone

The male reproductive system

1. This is needed to make immature sperm mature

- A) FHS
- B) LH
- C) FSH
- D) HL

2. These become engorged with blood in an erection

- A) corpora cavernosa
- B) fibrous envelope
- C) septum pectiniforme
- D) integument
- E) dorsal veins

3. The difference between male and female sperm

- A) female sperm have a larger head
- B) male sperm are lighter
- C) female sperm are faster
- D) male sperm are weaker
- E) A and B
- F) C and D

4. The entire process of sperm formation takes about

- A) 5-6 weeks
- B) 7-8 weeks
- C) 3-4 weeks
- D) 9-10 weeks

5. Hyper Activation occurs when

- A) the sperm are introduced into the urethra
- B) the sperm are ejaculated into the vaginal canal
- C) the sperm begin to interact with the fertilizing layer of an egg cell
- D) the sperm reach the cervix

6. It takes sperm _____ weeks to travel through the epididymis

- A) 6-8
- B) 1-3
- C) 2-4
- D) 4-6

7. While singing in the choir, Ben suddenly notices his voice is constantly cracking. This is caused by

- A) androgens
- B) LH
- C) FSH
- D) Ben's inability to sing

8. In sexual homology, the glans penis in the male is equal to _____ in the female

- A) clitoral hood
- B) clitoris
 - C) clitoral glans
- D) clitoral crura

9. In sexual homology, the _____ in the male is equal to the fallopian tubes in the female

- A) testis
 - B) appendix testis
- C) vas deferens
- D) seminal vesicle
- E) efferent ducts

10. Joe has a bulge in the groin area that seems to get worse when he lifts things. This most likely is

- A) epididymitis
- B) testicular cancer
- C) varicocele
- D) hydrocele
 - E) inguinal hernia

The female reproductive system

1. In homology, the _____ in the female is equal to the penis in the male

- A) labia majora
- B) clitoral hood
 - C) clitoris
- D) labia minora
- E) none of the above

2. This contains some of the strongest muscles in the human body

- A) uterus
- B) clitoris
- C) cervix
- D) labia majora

3. This protects the vaginal and urethral openings

- A) labia majora
 - B) labia minora
- C) clitoris
- D) urethra

4. Sally has noticed that her cervical mucus has changed and now resembles egg whites- from this Sally could assume

- A) her period will begin soon
- B) nothing, this is a normal occurrence
- C) she has a yeast infection
 - D) she is ovulating

5. Debbie recently went to the OBGYN and was diagnosed with PCOD (polycystic ovary syndrome) because of this she has

- A) nothing, its normal in women
- B) antisperm antibodies
- C) an overproduction of LH
- D) leaking of milk from her mammary glands
 - E) problems becoming pregnant

6. Angie went to the doctor because she has had pain in her lower abdomen- this could be caused by

- A) ovulation pain
- B) her period that will be starting tomorrow
- C) premenstrual syndrome
 - D) a blood clot resulting from her birth control pill

7. Sue recently started her period and has noticed that they are very heavy and painful, and that they are inconsistent in their timing. One explanation could be

- A) endometriosis
- B) ovarian cancer
- C) candidiasis
- D) toxic shock syndrome
- E) amenorrhea

8. Mary is getting married and is not ready to become a mother- she chooses this birth control because of its high effectiveness

- A) natural family planning
- B) a diaphragm
 - C) contraceptive injections
- D) a spermicide foam

9. The release of LH in woman causes

respiratory infections, delayed growth, excessive fatigue

3: Insulin growth in hormones, used in vaccines to help prevent hepatitis, treatment to help prevent viral infections, and helps treat hemophilia

4: X-rays, radiation from the sun, toxins in the air

5: Parkinson's, cystic fibrosis, some cancers, and sickle cell

6: Yes- the parents can be carriers with out having the birth defect themselves

7: Behavior genetics studies the effects of human disorders as well as their causes.

8: a genotype is the actual set of genes that an organism has. A phenotype is the genes physical appearance.

9: Classical- the techniques and methodologies of genetic. Behavioral- studies the influence of varying genetics on animal behavior. Clinical- physicians who are trained as geneticists diagnose, treat, and counsel patients with genetic disorders and syndromes. Molecular- builds up on the foundation of classical genetics but focuses on the structure and function of genes at a molecular level.

10: Regulator genes initiates or blocks the expression of other genes and modifying genes alter how other genes are expressed in the phenotype.

Development: birth through death

1. Why are women more prone to osteoporosis than men?
 - Differences in average adult bone mass between men and women, menopause (decline in estrogen)
2. Why is an injury to the epiphyseal plate of a long bone during puberty more significant than a regular fracture?
 - A fracture to the epiphyseal plate during puberty can cause the plate to seal resulting in a stoppage of bone growth.
3. What is the average age of menarche (the first menstrual bleeding) in American girls? What factors contribute to onset of menarche?
 - About 12.7 years

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