SCIENTIFIC BASIS OF YOGA EDUCATION (Compilation)

Ananda Balayogi Bhavanani
Mahatma Gandhi Medical College and Research Institute

SCIENTIFIC BASIS OF YOGA EDUCATION

STUDY MATERIALS

COMPILED AND EDITED

BY

YOGACHARYA

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M.B.B.S, A.D.Y, D.S.M, D.P.C, P.G.D.F.H, P.G.D.Y, F.I.A.Y

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BODY FUNCTIONS AND LIFE PROCESS

BODY FUNCTIONS

Body functions are the physiological or psychological functions of body systems. The body's functions are ultimately its cells' functions. Survival is the body's most important business. Survival depends on the body's maintaining or restoring homeostasis, a state of relative constancy, of its internal environment.

More than a century ago, French physiologist, Claude Bernard (1813-1878), made a remarkable observation. He noted that body cells survived in a healthy condition only when the temperature, pressure, and chemical composition of their environment remained relatively constant. Later, an American physiologist, Walter B. Cannon (1871-1945), suggested the name **homeostasis** for the relatively constant states maintained by the body. Homeostasis is a key word in modern physiology. It comes from two Greek words - "homeo," meaning the same, and "stasis," meaning standing.

"Standing or staying the same" then is the literal meaning of homeostasis. However, as Cannon emphasized, homeostasis does not mean something set and immobile that stays exactly the same all the time. In his words, homeostasis "means a condition that may vary, but which is relatively constant."

Homeostasis depends on the body's ceaselessly carrying on many activities. Its major activities or functions are responding to changes in the body's environment, exchanging materials between the environment and cells, metabolizing foods, and integrating all of the body's diverse activities.

The body's ability to perform many of its functions changes gradually over the years. In general, the body performs its functions least well at both ends of life - in infancy and in old age. During childhood, body functions gradually become more and more efficient and effective. During late maturity and old age the opposite is true. They gradually become less and less efficient and effective. During young adulthood, they normally operate with maximum efficiency and effectiveness.

LIFE PROCESS

All living organisms have certain characteristics that distinguish them from non-living forms. The basic processes of life include organization, metabolism, responsiveness, movements, and reproduction. In humans, who represent the most complex from of life, there are additional requirements such as growth, differentiation, respiration, digestion, and excretion. All of these processes are interrelated. No part of the body, from the smallest cell to a complete body system, works in isolation. All function together, in fine-tuned balance, for the well being of the individual and to maintain life. Disease such as cancer and death represent a disruption of the balance in these processes.

The following is a brief description of the life process:

Organization: At all levels of the organizational scheme, there is a division of labor. Each component has its own job to perform in cooperation with others. Even a single cell, if it loses its integrity or organization, will die.

Metabolism : Metabolism is a broad term that includes all the chemical reactions that occur in the body. One phase of metabolism is catabolism in which complex substances are broken down into simpler building blocks and energy is released.

Responsiveness: Responsiveness or irritability is concerned with detecting changes in the internal or external environments and reacting to that change. It is the act of sensing a stimulus and responding to it.

Movement: There are many types of movement within the body. On the cellular level, molecules move from one place to another. Blood moves from one part of the body to another. The diaphragm moves with every breath. The ability of muscle fibers to shorten and thus to produce movement is called contractility.

Reproduction : For most people, reproduction refers to the formation of a new person, the birth of a baby. In this way, life is transmitted from one generation to the next through reproduction of the organism. In a broader sense, reproduction also refers to the formation of new cells for the replacement and repair of old cells as well as for growth. This is cellular reproduction. Both are essential to the survival of the human race.

Growth : Growth refers to an increase in size either through an increase in the number of cells or through an increase in the size of each individual cell. In order for growth to occur, anabolic processes must occur at a faster rate than catabolic processes.

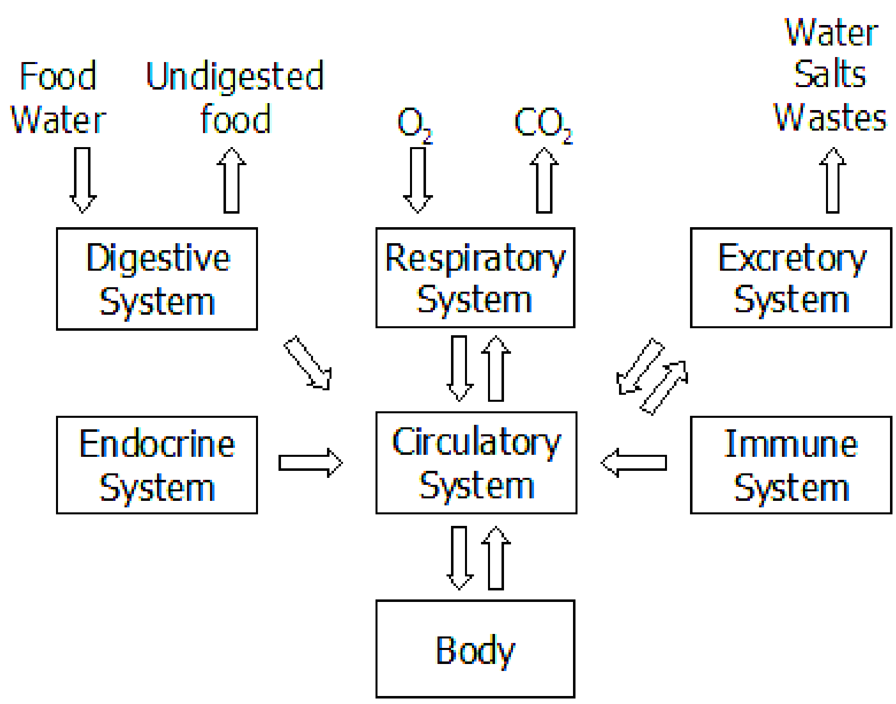
Differentiation : Differentiation is a developmental process by which unspecialized cells change into specialized cells with distinctive structural and functional characteristics. Through differentiation, cells develop into tissues and organs.

Respiration: Respiration refers to all the processes involved in the exchange of oxygen and carbon dioxide between the cells and the external environment. It includes ventilation, the diffusion of oxygen and carbon dioxide, and the transport of the gases in the blood. Cellular respiration deals with the cell's utilization of oxygen and release of carbon dioxide in its metabolism.

Digestion: Digestion is the process of breaking down complex ingested foods into simple molecules that can be absorbed into the blood and utilized by the body.

Excretion : Excretion is the process that removes the waste products of digestion and metabolism from the body. It gets rid of by-products that the body is unable to use, many of which are toxic and incompatible with life.

The ten life processes described above are not enough to ensure the survival of the individual. In addition to these processes, life depends on certain physical factors from the environment. These include water, oxygen, nutrients, heat, and pressure.



ANATOMICAL TERMINOLOGY

Before we get into the following learning units, which will provide more detailed discussion of topics on different human body systems, it is necessary to learn some useful terms for describing body structure. Knowing these terms will make it much easier for us to understand the content of the following learning units. Three groups of terms are introduced here: directional terms, terms describing planes of the body, and terms describing body cavities.

- Directional Terms
- Planes of the Body
- Body Cavities

DIRECTIONAL TERMS: Directional terms describe the positions of structures relative to other structures or locations in the body.

Superior or cranial: toward the head end of the body; upper (example, the hand is part of the superior extremity).

Inferior or caudal : away from the head; lower (example, the foot is part of the inferior extremity).

Anterior or ventral: front (example, the kneecap is located on the anterior side of the leg).

Posterior or dorsal: back (example, the shoulder blades are located on the posterior side of the body).

Medial : toward the midline of the body (example, the middle toe is located at the medial side of the foot).

Lateral : away from the midline of the body (example, the little toe is located at the lateral side of the foot).

Proximal : toward or nearest the trunk or the point of origin of a part (example, the proximal end of the femur joins with the pelvic bone).

Distal : away from or farthest from the trunk or the point or origin of a part (example, the hand is located at the distal end of the forearm).

PLANES OF THE BODY

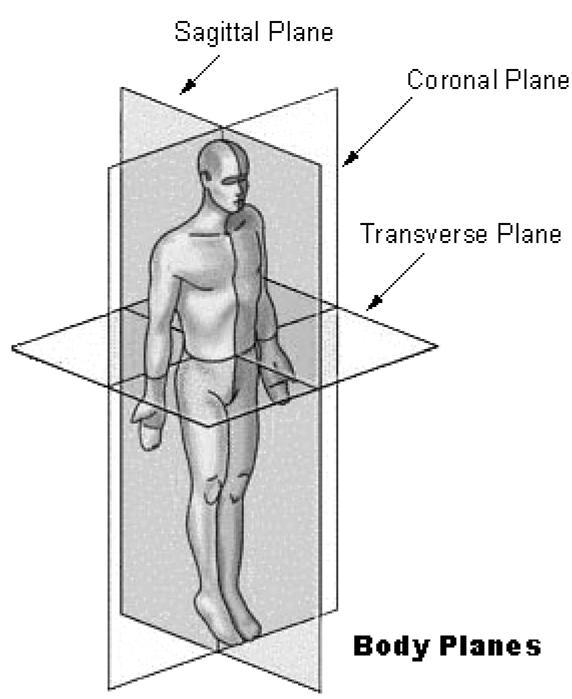
Medical professionals often refer to sections of the body in terms of anatomical planes (flat surfaces). These planes are imaginary lines - vertical or horizontal - drawn through an upright body. The terms are used to describe a specific body part.

Coronal Plane (Frontal Plane): A verticle plane running from side to side; divides the body or any of its parts into anterior and posterior portions.

Sagittal Plane (Lateral Plane): A verticle plane running from front to back; divides the body or any of its parts into right and left sides.

Axial Plane (Transverse Plane): A horizontal plane; divides the body or any of its parts into upper and lower parts.

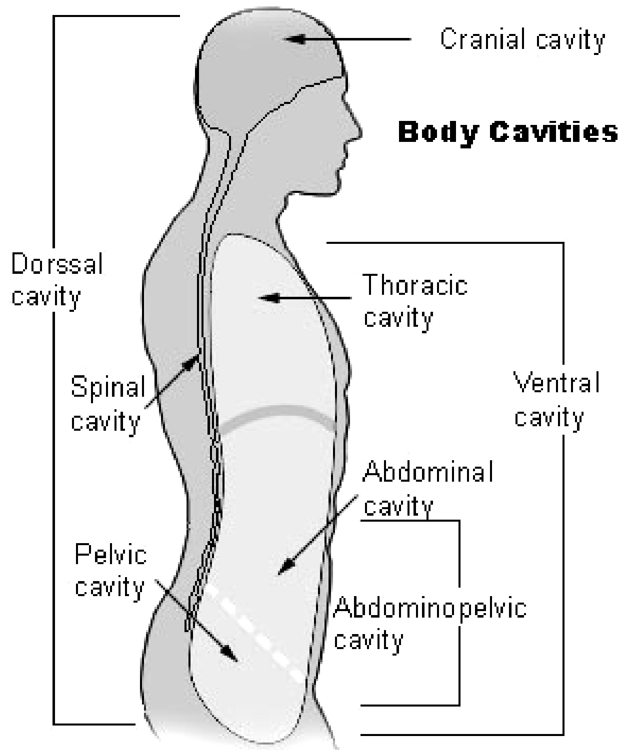
Median plane: Sagittal plane through the midline of the body; divides the body or any of its parts into right and left halves.



Body Planes

BODY CAVITIES

The cavities, or spaces, of the body contain the internal organs, or viscera. The two main cavities are called the ventral and dorsal cavities. The ventral is the larger cavity and is subdivided into two parts (thoracic and abdominopelvic cavities) by the diaphragm, a dome-shaped respiratory muscle.



Thoracic cavity

The upper ventral, thoracic, or chest cavity contains the heart, lungs, trachea, esophagus, large blood vessels, and nerves. The thoracic cavity is bound laterally by the ribs (covered by costal pleura) and the diaphragm caudally (covered by diaphragmatic pleura).

Abdominal and pelvic cavity

The lower part of the ventral (abdominopelvic) cavity can be further divided into two portions: abdominal portion and pelvic portion. The abdominal cavity contains most of the gastrointestinal tract as well as the kidneys and adrenal glands. The abdominal cavity is bound cranially by the diaphragm, laterally by the body wall, and caudally by the pelvic cavity. The pelvic cavity contains most of the urogenital system as well as the rectum. The pelvic cavity is bounded cranially by the abdominal cavity, dorsally by the sacrum, and laterally by the pelvis.

Dorsal cavity

The smaller of the two main cavities is called the dorsal cavity. As its name implies, it contains organs lying more posterior in the body. The dorsal cavity, again, can be divided into two portions. The upper portion, or the cranial cavity, houses the brain, and the lower portion, or vertebral canal houses the spinal cord.

HUMAN BODY STRUCTURE

Human beings are arguably the most complex organisms on this planet. Imagine billions of microscopic parts, each with its own identity, working together in an organized manner for the benefit of the total being. The human body is a single structure but it is made up of billions of smaller structures of four major kinds:

Cells

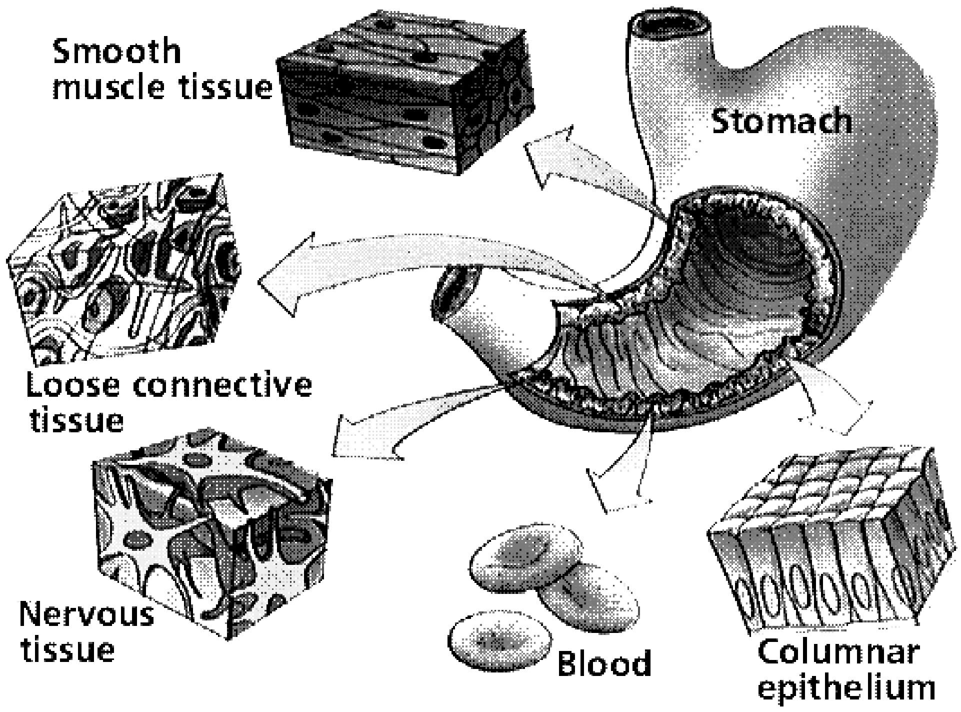
Cells have long been recognized as the simplest units of living matter that can maintain life and reproduce themselves. The human body, which is made up of numerous cells, begins as a single, newly fertilized cell.

Tissues

Tissues are somewhat more complex units than cells. By definition, a tissue is an organization of a great many similar cells with varying amounts and kinds of nonliving, intercellular substance between them. The four major types of tissues are the epithelial, connective, muscular and nervous tissues.

Organs

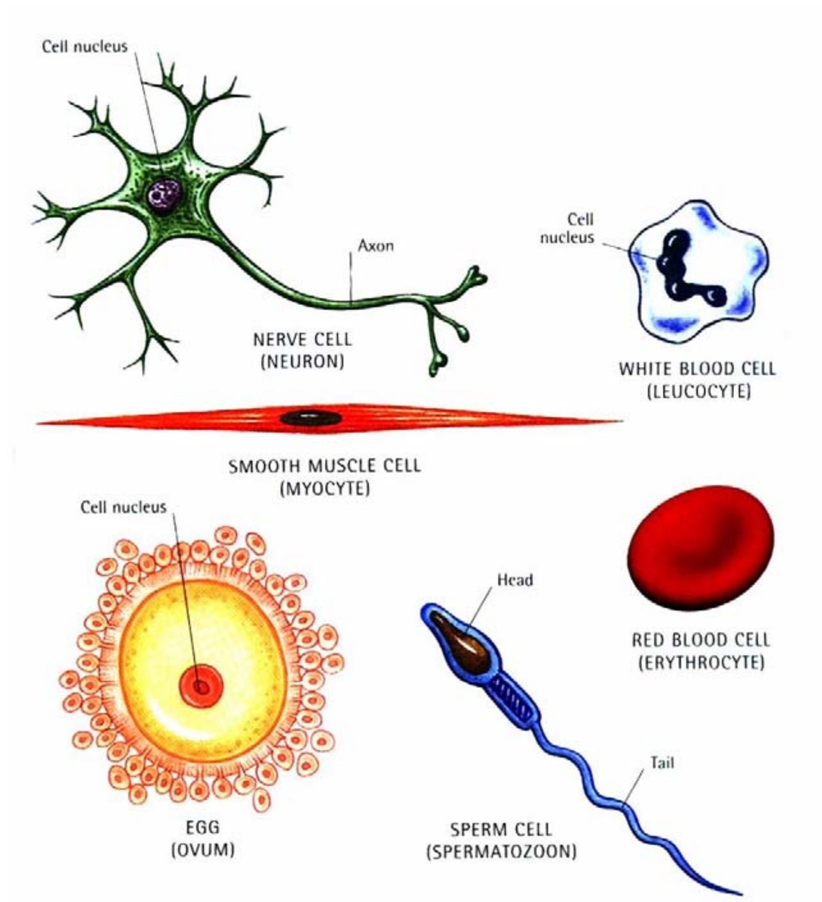
Organs are more complex units than tissues. An organ is an organization of several different kinds of tissues so arranged that together they can perform a special function. For example, the stomach is an organization of muscle, connective, epithelial, and nervous tissues. Muscle and connective tissues form its wall, epithelial and connective tissues form its lining, and nervous tissue extends throughout both its wall and its lining.



Systems

Systems are the most complex of the component units of the human body. A system is an organization of varying numbers and kinds of organs so arranged that together they can perform complex functions for the body. Ten major systems compose the human body:

- Skeletal
- Muscular
- Nervous
- Endocrine
- Cardiovascular
- Lymphatic
- Respiratory
- Digestive
- Urinary
- Reproductive



THE HUMAN CELL

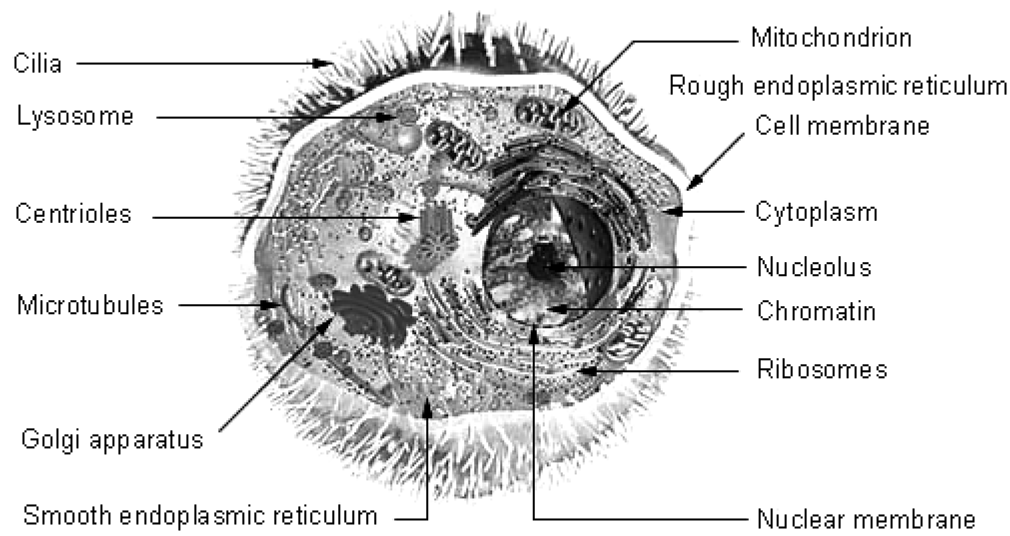
Ideas about cell structure have changed considerably over the years.

Early biologists saw cells as simple membranous sacs containing fluid and a few floating particles.

Today's biologists know that cells are infinitely more complex than this.

There are many different types, sizes, and shapes of cells in the body.

For descriptive purposes, the concept of a "generalized cell" is introduced. It includes features from all cell types. A cell consists of three parts: the cell membrane, the nucleus, and between the two, the cytoplasm. Within the cytoplasm lie intricate arrangements of fine fibers and hundreds or even thousands of miniscule but distinct structures called organelles.



Cell membrane

Every cell in the body is enclosed by a cell (Plasma) membrane. The cell membrane separates the material outside the cell, extracellular, from the material inside the cell, intracellular. It maintains the integrity of a cell and controls passage of materials into and out of the cell. All materials within a cell must have access to the cell membrane (the cell's boundary) for the needed exchange.

The cell membrane is a double layer of phospholipid molecules. Proteins in the cell membrane provide structural support, form channels for passage of materials, act as receptor sites, function as carrier molecules, and provide identification markers.

Nucleus and Nucleolus

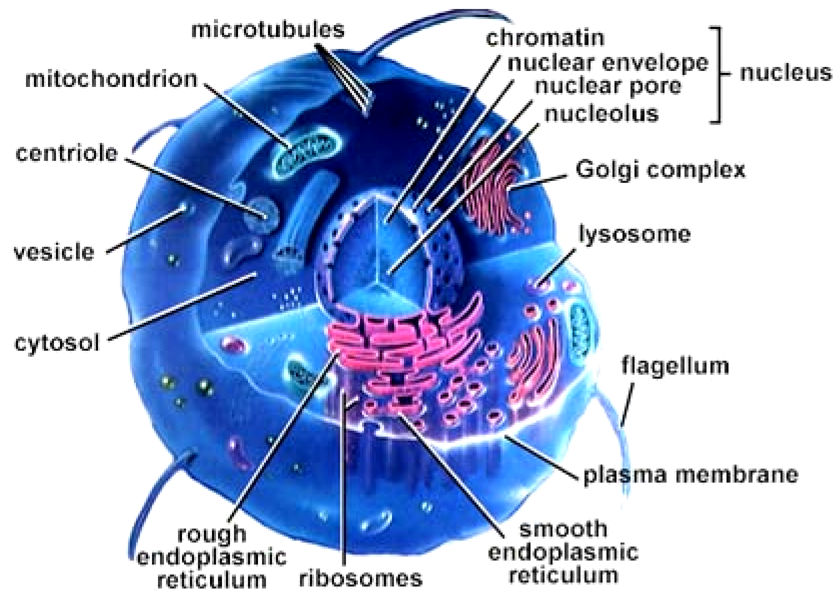
The nucleus, formed by a nuclear membrane around a fluid nucleoplasm, is the control center of the cell. Threads of chromatin in the nucleus contain deoxyribonucleic acid (DNA), the genetic material of the cell. The nucleolus is a dense region of ribonucleic acid (RNA) in the nucleus and is the site of ribosome formation. The nucleus determines how the cell will function, as well as the basic structure of that cell.

Cytoplasm

The cytoplasm is the gel-like fluid inside the cell. It is the medium for chemical reaction. It provides a platform upon which other organelles can operate within the cell. All of the functions for cell expansion, growth and replication are carried out in the cytoplasm of a cell. Within the cytoplasm, materials move by diffusion, a physical process that can work only for short distances.

Cytoplasmic organelles

Cytoplasmic organelles are "little organs" that are suspended in the cytoplasm of the cell. Each type of organelle has a definite structure and a specific role in the function of the cell. Examples of Cytoplasmic organelles are mitochondrion, ribosomes, endoplasmic reticulum, golgi apparatus, and lysosomes.



Mitochondria contain their own DNA (termed mDNA) and are thought to represent bacteria-like organisms incorporated into eukaryotic cells over 700 million years ago (perhaps even as far back as 1.5 billion years ago). They function as the sites of energy release (following glycolysis in the cytoplasm) and ATP formation (by chemiosmosis). The mitochondrion has been termed the powerhouse of the cell. Mitochondria are bounded by two membranes. The inner membrane folds into a series of cristae, which are the surfaces on which ATP is generated.

Ribosomes are the sites of protein synthesis. They are not membrane-bound and thus occur in both prokaryotes and eukaryotes. Eukaryotic ribosomes are slightly larger than prokaryotic ones. Structurally the ribosome consists of a small and larger subunit. Biochemically the ribosome consists of ribosomal RNA (rRNA) and some 50 structural proteins. Often ribosomes cluster on the endoplasmic reticulum, in which case they resemble a series of factories adjoining a railroad line.

Endoplasmic reticulum is a mesh of interconnected membranes that serve a function involving protein synthesis and transport. Rough endoplasmic reticulum (Rough ER) is so-named because of its rough appearance due to the numerous ribosomes that occur along the ER. Rough ER connects to the nuclear envelope through which the messenger RNA (mRNA) that is the blueprint for proteins travels to the ribosomes. Smooth ER; lacks the ribosomes characteristic of Rough ER and is thought to be involved in transport and a variety of other functions.

Golgi Complexes are flattened stacks of membrane-bound sacs. They function as a packaging plant, modifying vesicles from the Rough ER. New membrane material is assembled in various cisternae of the golgi.

Lysosomes are relatively large vesicles formed by the Golgi. They contain hydrolytic enzymes that could destroy the cell. Lysosome contents function in the extracellular breakdown of materials.

CELL FUNCTIONS

The structural and functional characteristics of different types of cells are determined by the nature of the proteins present. Cells of various types have different functions because cell structure and function are closely related. It is apparent that a cell that is very thin is not well suited for a protective function. Bone cells do not have an appropriate structure for nerve impulse conduction. Just as there are many cell types, there are varied cell functions. The generalized cell functions include movement of substances across the cell membrane, cell division to make new cells, and protein synthesis.

Movement of substances across the cell membrane

The survival of the cell depends on maintaining the difference between extracellular and intracellular material. Mechanisms of movement across the cell membrane include simple diffusion, osmosis, filtration, active transport, endocytosis, and exocytosis. Simple diffusion is the movement of particles (solutes) from a region of higher solute concentration to a region of lower solute concentration. Osmosis is the diffusion of solvent or water molecules through a selectively permeable membrane. Filtration utilizes pressure to push substances through a membrane. Active transport moves substances against a concentration gradient from a region of lower concentration to a region of higher concentration. It requires a carrier molecule and uses energy. Endocytosis refers to the formation of vesicles to transfer particles and droplets from outside to inside the cell. Secretory vesicles are moved from the inside to the outside of the cell by exocytosis.

Cell division

Cell division is the process by which new cells are formed for growth, repair, and replacement in the body. This process includes division of the nuclear material and division of the cytoplasm. All cells in the body (somatic cells), except those that give rise to the eggs and sperm (gametes), reproduce by mitosis. Egg and sperm cells are produced by a special type of nuclear division called meiosis in which the number of chromosomes is halved. Division of the cytoplasm is called cytokinesis.

Somatic cells reproduce by mitosis, which results in two cells identical to the one parent cell. Interphase is the period between successive cell divisions. It is the longest part of the cell cycle. The successive stages of mitosis are prophase, metaphase, anaphase, and telophase. Cytokinesis, division of the cytoplasm, occurs during telophase.

Meiosis is a special type of cell division that occurs in the production of the gametes, or eggs and sperm. These cells have only 23 chromosomes, one-half the number found in somatic cells, so that when fertilization takes place the resulting cell will again have 46 chromosomes, 23 from the egg and 23 from the sperm.

DNA replication and protein synthesis

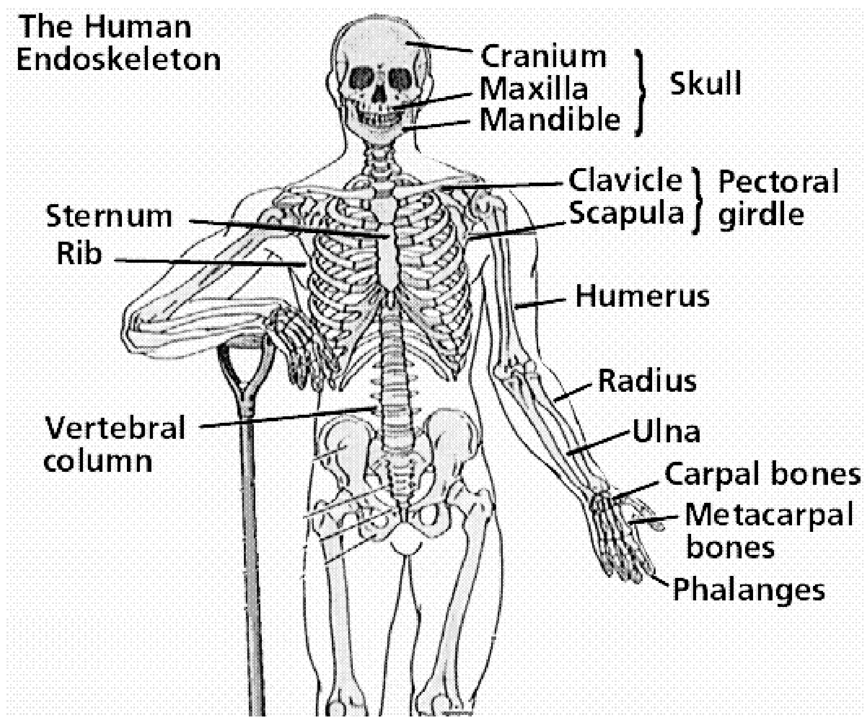
Proteins that are synthesized in the cytoplasm function as structural materials, enzymes that regulate chemical reactions, hormones, and other vital substances. DNA in the nucleus directs protein synthesis in the cytoplasm. A gene is the portion of a DNA molecule that controls the synthesis of one specific protein molecule. Messenger RNA carries the genetic information from the DNA in the nucleus to the sites of protein synthesis in the cytoplasm.

MUSCULOSKELETAL SYSTEM

Bones, Muscles, and Joints

Every time you walk your child to school, settle into a chair for a good-night story, or wrap your arms around your child in a hug, you're using your bones, muscles, and joints. Without these important body parts, you and your child wouldn't be able to stand, walk, run, or even sit.

From our head to our toes, our **bones** provide support for our bodies and help form our shape. The skull protects the brain and forms the shape of our face. The spinal cord, a pathway for messages between the brain and the body, is protected by the backbone, or spinal column. The ribs form a cage that shelters the heart, lungs, liver, and spleen, and the pelvis helps protect the bladder, intestines, and in women, the reproductive organs. Although they're very light, bones are strong enough to support our entire weight.



Joints occur where two bones meet. They make the skeleton flexible - without them, movement would be impossible. **Muscles** are also necessary for movement: They're the masses of tough, elastic tissue that pull our bones when we move. Together, our bones, muscles, and joints - along with tendons, ligaments, and cartilage - form our musculoskeletal systems and enable us to do everyday physical activities.

What Are the Bones and What Do They Do?

The human skeleton has 206 bones. Our bones begin to develop before birth. When the skeleton first forms, it is made of flexible cartilage, but within a few weeks it begins the process of **ossification** (pronounced: ah-suh-fuh-**kay**-shun). Ossification is when the cartilage is replaced by hard deposits of calcium phosphate and stretchy collagen, the two main components of bone. It takes about 20 years for this process to be completed.

The bones of kids and young teens are smaller than those of adults and contain "growing zones" called **growth plates**. These plates consist of columns of multiplying cartilage cells that grow in length, and then change into hard, mineralized bone. These growth plates are easy to spot on an X-ray. Because girls mature at an earlier age than boys, their growth plates change into hard bone at an earlier age.

Bone building continues throughout your life, as your body constantly renews and reshapes the bones' living tissue. Bone contains three types of cells: **osteoblasts** (pronounced: **ahs**-tee-uh-blastz), which make new bone and help repair damage; **osteocytes** (pronounced: **ahs**-tee-o-sites), which carry nutrients and waste products to and from blood vessels in the bone; and **osteoclasts** (pronounced: **ahs**-tee-o-klasts), which break down bone and help to sculpt and shape it. Osteoclasts are very active in kids and teens, working on bone as it is remodeled during growth. They also play an important role in the repair of fractures.

Bones are made up of calcium, phosphorus, sodium, and other minerals, as well as the protein collagen. **Calcium** is needed to make bones hard, which allows them to support your weight. Bones also store calcium and release some into the bloodstream when it's needed by other parts of the body.

The amounts of certain vitamins and minerals that you eat, especially vitamin D and calcium, directly affects how much calcium is stored in the bones.

The soft **bone marrow** inside many of the bones is where most of the blood cells flowing through our bodies are made. The bone marrow contains special cells called **stem cells**, which produce the body's **red blood cells** and **platelets.** Red blood cells carry oxygen to the body's tissues, and platelets help with blood clotting when a person has a cut or wound.

Bones are made up of two types of material - compact bone and cancellous bone. **Compact bone** is the solid, hard, outside part of the bone. It looks like ivory and is extremely strong. Holes and channels run through it, carrying blood vessels and nerves from the **periosteum**, the bone's membrane covering, to its inner parts. **Cancellous** (pronounced: **kan**-suh-lus) **bone**, which looks like a sponge, is inside the compact bone. It is made up of a mesh-like network of tiny pieces of bone called **trabeculae** (pronounced: truh-**beh**-kyoo-lee).

The spaces in this network are filled with red marrow, found mainly at the ends of bones, and yellow marrow, which is mostly fat.

Bones are fastened to other bones by long, fibrous straps called **ligaments** (pronounced: **lih**-guh-mentz). **Cartilage** (pronounced: **kar**-tul-ij), a flexible, rubbery substance in our joints, supports bones and protects them where they rub against each other.

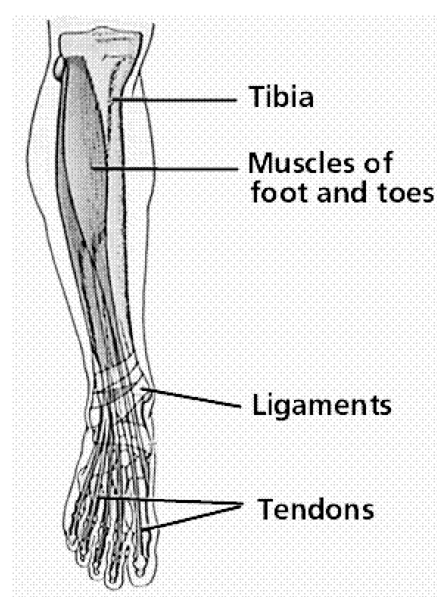
What Are the Muscles and What Do They Do?

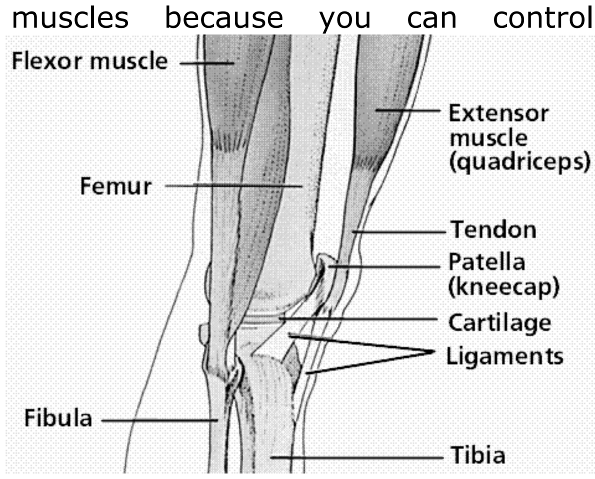
Bones don't work alone - they need help from the muscles and joints. Muscles pull on the joints, allowing us to move. They also help your body perform other functions so you can grow and remain strong, such as chewing food and then moving it through the digestive system.

The human body has more than 650 muscles, which make up half of a person's body weight. They are connected to bones by tough, cord-like tissues called **tendons**, which allow the muscles to pull on bones. If you wiggle your fingers, you can see the tendons on the back of your hand move as they do their work.

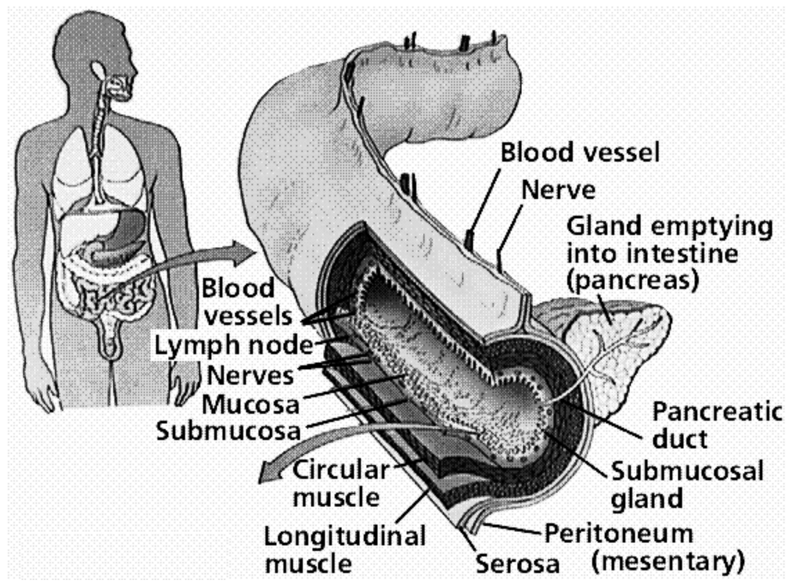
Humans have three different kinds of muscle:

- **Skeletal muscle** is attached to bone, mostly in the legs, arms, abdomen, chest, neck, and face. Skeletal muscles are called **striated** (pronounced: **stry**-ay-ted) because they are made up of fibers that have horizontal stripes when viewed under a microscope. These muscles hold the skeleton together, give the body shape, and help it with everyday movements (they are known as voluntary muscles because you can control their movement). They can contract (shorten or tighten) quickly and powerfully, but they tire easily and have to rest between workouts.



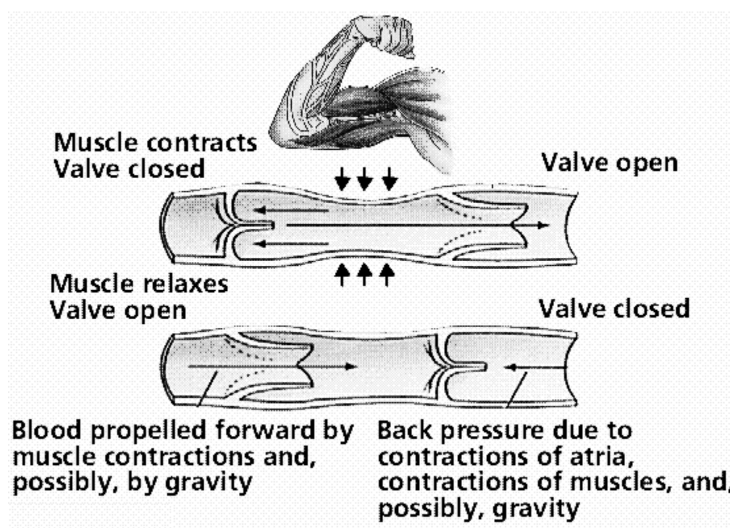


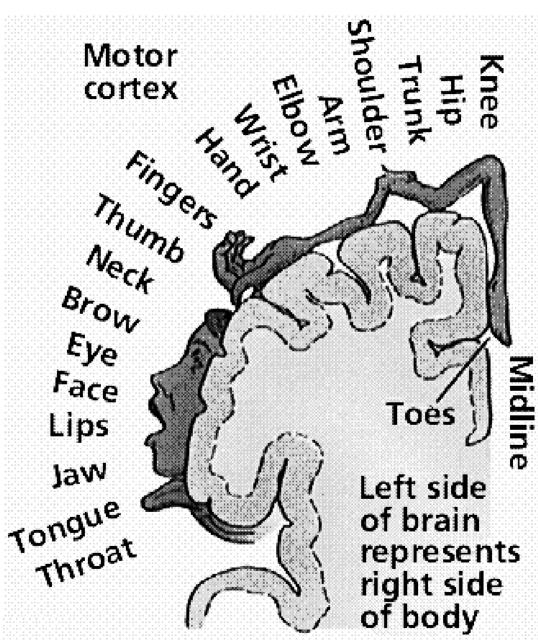
- **Smooth, or involuntary, muscle** is also made of fibers, but this type of muscle looks smooth, not striated. Generally, we can't consciously control our smooth muscles; rather, they're controlled by the nervous system automatically (which is why they are also called involuntary). Examples of smooth muscles are the walls of the stomach and intestines, which help break up food and move it through the digestive system. Smooth muscle is also found in the walls of blood vessels, where it squeezes the stream of blood flowing through the vessels to help maintain blood pressure. Smooth muscles take longer to contract than skeletal muscles do, but they can stay contracted for a long time because they don't tire easily.



- **Cardiac (pronounced: kar-dee-ak) muscle** is found in the heart. The walls of the heart's chambers are composed almost entirely of muscle fibers. Cardiac muscle is also an involuntary type of muscle. Its rhythmic, powerful contractions force blood out of the heart as it beats.

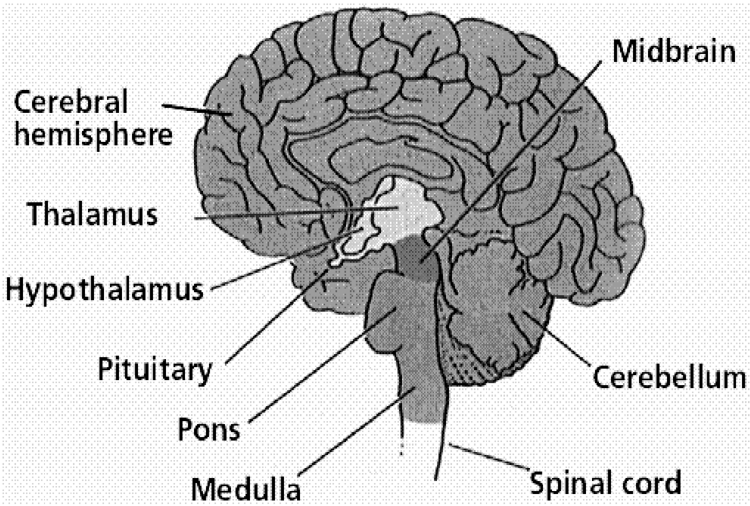
Even when you sit perfectly still, there are muscles throughout your body that are constantly moving. Muscles enable your heart to beat, your chest to rise and fall as you breathe, and your blood vessels to help regulate the pressure and flow of blood through your body. When we smile and talk, muscles are helping us communicate, and when we exercise, they help us stay physically fit and healthy.





The movements your muscles make are coordinated and controlled by the brain and nervous system. The involuntary muscles are controlled by structures deep within the brain and the upper part of the spinal cord called the brain stem. The voluntary muscles are regulated by the parts of the brain known as the cerebral motor cortex and the cerebellum.

When you decide to move, the **motor cortex** sends an electrical signal through the spinal cord and peripheral nerves to the muscles, causing them to contract. The motor cortex on the right side of the brain controls the muscles on the left side of the body and vice versa.



The **cerebellum** (pronounced: ser-uh-**beh**-lum) coordinates the muscle movements ordered by the motor cortex. Sensors in the muscles and joints send messages back through peripheral nerves to tell the cerebellum and other parts of the brain where and how the arm or leg is moving and what position it's in. This feedback results in smooth, coordinated motion.

If you want to lift your arm, your brain sends a message to the muscles in your arm and you move it. When you run, the messages to the brain are more involved, because many muscles have to work in rhythm.

Muscles move body parts by contracting and then relaxing. Your muscles can pull bones, but they can't push them back to the original position. So they work in pairs of flexors and extensors. The **flexor** contracts to bend a limb at a joint. Then, when you've completed the movement, the flexor relaxes and the **extensor** contracts to extend or straighten the limb at the same joint. For example, the biceps muscle, in the front of the upper arm, is a flexor, and the triceps, at the back of the upper arm, is an extensor. When you bend at your elbow, the biceps contracts. Then the biceps relaxes and the triceps contracts to straighten the elbow.

What Are the Joints and What Do They Do?

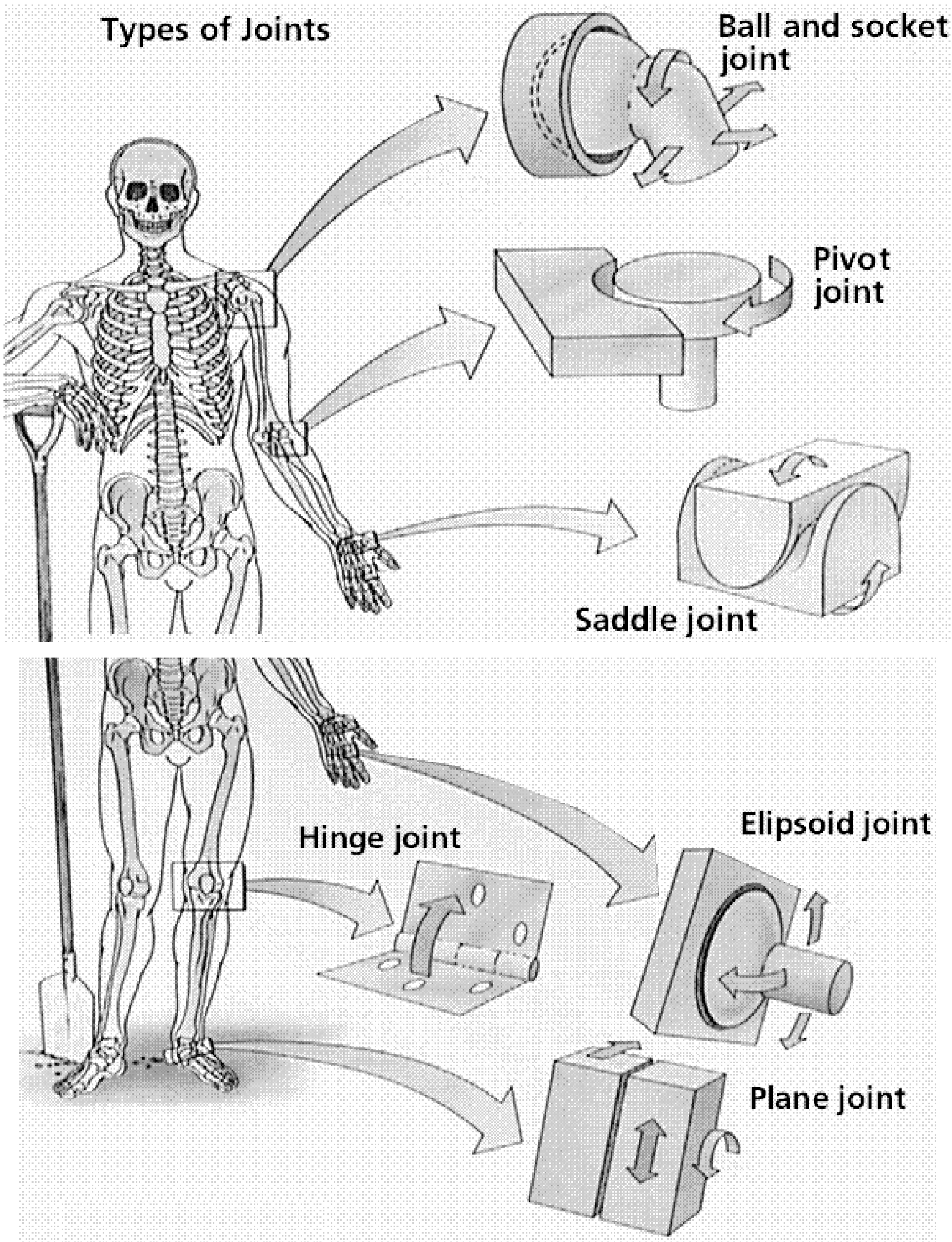
Joints allow our bodies to move in many ways. Some joints open and close like a hinge (such as knees and elbows), whereas others allow for more complicated movement - a shoulder or hip joint, for example, allows for backward, forward, sideways, and rotating movement.

Joints are classified by their range of movement. **Immovable**, or **fibrous**, **joints** don't move. The dome of the skull, for example, is made of bony plates, which must be immovable to protect the brain. Between the edges of these plates are links, or joints, of fibrous tissue. Fibrous joints also hold the teeth in the jawbone.

Partially movable, or **cartilaginous** (pronounced: kar-tuh-**lah**-juh-nus), **joints** move a little. They are linked by cartilage, as in the spine. Each of the vertebrae in the spine moves in relation to the one above and below it, and together these movements give the spine its flexibility.

Freely movable, or **synovial** (pronounced: sih-**no**-vee-ul), **joints** move in many directions. The main joints of the body - found at the hip, shoulders, elbows, knees, wrists, and ankles - are freely movable. They are filled with synovial fluid, which acts as a lubricant to help the joints move easily. There are three kinds of freely movable joints that play a big part in voluntary movement:

- **Hinge joints** allow movement in one direction, as seen in the knees and elbows.
- **Pivot joints** allow a rotating or twisting motion, like that of the head moving from side to side.
- **Ball-and-socket joints** allow the greatest freedom of movement. The hips and shoulders have this type of joint, in which the round end of a long bone fits into the hollow of another bone.



THINGS THAT CAN GO WRONG WITH THE BONES, MUSCLES, AND JOINTS

As strong as bones are, they can break. Muscles can weaken, and joints (as well as tendons, ligaments, and cartilage) can be damaged by injury or disease. The following are problems that can affect the bones, muscles, and joints in kids and teens:

- **Arthritis.** Arthritis (pronounced: ar-**threye**-tus) is the inflammation of a joint, and people who have it experience swelling, warmth, pain, and often have trouble moving. Although we often think of arthritis as a condition that affects only older people, arthritis can also occur in children and teens. Health problems that involve arthritis in kids and teens include juvenile rheumatoid arthritis (JRA), lupus, Lyme disease, and septic arthritis - a bacterial infection of a joint.
- **Fracture**. A fracture occurs when a bone breaks; it may crack, snap, or shatter. After a bone fracture, new bone cells fill the gap and repair the break. Applying a strong plaster cast, which keeps the bone in the correct position until it heals, is the usual treatment. If the fracture is complicated, metal pins and plates can be placed to better stabilize the fracture while the bone heals.
- **Muscular dystrophy**. Muscular dystrophy (pronounced: **mus**-kyoo-lur **dis**-truh-fee) is an inherited group of diseases that affect the muscles, causing them to weaken and break down over time. The most common form in childhood is called Duchenne muscular dystrophy, and it most often affects boys.

- **Osgood-Schlatter disease(OSD)**. Osgood-Schlatter disease is an inflammation (pain and swelling) of the bone, cartilage, and/or tendon at the top of the shinbone, where the tendon from the kneecap attaches. OSD usually strikes active teens around the beginning of their growth spurts, the approximately 2-year period during which they grow most rapidly.
- **Osteomyelitis.** Osteomyelitis (pronounced: os-tee-oh-my-uh-**lie**-tus) is a bone infection that is often caused by Staphylococcus aureus (pronounced: sta-fuh-low-**kah**-kus **are**-ee-us) bacteria, though other types of bacteria can cause it, too. In kids and teens, osteomyelitis usually affects the long bones of the arms and legs. Osteomyelitis often develops after an injury or trauma.
- **Osteoporosis.** In osteoporosis (pronounced: ahs-tee-o-puh-**row**-sus), bone tissue becomes brittle, thin, and spongy. Bones break easily, and the spine sometimes begins to crumble and collapse. Although the condition usually affects older people, kids and teens with eating disorders can get the condition, as can girls with female athlete triad - a combination of three conditions that some girls who exercise or play sports may be at risk for: **disordered eating**, **amenorrhea** (which means loss of a girl's period), and **osteoporosis**. Participation in sports where a thin appearance is valued can put a girl at risk for female athlete triad. Exercising regularly and getting plenty of calcium when you're a kid and teen can prevent or delay you from getting osteoporosis later in life.
- **Repetitive stress injuries**. Repetitive stress injuries (RSIs) are a group of injuries that happen when too much stress is placed on a part of the body, resulting in inflammation (pain and swelling), muscle strain, or tissue damage. This stress generally occurs from repeating the same movements over and over again. RSIs are becoming more common in kids and teens because they spend more time than ever using computers. Playing sports like tennis that involve repetitive motions can also lead to RSIs. Kids and teens who spend a lot of time playing musical instruments or video games are also at risk for RSIs.
- **Scoliosis**. Every person's spine curves a little bit; a certain amount of curvature is necessary for people to move and walk properly. But three to five people out of 1,000 have a condition called scoliosis (pronounced: sko-lee-**o**-sus), which causes the spine to curve too much. The condition can be hereditary, so a person who has scoliosis often has family members who have it.
- **Strains and sprains**. Strains occur when a muscle is overstretched. Sprains are an overstretching or a partial tear of the ligaments or tendons. Strains usually happen when a person takes part in a strenuous activity when the muscles haven't properly warmed up or the muscle is not used to the activity (such as a new sport or playing a familiar sport after a long break). Sprains, on the other hand, are usually the result of an injury, such as twisting an ankle or knee. A common sprain injury is a torn Achilles tendon, which connects the calf muscles to the heel. This tendon can snap, but it usually can be repaired by surgery. Both strains and sprains are common in children and teens because they're active and still growing.
- **Tendinitis.**Tendinitis (pronounced: ten-duh-**neye**-tus) is a common sports injury that usually happens after overexercising a muscle. The tendon and tendon sheath become inflamed, which can be painful. Resting the muscles and taking anti-inflammatory medication can help to relieve this condition.

REVIEW AND FACTS

Bones:

206 bones support the body and provide protection for organs such as the brain, heart and lungs. The bones of the skeleton act as a frame to which muscles are attached. These skeletal muscles allow the body to move; they are attached to bones by bands of tough elastic tissue, called tendons, and it is by means of tendons that they exert their pull. Another important task of bones is to produce blood cells. Finally, the bones provide a store of chemicals such as calcium salts, which are released into the bloodstream, as they are needed.

Types of bones: -

Man has evolved with bones specialized into four main types, each with a different role:-

1. The long bones: - eg:- in the limbs, they are thin, hollow and light, they play as essential role in all types of movements.
2. Flat Circular bones: - eg:- bones that form the spine or vertebral column
3. Long Circular Bones: - eg. Ribs, they are strong but elastic giving the chest the flexibility and springiness it needs for breathing.
4. Flat irregular bones: - eg:- shoulder, blades, hips and skull these are strong but light and protect delicate organs, such as the brain.

The framework of the body: -

The body owes its shape & support to the skeleton a frame consisting of hundreds of jointed bones.

- Head : The bones of the skull surround & protect the brain; the lower jaw is hinged to the skull.
- Chest : The bony cage of the ribs, connected to the spine at the back and the breastbone at the front, surround and protect the organs in the chest.
- Arm : The bones of the arms are jointed to sockets in the shoulder blades.
- Spinal Column : The 7 vertebrae in the neck and the 20 in the back make the spinal column.
- Pelvis : The bones of the pelvis surround the lower abdominal organs, support the spine and provide attachment for the legs.
- Hand : Eight bones make up the wrist, five the palm, and 14 hinged bones form the fingers and thumb.
- Leg : Three major leg bones are suspended by ball and socket joints from the pelvis
- Foot : The bones of the foot form arches, so that the weight is carried on the heel and toes.

Muscles:
There are about 650 muscles in the body, and they are divided into three different types, skeletal, visceral and cardiac The skeletal muscles move the arms, legs, and spine The visceral muscles control movements in the walls of blood vessels, the stomach and intestines. The cardiac muscles produce the pumping action of the heart. All the muscles are present in the body at birth, and everyone has the same number of muscles, consisting of the same number of fibres.

Interesting facts:

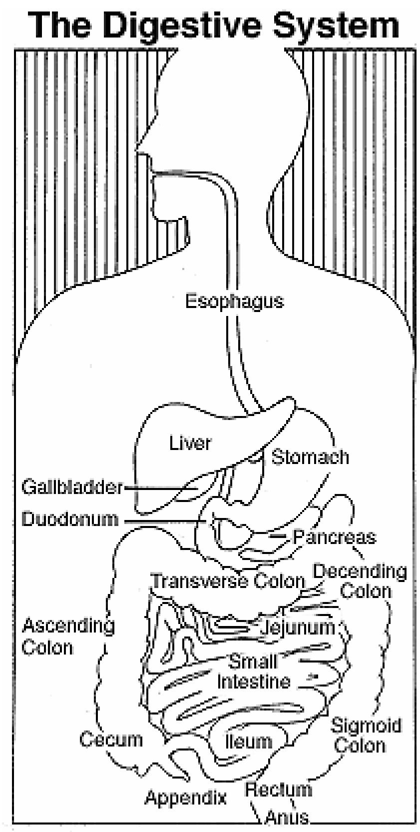
- At birth we have over 300 bones. As we grow up, some of these bones fuse together as a result an adult has only 206 bones.
- The Human hand has 27 bones.

- The Femur, or thigh bone is the longest bone in our body and is about a quarter of our height.
- The human body has 230 movable and semi- movable joints.
- The Human skull is made up of 29 different bones
- The strongest muscles of the human body are masseters, these are present on either side of the mouth and help with chewing and grinding food in our mouth.
- The Thighbone is so strong that it withstands the axial load of about 1600-1800 kilos.
- Most of the bones in the human body constitutes about ¾ of water.
- The whole leg consists of 31 bones.
- Almost every seven years, the human body replaces the equivalent of an entirely new skeleton.
- Laughing and coughing creates more pressure on the spine than walking or standing.
- The shoulder blade is connected to the body by means of 15 different muscles and it is not attached to a single bone.
- An average of 17 muscles contracts for a smile.
- The human body consists of over 600 muscles.
- The middle part of the back is the least sensitive part of our body.
- The Tongue is the most versatile muscle in the human body.
- The longest muscle in the human body is the sartorius, which is present in the hip region and it is commonly known as "Tailor's muscle".
- The smallest muscle in the human body is the stapedius, which is present deep inside the ear.
- The muscles of our body constitute 40% of our body weight.
- Our muscles often work in pairs so that they can pull in different or opposite directions.
- An average person laughs about 15 times a day.

DIGESTIVE SYSTEM

What's the first step in digesting food? Believe it or not, the digestive process starts even before you put food in your mouth. It begins when you smell something irresistible or when you see a favorite food you know will taste good. Just by smelling that homemade apple pie or thinking about how delicious that ice cream sundae is going to taste, you begin to salivate - and the digestive process kicks in, preparing for that first scrumptious bite.

If it's been a while since your last meal or if you even think about something tasty, you feel hungry. You eat until you're satisfied and then go about your business. But for the next 20 hours or so, your digestive system is doing its job as the food you ate travels through your body.



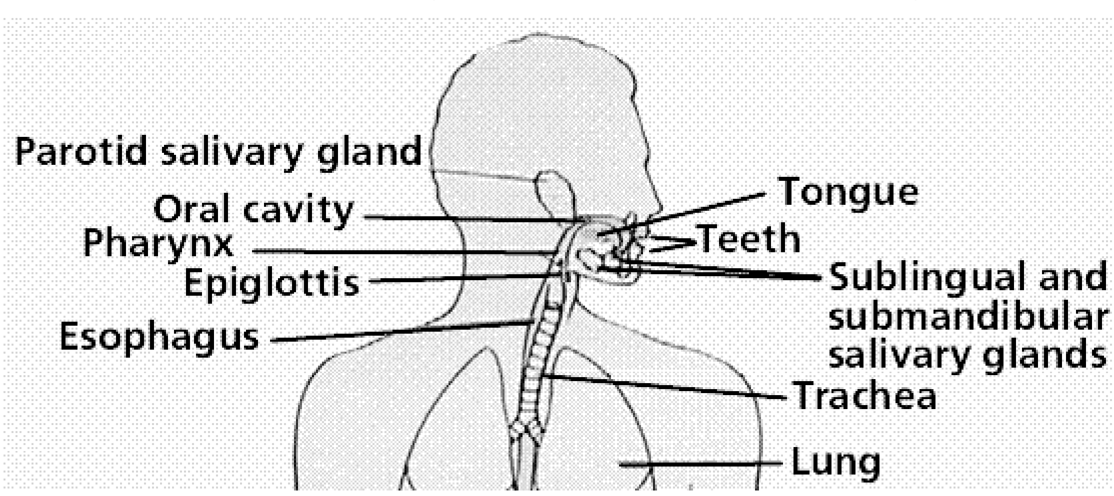
Food is the body's fuel source. The nutrients in food give the body's cells the energy and other substances they need to operate. But before food can do any of these things, it has to be digested into small pieces the body can absorb and use.

Almost all animals have a tube-type digestive system in which food enters the mouth, passes through a long tube, and exits as **feces** (poop) through the anus. The smooth muscle in the walls of the tube-shaped digestive organs rhythmically and efficiently moves the food through the system, where it is broken down into tiny absorbable atoms and molecules. During the process of absorption, nutrients that come from the food (including carbohydrates, proteins, fats, vitamins, and minerals) pass through channels in the intestinal wall and into the bloodstream. The blood works to distribute these nutrients to the rest of the body. The waste parts of food that the body can't use are passed out of the body as feces.

What Is the Digestive System and What Does It Do?

Every morsel of food we eat has to be broken down into nutrients that can be absorbed by the body, which is why it takes hours to fully digest food. In humans, protein must be broken down into amino acids, starches into simple sugars, and fats into fatty acids and glycerol. The water in our food and drink is also absorbed into the bloodstream to provide the body with the fluid it needs.

The digestive system is made up of the **alimentary canal** and the other abdominal organs that play a part in digestion, such as the liver and pancreas. The alimentary canal (also called the **digestive tract**) is the long tube of organs - including the esophagus, the stomach, and the intestines - that runs from the mouth to the anus. An adult's digestive tract is about 30 feet long.

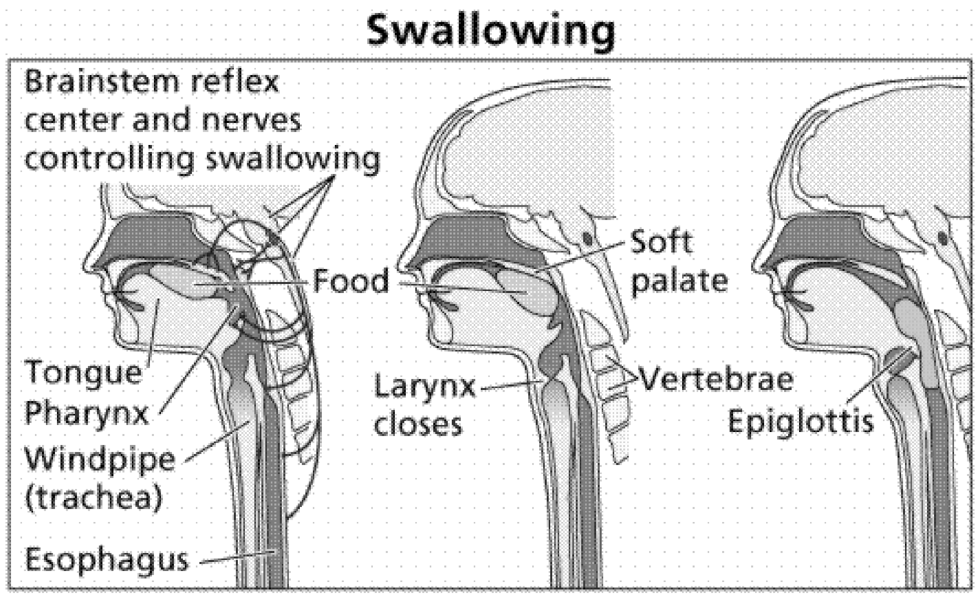


Digestion begins in the **mouth**, well before food reaches the stomach. When we see, smell, taste, or even imagine a tasty snack, our **salivary glands**, which are located under the tongue and near the lower jaw, begin producing saliva.

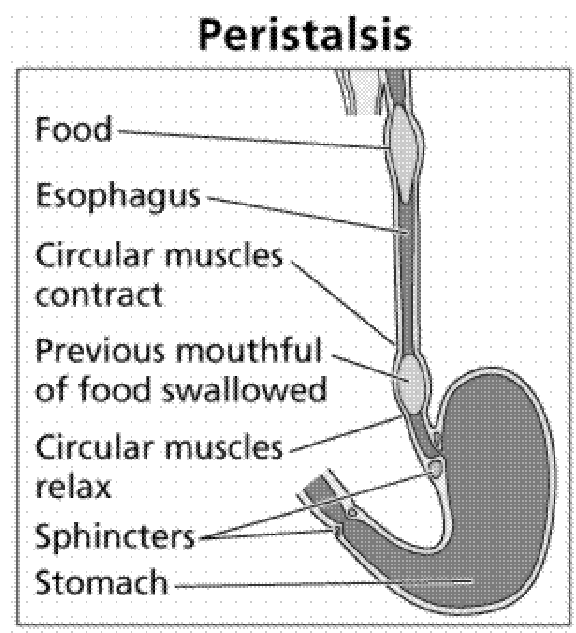
This flow of saliva is set in motion by a brain reflex that's triggered when we sense food or even think about eating. In response to this sensory stimulation, the brain sends impulses through the nerves that control the salivary glands, telling them to prepare for a meal.

As the teeth tear and chop the food, **saliva** moistens it for easy swallowing. A digestive enzyme called **amylase** (pronounced: **ah**-meh-lace), which is found in saliva, starts to break down some of the carbohydrates (starches and sugars) in the food even before it leaves the mouth.

Swallowing, which is accomplished by muscle movements in the tongue and mouth, moves the food into the throat, or **pharynx**. The pharynx (pronounced: **fair**-inks), a passageway for food and air, is about 5 inches long. A flexible flap of tissue called the **epiglottis** (pronounced: ep-ih-**glah**-tus) reflexively closes over the windpipe when we swallow to prevent choking.

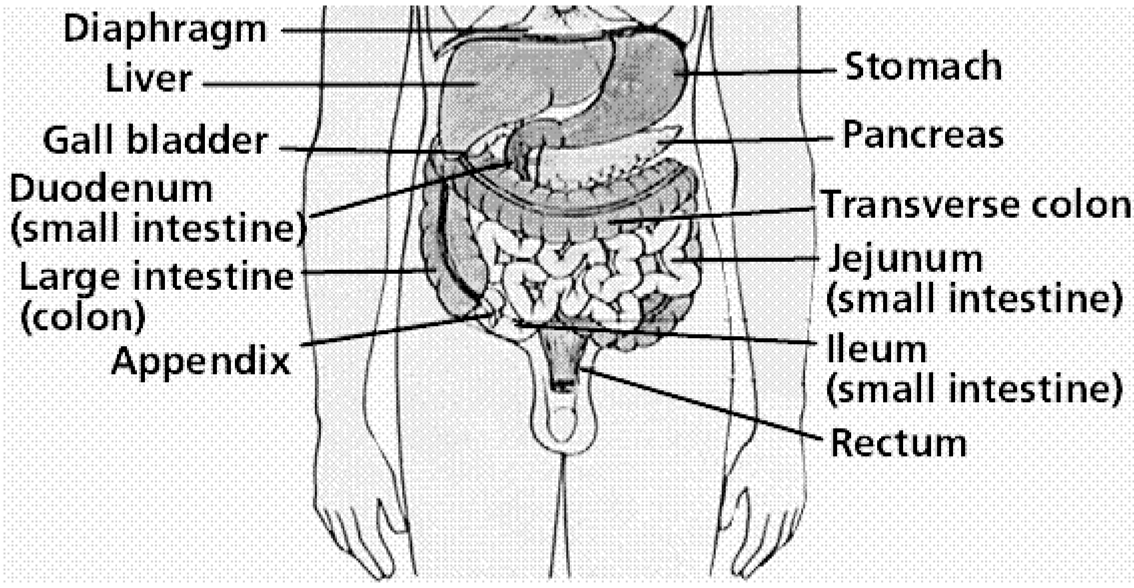


From the throat, food travels down a muscular tube in the chest called the **esophagus** (pronounced: ih-**sah**-fuh-gus). Waves of muscle contractions called **peristalsis** (pronounced: per-uh-**stall**-sus) force food down through the esophagus to the stomach. A person normally isn't aware of the movements of the esophagus, stomach, and intestine that take place as food passes through the digestive tract.



At the end of the esophagus, a muscular ring called a **sphincter** (pronounced: **sfink**-ter) allows food to enter the stomach and then squeezes shut to keep food or fluid from flowing back up into the esophagus. The stomach muscles churn and mix the food with acids and enzymes, breaking it into much smaller, digestible pieces. An acidic environment is needed for the digestion that takes place in the stomach. Glands in the stomach lining produce about 3 quarts of these digestive juices each day.

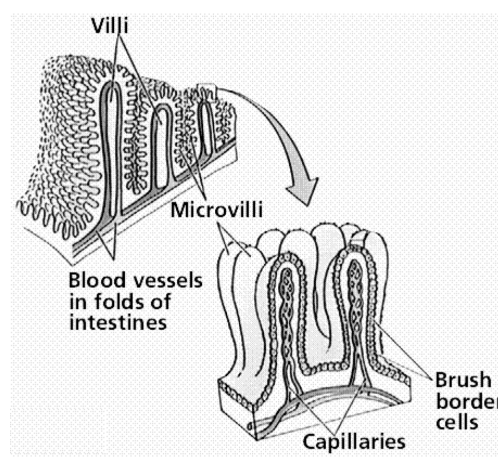
Some substances, such as water, salt, sugars, and alcohol can be absorbed directly through the stomach wall. Most other substances in the food we eat need further digestion and must travel into the intestine before being absorbed. When it's empty, an adult's stomach has a volume of one fifth of a cup, but it can expand to hold more than 8 cups of food after a large meal.



By the time food is ready to leave the stomach, it has been processed into a thick liquid called **chyme** (pronounced: **kime**). A walnut-sized muscular tube at the outlet of the stomach called the **pylorus** (pronounced: py-**lore**-us) keeps chyme in the stomach until it reaches the right consistency to pass into the small intestine. Chyme is then squirted down into the small intestine, where digestion of food continues so the body can absorb the nutrients into the bloodstream.

The small intestine is made up of three parts:

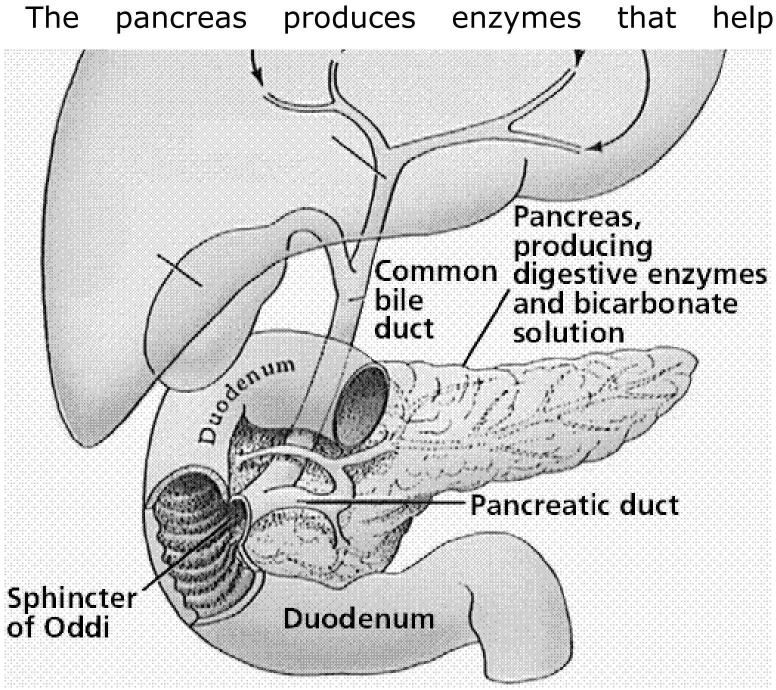
- the **duodenum** (pronounced: due-uh-**dee**-num), the C-shaped first part
- the **jejunum** (pronounced: jih-**ju**-num), the coiled midsection
- the **ileum** (pronounced: **ih**-lee-um), the final section that leads into the large intestine



The inner wall of the small intestine is covered with millions of microscopic, finger-like projections called **villi** (pronounced: **vih**-lie). The villi are the vehicles through which nutrients can be absorbed into the body.

The **liver** (located under the rib cage in the right upper part of the abdomen), the **gallbladder** (hidden just below the liver), and the **pancreas** (beneath the stomach) are not part of the alimentary canal, but these organs are essential to digestion.

The pancreas produces enzymes that help digest proteins, fats, and carbohydrates. It also makes a substance that neutralizes stomach acid. The liver produces bile, which helps the body absorb fat. Bile is stored in the gallbladder until it is needed. These enzymes and bile travel through special channels (called ducts) directly into the small intestine, where they help to break down food. The liver also plays a major role in the handling and processing of nutrients, which are carried to the liver in the blood from the small intestine.



From the small intestine, food that has not been digested (and some water) travels to the **large intestine** through a muscular ring that prevents food from returning to the small intestine. By the time food reaches the large intestine, the work of absorbing nutrients is nearly finished. The large intestine's main function is to remove water from the undigested matter and form solid waste that can be excreted. The large intestine is made up of three parts:

- The **cecum** (pronounced: **see**-kum) is a pouch at the beginning of the large intestine that joins the small intestine to the large intestine. This transition area expands in diameter, allowing food to travel from the small intestine to the large. The **appendix**, a small, hollow, finger-like pouch, hangs at the end of the cecum. Doctors believe the appendix is left over from a previous time in human evolution. It no longer appears to be useful to the digestive process.
- The **colon** extends from the cecum up the right side of the abdomen, across the upper abdomen, and then down the left side of the abdomen, finally connecting to the rectum. The colon has three parts: the ascending colon and transverse colon, which absorb fluids and salts, and the descending colon, which holds the resulting waste. Bacteria in the colon help to digest the remaining food products.
- The **rectum** is where feces are stored until they leave the digestive system through the **anus** as a bowel movement.

THINGS THAT CAN GO WRONG WITH THE DIGESTIVE SYSTEM

Nearly everyone has a digestive problem at one time or another. Some conditions, such as indigestion or mild diarrhea, are common; they result in mild discomfort and get better on their own or are easy to treat. Others, such as inflammatory bowel disease, can be long lasting or troublesome. A doctor who specializes in the digestive system is called a GI specialist or gastroenterologist.

Conditions Affecting the Esophagus

Conditions affecting the esophagus may be **congenital** (which means a person is born with them) or **noncongenital** (meaning a person can develop them after birth). Some examples include:

- **Tracheoesophageal fistula** (pronounced: tray-**kee**-oh-ih-saf-uh-jee-ul **fish**-chuh-luh) and **esophageal atresia** (pronounced: ih-saf-uh-**jee**-ul uh-**tree**-zhuh) are both examples of congenital conditions. Tracheoesophageal fistula is where there is a connection between the esophagus and the trachea (windpipe) where there shouldn't be one. In babies with esophageal atresia, the esophagus comes to a dead end instead of connecting to the stomach. Both conditions are usually detected soon after a baby is born - sometimes even beforehand. They require surgery to repair.
- **Esophagitis** (pronounced: ih-saf-uh-**jeye**-tus) or inflammation of the esophagus, is an example of a noncongenital condition. Esophagitis can be caused by infection or certain medications. It can also be caused by **gastroesophageal reflux disease** (GERD), a condition in which the esophageal sphincter (the tube of muscle that connects the esophagus with the stomach) allows the acidic contents of the stomach to move backward up into the esophagus. GERD can sometimes be corrected through lifestyle changes, such as adjusting the types of things a person eats. Sometimes, though, it requires treatment with medication.

Conditions Affecting the Stomach and Intestines

Almost everyone has experienced diarrhea or constipation at some point in their lives. With diarrhea, muscle contractions move the contents of the intestines along too quickly and there isn't enough time for water to be absorbed before the feces are pushed out of the body. Constipation is the opposite: The contents of the large intestines do not move along fast enough and waste materials stay in the large intestine so long that too much water is removed and the feces become hard. Some other examples of the common stomach and intestinal disorders are:

- **Celiac disease** is a digestive disorder caused by the abnormal response of the immune system to a protein called gluten, which is found in certain foods. People with celiac disease have difficulty digesting the nutrients from their food because eating things with gluten damages the lining of the intestines over time. Some of the symptoms are diarrhea, abdominal pain, and bloating. The disease can be managed by following a gluten-free diet.
- **Irritable bowel syndrome** (IBS) is a common intestinal disorder that affects the colon. When the muscles in the colon don't work smoothly, a person can feel the abdominal cramps, bloating, constipation, and diarrhea that may be signs of IBS. There's no cure for IBS, but it can be managed by making some dietary and lifestyle changes.
- **Gastritis and peptic ulcers**. Under normal conditions, the stomach and duodenum are extremely resistant to irritation by the strong acids produced in the stomach. Sometimes, though, a bacterium called Helicobacter pylori or the chronic use of drugs or certain medications weakens the protective mucous coating of the stomach and duodenum, allowing acid to get through to the sensitive lining beneath. This can irritate and inflame the lining of the stomach (a condition known as gastritis) or cause **peptic ulcers**, which are sores or holes that form in the lining of the stomach or the duodenum and cause pain or bleeding. Medications are usually successful in treating these conditions.
- **Inflammatory bowel disease** is chronic inflammation of the intestines that affects older kids, teens, and adults. There are two major types: **ulcerative colitis**, which usually affects just the rectum and the large intestine, and **Crohn's disease**, which can affect the whole gastrointestinal tract from the mouth to the anus as well as other parts of the body. They are treated with medications and, if necessary, intravenous (IV) feedings to provide nutrition. In some cases, surgery may be necessary to remove inflamed or damaged areas of the intestine.

Disorders of the Pancreas, Liver, and Gallbladder

Conditions affecting the pancreas, liver, and gallbladder often affect the ability of these organs to produce enzymes and other substances that aid in digestion. Some examples are:

- **Cystic fibrosis** is a chronic, inherited illness where the production of abnormally thick mucus blocks the ducts or passageways in the pancreas and prevents its digestive juices from entering the intestines, making it difficult for a person with this condition to properly digest proteins and fats. This causes important nutrients to pass out of the body unused. To help manage their digestive problems, people with cystic fibrosis can take digestive enzymes and nutritional supplements.
- **Hepatitis** is a viral infection in which a person's liver becomes inflamed and can lose its ability to function. Some forms of viral hepatitis are highly contagious. Mild cases of hepatitis A can be treated at home; however, serious cases involving liver damage may require hospitalization.
- The gallbladder can develop gallstones and become inflamed - a condition called **cholecystitis** (pronounced: ko-lee-sis-**teye**-tus). Although gallbladder conditions are uncommon in kids and teens, they can occur when a kid or teen has sickle cell anemia or in kids being treated with certain long-term medications.

The kinds and amounts of food a person eats and how the digestive system processes that food play key roles in maintaining good health. Eating a healthy diet is the best way to prevent common digestive problems.

REVIEW AND FACTS ABOUT THE DIGESTIVE SYSTEM

Living organisms need food

- In order to keep alive and to carry on their various life activities such as ingestion, digestion, absorption, respiration, movement, circulation, co-ordination, secretion, excretion and reproduction
- For building and maintaining their cellular and metabolic machinery (growth maintenance and repair of the organism)
- For regulating metabolic processes.
- For building up the resistance against disease

Food thus can be defined as any essential substance that when absorbed into the body tissues yields materials for the production of energy, the growth and regulation of life processes, without harming the organism.

1. The particles or pieces of food, small or big are taken into the body. This is called as eating or ingestion.
2. The ingested food is then digested, where the complex and large food particles are broken down into simpler, smaller and soluble molecules.
3. Then, the simpler substances obtained from digestion are then absorbed into the cells of the body.
4. Then the undigested waste material is removed and thrown out of the body by excretion. The process of digestion includes mechanical and chemical breakdown of the ingested food.
5. The chunks of food chewed by us are broken down into small pieces and are acted upon a variety of enzymes secreted into the mouth. Thus, inside the mouth, saliva moistens the masticated food and causes chemical digestion (of starch by the amylase enzymes into smaller molecules). The masticated food and partially digested food then passes the esophagus or the food pipe into the stomach. Here, it is acted upon by gastric juice of the stomach, which contains hydrochloric acid, pepsin and other enzymes. These enzymes break down the proteins of the food into smaller molecules, which pass onto small intestine.
6. In the first part of the small intestine, called the duodenum, food (now called chyme) is acted upon the by bile juice from the liver and pancreatic juice from the pancreas. The walls of a part of small intestine called ileum also pour some enzymes for food digestion.
7. All the food, which is digested by the mouth, stomach, duodenum and ileum, is ultimately absorbed by the villi, which are numerous minute finger like projections into the cavity of the small intestine. The absorbed food is then sent through blood to different parts of the body. The absorbed food materials are utilized by the body in various ways, by a process called assimilation. The undigested food is sent to the large intestine and removed through the rectum and anus in the form of stool or faeces. This process is called excretion.

Interesting facts:

- For every 2 weeks, the human stomach produces a new layer of mucous lining, otherwise the stomach will digest itself.
- The human liver performs 500 different functions.
- Liver is the largest and heaviest internal organ of the body and weighs about 1.6 kilos.
- The Liver is the only organ of the body, which has the capacity to regenerate itself completely even after being removed almost completely.
- Liver cells take several years to replace themselves.

- A healthy liver processes 720 liters of blood per day.
- The human stomach contains about 35 million small digestive glands.
- The human stomach produces about 2.5 liters of gastric juice everyday.
- In an average person, it takes 8 seconds for food to travel down the food pipe, 3-5 hours in small intestine and 3-4 days in the large intestine.
- The human body takes 6 hours to digest a high fat meal and takes 2 hours for a carbohydrate meal.
- The food will get into the stomach even if one stands on their head.
- On an average, the human stomach holds about 2 liters of contents.
- We produce 1 liter of saliva per day.
- It takes 5- 30 seconds to chew food.
- Swallowing of the food takes about 10 seconds.
- In a human body, the small intestine is 21 feet and the large intestine is 6 feet long.
- For every 24 hours, in a healthy adult, more than a gallon of water containing over an ounce of salt is absorbed from the intestine.

LUNGS AND RESPIRATORY SYSTEM

Whether you're wide awake while prepping for that big date or asleep during your most snooze-worthy afternoon class, you don't have to think about breathing. It's so important to life that it happens automatically. Each day you breathe about 25,000 times, and by the time you're 70 years old, you'll have taken at least 600 million breaths. If you didn't breathe, you couldn't live. It's one of the most important functions your body performs.

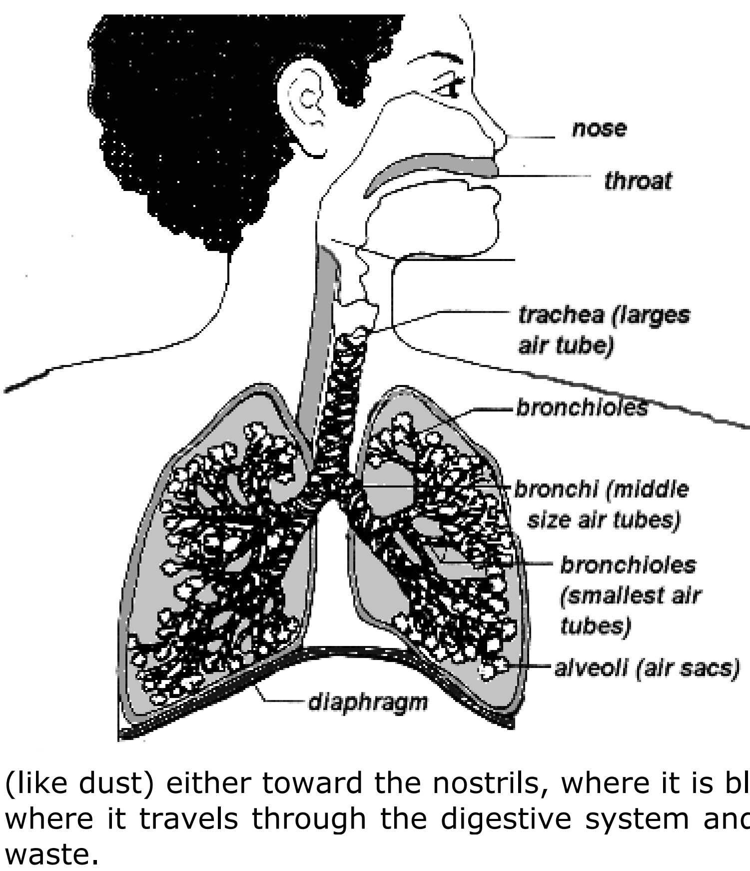
What Are the Lungs and Respiratory System and What Do They Do?

All of this breathing couldn't happen without help from the respiratory system, which includes the nose, throat, voice box, windpipe, and lungs. With each breath, you take in air through your **nostrils** and mouth, and your lungs fill up and empty out. As air is inhaled, the mucous membranes of the nose and mouth warm and humidify the air.

Although we can't see it, the air we breathe is made up of several gases. Oxygen is the most important for keeping us alive because body cells need it for energy and growth. Without oxygen, the body's cells would die.

Carbon dioxide is the waste gas that is produced when carbon is combined with oxygen as part of the body's energy-making processes. The lungs and respiratory system allow oxygen in the air to be taken into the body, while also enabling the body to get rid of carbon dioxide in the air breathed out.

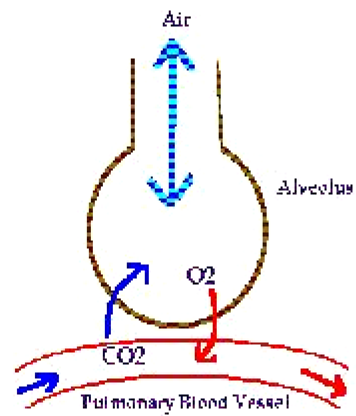
Respiration is the term for the exchange of oxygen from the environment for carbon dioxide from the body's cells. The process of taking air into the lungs is called inhalation or inspiration, and the process of breathing it out is called exhalation or expiration.



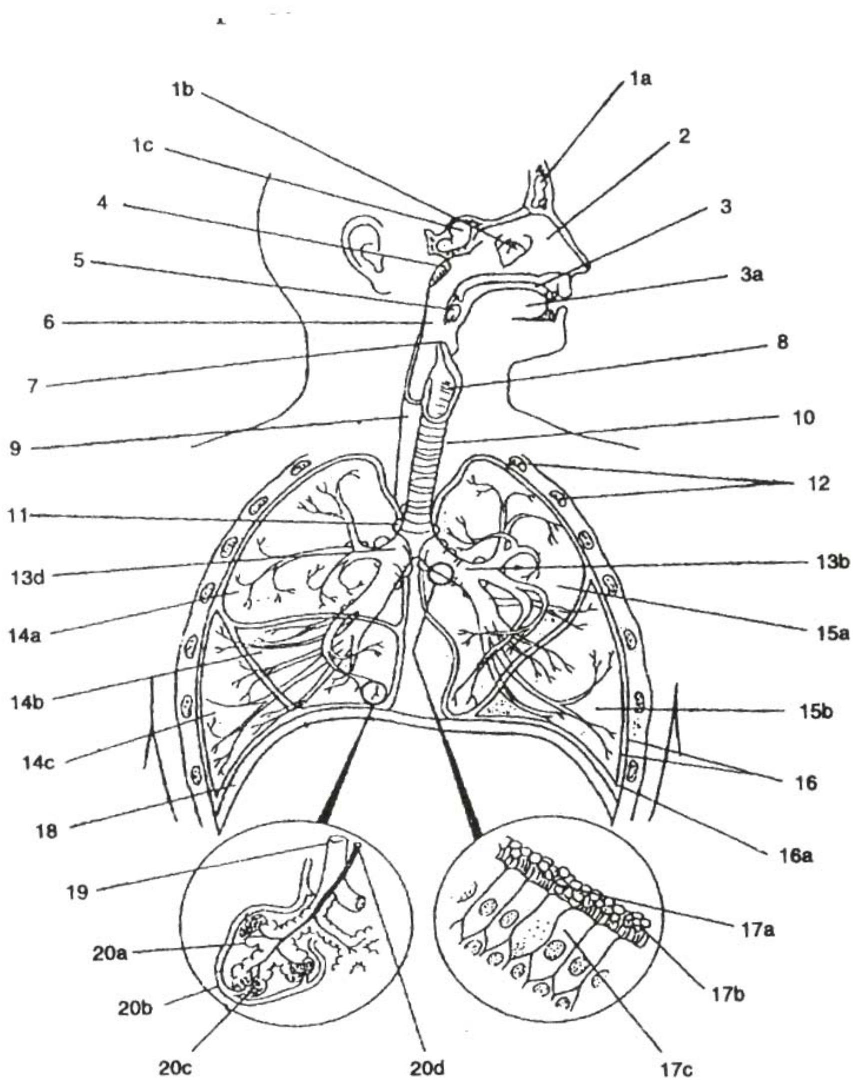
Even if the air you breathe is dirty or polluted, your respiratory system filters out foreign matter and organisms that enter through the nose and mouth. Pollutants are breathed or coughed out, destroyed by digestive juices, or eaten by macrophages, a type of blood cell that patrols the body looking for germs to destroy. Tiny hairs called **cilia** (pronounced: **sih**-lee-uh) protect the nasal passageways and other parts of the respiratory tract, filtering out dust and other particles that enter the nose with the breathed air. As air is inhaled, the cilia move back and forth, pushing any foreign matter (like dust) either toward the nostrils, where it is blown out, or toward the pharynx, where it travels through the digestive system and out with the rest of the body's waste.

The two openings of the airway (the nasal cavity and the mouth) meet at the **pharynx** (pronounced: **far**-inks), or throat, at the back of the nose and mouth. The pharynx is part of the digestive system as well as the respiratory system because it carries both food and air. At the bottom of the pharynx, the pathway for both food and air divides in two. One passageway is exclusively for food (the **esophagus**, pronounced: ih-**sah**-fuh-gus, which leads to the stomach) and the other for air. The **epiglottis** (pronounced: eh-pih-**glah**-tus), a small flap of tissue, covers the air-only passage when we swallow, keeping food and liquid from going into our lungs.

The **larynx** (pronounced: **lar**-inks), or voice box, is the uppermost part of the air-only passage. This short tube contains a pair of **vocal cords**, which vibrate to make sounds. The **trachea** (pronounced: **tray**-kee-uh), or windpipe, extends downward from the base of the larynx. It lies partly in the neck and partly in the chest cavity. The walls of the trachea are strengthened by stiff rings of cartilage to keep it open so air can flow through on its way to the lungs. The trachea is also lined with cilia, which sweep fluids and foreign particles out of the airway so that they stay out of the lungs.



At its bottom end, the trachea divides into left and right air tubes called **bronchi** (pronounced: **brahn**-ky), which connect to the lungs. Within the lungs, the bronchi branch into smaller bronchi and even smaller tubes called **bronchioles** (pronounced: **brahn**-kee-olz). Bronchioles, which are as thin as a strand of hair, end in tiny air sacs called **alveoli** (pronounced: al-**vee**-oh-lie), where the exchange of oxygen and carbon dioxide actually takes place. Each lung houses about 300 to 400 million alveoli.

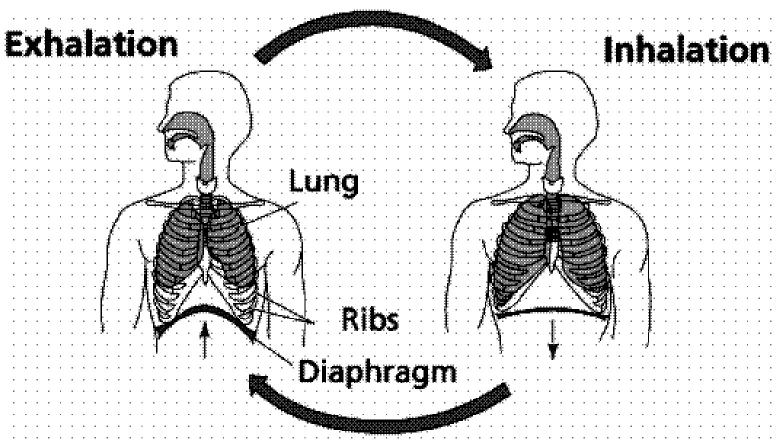


With each inhalation, air fills a large portion of the millions of alveoli. In a process called **diffusion** (pronounced: dih-**fyoo**-zhun), oxygen moves from the alveoli to the blood through the **capillaries** (tiny blood vessels, pronounced: **kah**-puh-ler-eez) that line the alveolar walls. Once in the bloodstream, oxygen gets picked up by a molecule called **hemoglobin** (pronounced: **hee**-muh-glo-bun) in the red blood cells. This oxygen-rich blood then flows back to the heart, which pumps it through the arteries to oxygen-hungry tissues throughout the body.

In the tiny capillaries of the body tissues, oxygen is freed from the hemoglobin and moves into the cells. Carbon dioxide, which is produced during the process of diffusion, moves out of these cells into the capillaries, where most of it is dissolved in the plasma of the blood. Blood rich in carbon dioxide then returns to the heart via the veins. From the heart, this blood is pumped to the lungs, where carbon dioxide passes into the alveoli to be exhaled.

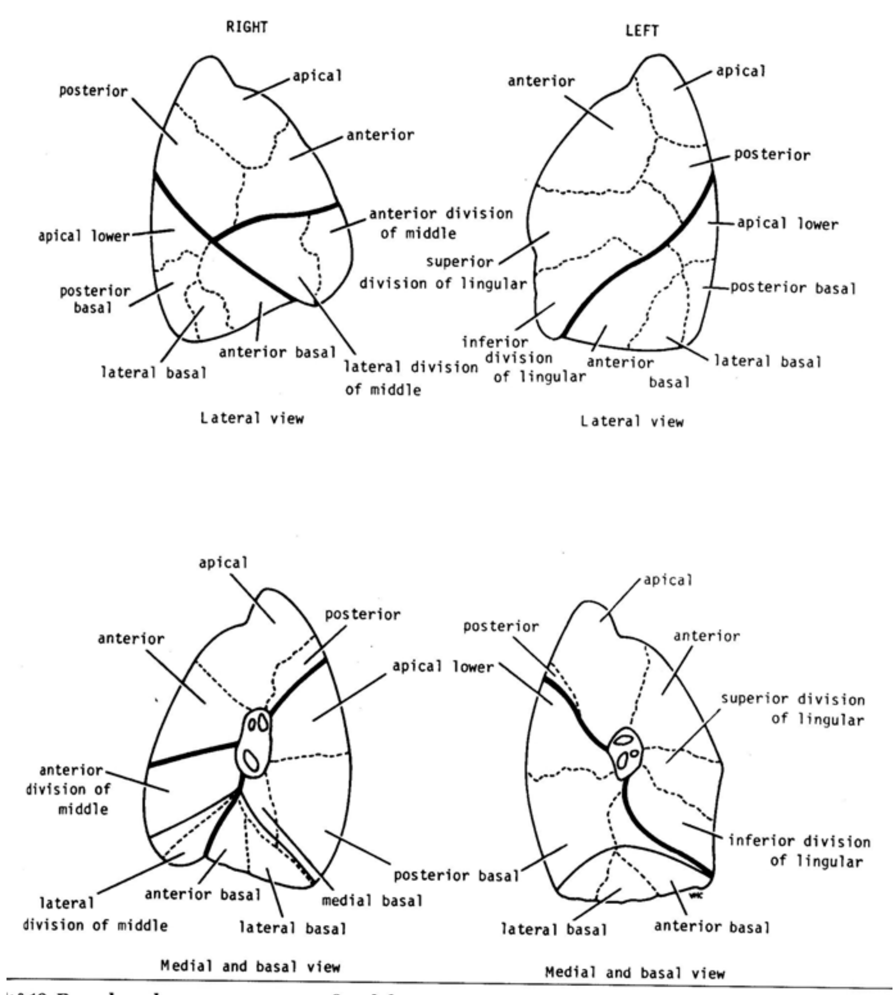
The lungs also contain elastic tissues that allow them to inflate and deflate without losing shape and are encased by a thin lining called the **pleura** (pronounced: **plur**-uh). This network of alveoli, bronchioles, and bronchi is known as the **bronchial tree.**

The **chest cavity**, or **thorax** (pronounced: **thor**-aks)**,** is the airtight box that houses the bronchial tree, lungs, heart, and other structures. The top and sides of the thorax are formed by the ribs and attached muscles, and the bottom by a large muscle called the diaphragm. The chest walls form a protective cage around the lungs and other contents of the chest cavity.



The diaphragm (pronounced: **dye**-uh-fram), which separates the chest from the abdomen, plays a lead role in breathing. When we breathe out, the diaphragm moves upward, forcing the chest cavity to get smaller and pushing the gases in the lungs up and out of the nose and mouth. When we breathe in, the diaphragm moves downward toward the abdomen, and the rib muscles pull the ribs upward and outward, enlarging the chest cavity and pulling air in through the nose or mouth. Air pressure in the chest cavity and lungs is reduced, and because gas flows from high pressure to low, air from the environment flows through the nose or mouth into the lungs. As we exhale, the diaphragm moves upward and the chest wall muscles relax, causing the chest cavity to contract. Air pressure in the lungs rises, so air flows from the lungs and up and out of respiratory system through the nose or mouth.

The respiratory system can easily be divided into two main divisions. The part described above conducts the air (Conduction Zone) and as a corollary of this action produces the voice. Its main parts are the nose, Pharynx, Larynx, Trachea and the Bronchial tree. The second part of the respiratory system (Respiratory Zone) receives air and exchanges gases. This action mainly occurs through Alveoli that are contained within the spongy structure of the lungs that occupy the major part of the Thoracic cavity. The lungs are two voluminous, sponge-like organs in the Thoracic cavity.



3-10. Bronchopulmonary segments of each lung.

A delicate membrane, the Pleura, covers both lungs. Along with the heart and its great blood vessels, these two lungs completely fill the chest cavity. The lungs are cone-shaped and the apex lies above while the base rests on the floor of the Thoracic cavity, the diaphragm. Each of the lungs is divided into numerous lobes by vertical and horizontal fissures. The right lung has three lobes where as the left has two. Each of these lobes is composed of a number of lobules. A small Bronchial tube enters each lobule, conducting air into the dilated sacs and removing Carbon-di-oxide. Lung tissue is elastic, porous and spongy. There are ten Bronchopulmonary segments in each lung that are distinct anatomical and functional units of the lung.

THINGS THAT CAN GO WRONG WITH THE RESPIRATORY SYSTEM

Many factors — including genetics, pollutants and irritants, and infectious diseases — can affect the health of your lungs and respiratory system and cause respiratory problems. Problems of the respiratory system that can affect people during their teen years include:

Asthma. Over 20 million people have asthma (pronounced: **az**-muh) in the United States, and it's the number-one reason that kids and teens chronically miss school. Asthma is a long-term, inflammatory lung disease that causes airways to tighten and narrow when a person with the condition comes into contact with irritants such as cigarette smoke, dust, or pet dander.

Bronchitis. Although bronchitis doesn't affect most teens, it can affect those who smoke. In bronchitis, the membranes lining the larger bronchial tubes become inflamed and an excessive amount of mucus is produced. The person with bronchitis develops a bad cough to get rid of the mucus.

Common cold. Colds are caused by over 200 different viruses that cause inflammation in the upper respiratory tract. The common cold is the most common respiratory infection. Symptoms may include a mild fever, cough, headache, runny nose, sneezing, and sore throat.

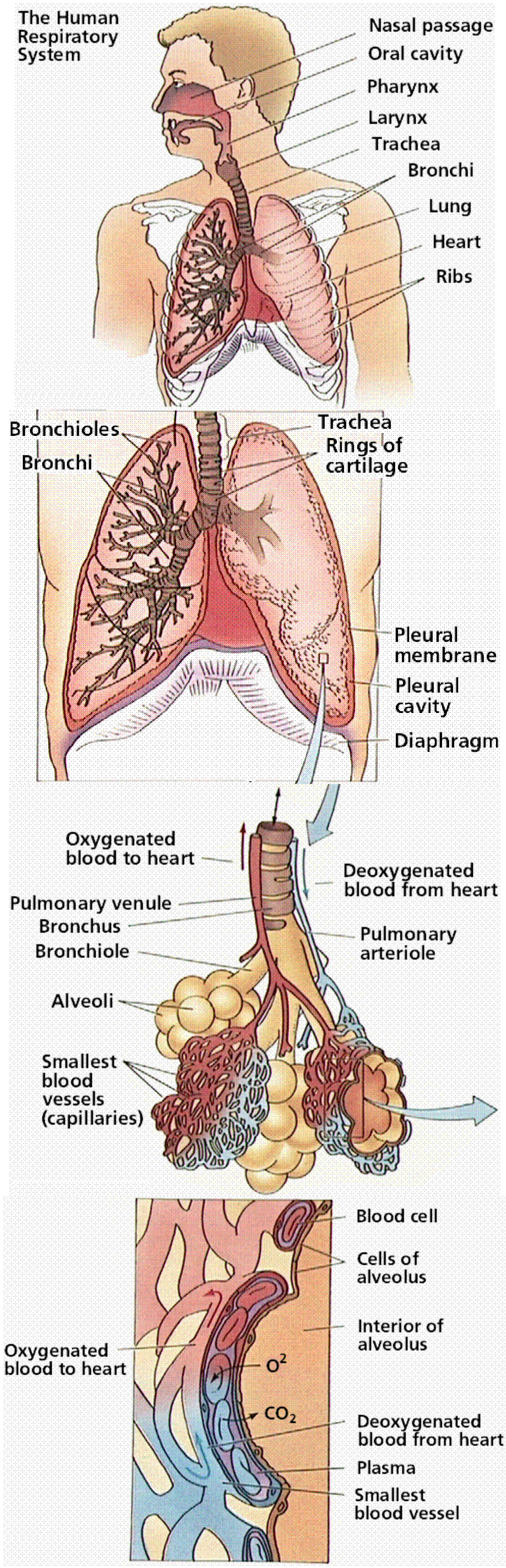
Cough. A cough is a symptom of an illness, not an illness itself. There are many different types of cough and many different causes, ranging from not-so-serious to life threatening. Some of the more common causes affecting kids and teens are the common cold, asthma, sinusitis, seasonal allergies, and pneumonia.

Cystic fibrosis (CF). CF is an inherited disease affecting the lungs. CF causes mucus in the body to be abnormally thick and sticky. The mucus can clog the airways in the lungs and make a person more likely to get bacterial infections.

Pneumonia. Pneumonia is an inflammation of the lungs, which usually occurs because of infection with a bacteria or virus. Pneumonia causes fever, inflammation of lung tissue, and makes breathing difficult because the lungs have to work harder to transfer oxygen into the bloodstream and remove carbon dioxide from the blood. Common causes of pneumonia are influenza and infection with the bacterium Streptococcus pneumoniae.

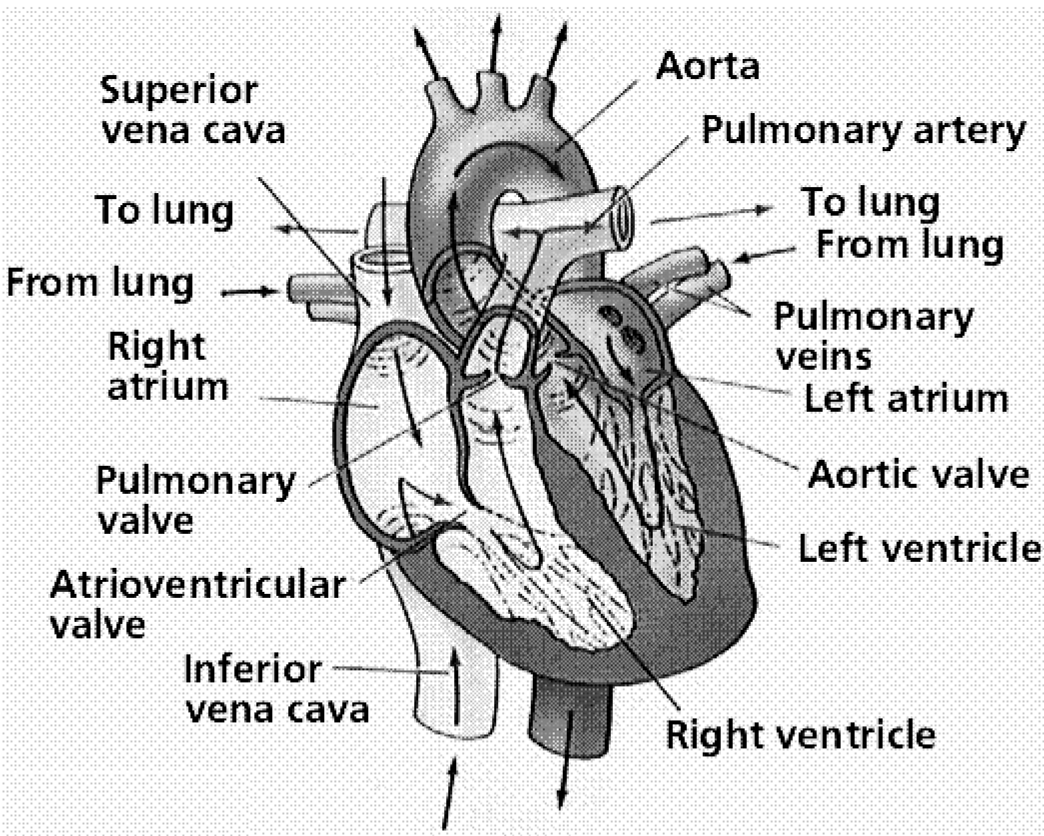
Although some respiratory diseases like asthma or cystic fibrosis can't be prevented, you **can** prevent many chronic lung and respiratory illnesses by avoiding smoking, staying away from pollutants and irritants, washing your hands often to avoid infection, and getting regular medical checkups.

THE HUMAN RESPIRATORY SYSTEM



HEART AND CIRCULATORY SYSTEM

The heart and circulatory system (also called the **cardiovascular system**) make up the network that delivers blood to the body's tissues. With each heartbeat, blood is sent throughout our bodies, carrying oxygen and nutrients to all of our cells. Each day, 2,000 gallons (more than 7,570 liters) of blood travel many times through about 60,000 miles (96,560 kilometers) of blood vessels that branch and cross, linking the cells of our organs and body parts. From the hard-working heart, to our thickest arteries, to capillaries so thin that they can only be seen through a microscope, the cardiovascular system is our body's lifeline.

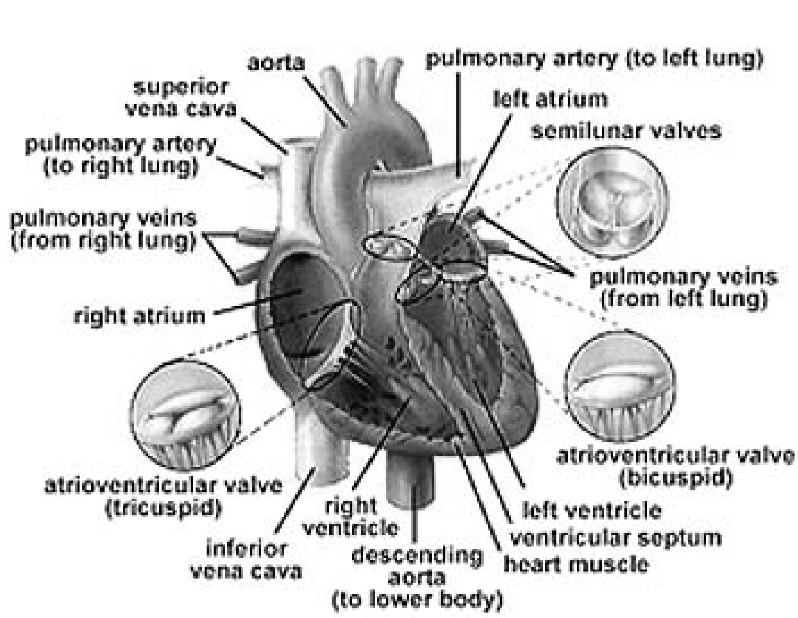


What Is the Cardiovascular System?

The circulatory system is composed of the heart and blood vessels, including arteries, veins, and capillaries. Our bodies actually have two circulatory systems: The **pulmonary** (pronounced: **pul**-muh-ner-ee) **circulation** is a short loop from the heart to the lungs and back again, and the **systemic** (pronounced: sis-**teh**-mik) **circulation** (the system we usually think of as our circulatory system) sends blood from the heart to all the other parts of our bodies and back again.

The heart is the key organ in the circulatory system. As a hollow, muscular pump, its main function is to propel blood throughout the body. It usually beats from 60 to 100 times per minute, but can go much faster when it needs to. It beats about 100,000 times a day, more than 30 million times per year, and about 2.5 billion times in a 70-year lifetime.

The heart gets messages from the body that tell it when to pump more or less blood depending on a person's needs. When we're sleeping, it pumps just enough to provide for the lower amounts of oxygen needed by our bodies at rest. When we're exercising or frightened, the heart pumps faster to get more oxygen to our bodies.



The heart has four chambers that are enclosed by thick, muscular walls. It lies between the lungs and just to the left of the middle of the chest cavity. The bottom part of the heart is divided into two chambers called the **right** and **left ventricles** (pronounced: **ven**-trih-kulz), which pump blood out of the heart. A wall called the **interventricular septum** (pronounced: in-tur-ven-**trih**-kyoo-lur **sep**-tum) divides the ventricles.

The upper part of the heart is made up of the other two chambers of the heart, called the **right** and **left atria** (pronounced: **ay**-tree-uh). The right and left atria receive the blood entering the heart. A wall called the **interatrial septum** (pronounced: in-tur-**ay**-tree-ul **sep**-tum) divides the atria, and they're separated from the ventricles by the **atrioventricular** (pronounced: **ay**-tree-oh-ven-trih-kyoo-lur) **valves**. The **tricuspid valve** separates the right atrium from the right ventricle, and the **mitral** (pronounced: **my**-trul) **valve** separates the left atrium and the left ventricle.

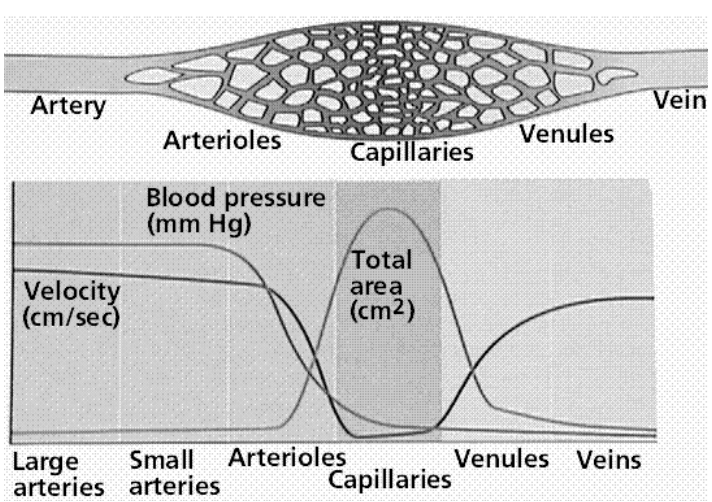
Two other heart valves separate the ventricles and the large blood vessels that carry blood leaving the heart. These valves are called the **pulmonic valve**, which separates the right ventricle from the **pulmonary artery** leading to the lungs, and the **aortic** (pronounced: a-**or**-tik) **valve**, which separates the left ventricle from the **aorta**, the body's largest blood vessel.

Blood vessels carrying blood away from the heart are called **arteries** (pronounced: **ar**-tuh-reez). They are the thickest blood vessels, with muscular walls that contract to keep the blood moving away from the heart and through the body. In the systemic circulation, oxygen-rich blood is pumped from the heart into the aorta. This huge artery curves up and back from the left ventricle, then heads down in front of the spinal column into the abdomen. Two **coronary** (pronounced: **kor**-uh-ner-ee) **arteries** branch off at the beginning of the aorta and divide into a network of smaller arteries that provide oxygen and nourishment to the muscles of the heart.

Unlike the aorta, the body's other main artery, the **pulmonary artery,** carries oxygen-poor blood. From the right ventricle, the pulmonary artery divides into right and left branches, on the way to the lungs where blood picks up oxygen.

Arterial walls have three layers:

- The **endothelium** (pronounced: en-doh-**thee**-lee-um) is on the inside and provides a smooth lining for blood to flow over as it moves through the artery.
- The **media** (pronounced: **me**-dee-uh) is the middle part of the artery, made up of a layer of muscle and elastic tissue.
- The **adventitia** (pronounced: ad-ven-**tih**-shuh) is the tough covering that protects the outside of the artery.



As they get farther from the heart, the arteries branch out into **arterioles** (pronounced: ar-**teer**-ee-olz), which are smaller and less flexible.

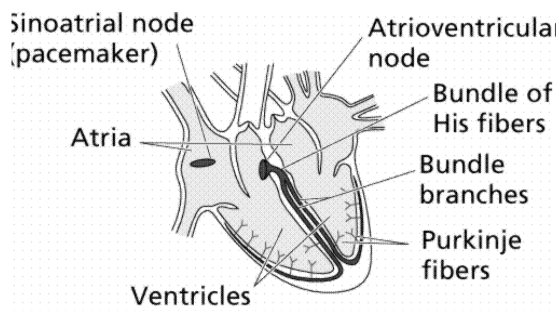
Blood vessels that carry blood back to the heart are called **veins** (pronounced: **vaynz**). They are not as muscular as arteries, but they contain valves that prevent blood from flowing backward. Veins have the same three layers that arteries do, but they are thinner and less flexible. The two largest veins are the **superior** and **inferior vena cavae** (pronounced: **vee**-nuh **kay**-vee). The terms superior and inferior do not mean that one vein is better than the other, but that they are located above (superior) and below (inferior) the heart.

A network of tiny **capillaries** (pronounced: **kah**-puh-ler-eez) connects the arteries and veins. Even though they're tiny, the capillaries are one of the most important parts of the circulatory system because it is through them that nutrients and oxygen are delivered to the cells. In addition, waste products such as carbon dioxide are also removed by the capillaries.

What Do the Heart and Circulatory System Do?

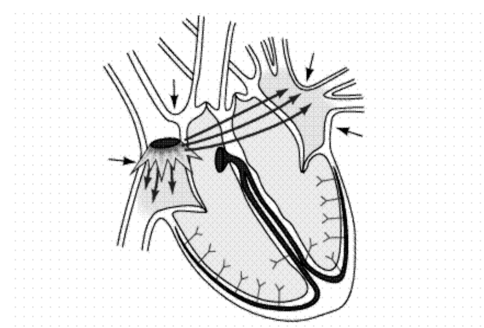
The circulatory system works closely with other systems in our bodies. It supplies oxygen and nutrients to our bodies by working with the respiratory system. At the same time, the circulatory system helps carry waste and carbon dioxide out of the body. Hormones - produced by the endocrine system - are also transported through the blood in our circulatory system. As the body's chemical messengers, hormones transfer information and instructions from one set of cells to another.

Did you ever wonder about the process behind your beating heart? Here's what happens. One complete heartbeat makes up a **cardiac cycle**, which consists of two phases. When the heart beats, the ventricles contract (this is called **systole**, which is pronounced **sis**-tuh-lee), sending blood into the pulmonary and systemic circulation. These are the "lub-dub" sounds you hear when you listen to someone's heart. Then the ventricles relax (this is called **diastole**, which is pronounced dy-**as**-tuh-lee) and fill with blood from the atria.



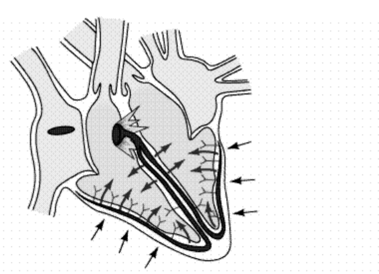
Heart at rest

A unique electrical system in the heart causes it to beat in its regular rhythm. The **sinoatrial** (pronounced: sy-no-**a**-tree-ul) or **SA node**, a small area of tissue in the wall of the right atrium, sends out an electrical signal to start the contracting of the heart muscle.

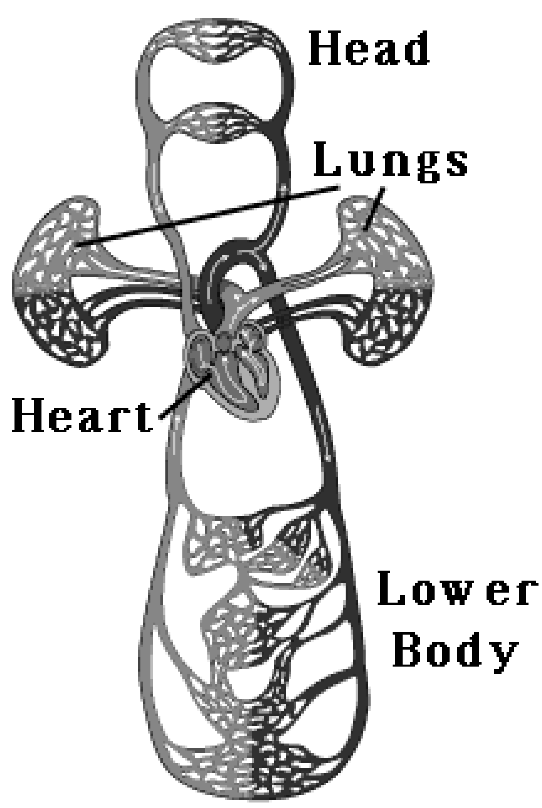

Sinoatrial node fires, action potentials spread through atria which contract

These electrical impulses cause the atria to contract first; they then travel down to the **atrioventricular** or **AV node**, which acts as a kind of relay station.

From here the electrical signal travels through the right and left ventricles, causing them to contract and force blood out into the major arteries.


Atrioventricular node fires, sending impulses along conducting fibers; ventricles contract

In the systemic circulation, blood travels out of the left ventricle, to the aorta, to every organ and tissue in the body, and then back to the right atrium. The arteries, capillaries, and veins of the systemic circulatory system are the channels through which this long journey takes place. Once in the arteries, blood flows to smaller arterioles and then to capillaries. While in the capillaries, the bloodstream delivers oxygen and nutrients to the body's cells and picks up waste materials. Blood then goes back through the capillaries into venules, and then to larger veins until it reaches the vena cavae. Blood from the head and arms returns to the heart through the superior vena cava, and blood from the lower parts of the body returns through the inferior vena cava. Both vena cavae deliver this oxygen-depleted blood into the right atrium. From here the blood exits to fill the right ventricle, ready to be pumped into the pulmonary circulation for more



oxygen.

In the pulmonary circulation, blood low in oxygen but high in carbon dioxide is pumped out the right ventricle into the pulmonary artery, which branches off in two directions. The right branch goes to the right lung, and vice versa. In the lungs, the branches divide further into capillaries. Blood flows more slowly through these tiny vessels, allowing time for gases to be exchanged between the capillary walls and the millions of **alveoli** (pronounced: al-**vee**-uh-lie), the tiny air sacs in the lung. During the process called oxygenation, oxygen is taken up by the bloodstream. Oxygen locks onto a molecule called hemoglobin in the red blood cells. The newly oxygenated blood leaves the lungs through the pulmonary veins and heads back to the heart. It enters the heart in the left atrium, then fills the left ventricle so it can be pumped into the systemic circulation.

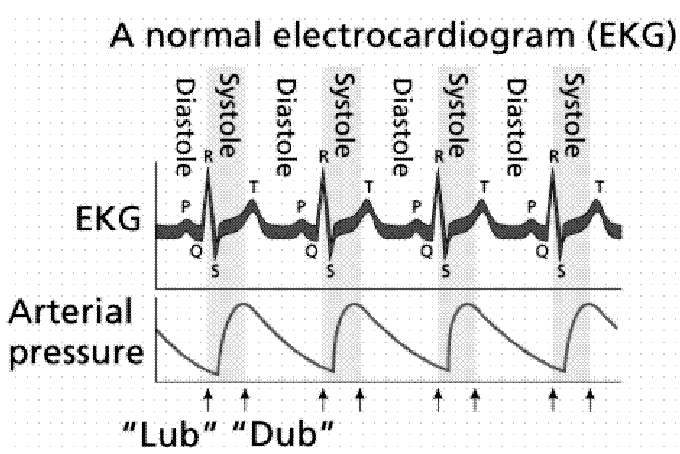
THINGS THAT CAN GO WRONG WITH THE CIRCULATORY SYSTEM

Problems with the cardiovascular system are common - more than 64 million Americans have some type of cardiac problem. But cardiovascular problems don't just affect older people - many heart and circulatory system problems affect teens, too.

Heart and circulatory problems are grouped into two categories: congenital, which means the problems were present at birth, and acquired, which means that the problems developed some time when a person was a kid or teen.

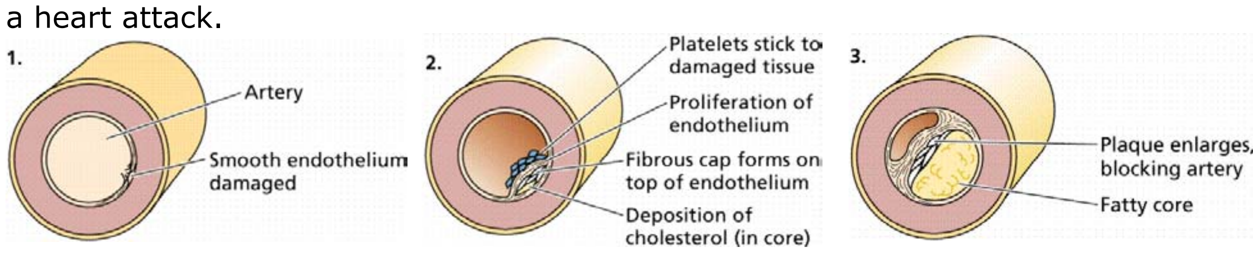
Congenital (pronounced: kun-**jeh**-nuh-tul) **heart defects.** Congenital heart defects are heart problems that babies have at birth. Congenital heart defects occur while a baby is developing in the mother's uterus. Doctors don't always know why congenital heart defects occur - some congenital heart defects are caused by genetic disorders, but most are not. A common sign of a congenital heart defect is a **heart murmur**. A heart murmur is an abnormal sound (like a blowing or whooshing sound) that's heard when listening to the heart. Lots of kids and teens have heart murmurs, which can be caused by congenital heart defects or other heart conditions.

Arrhythmia. Cardiac arrhythmias (pronounced: a-**rith**-mee-uz), which are also called dysrhythmias or rhythm disorders, are problems in the heart's rhythm. Arrhythmias may be caused by a congenital heart defect or a person may develop this condition later. An arrhythmia may cause the heart's rhythm to be irregular, abnormally fast, or abnormally slow. Arrhythmias can happen at any age and may be discovered when a teen has a checkup.



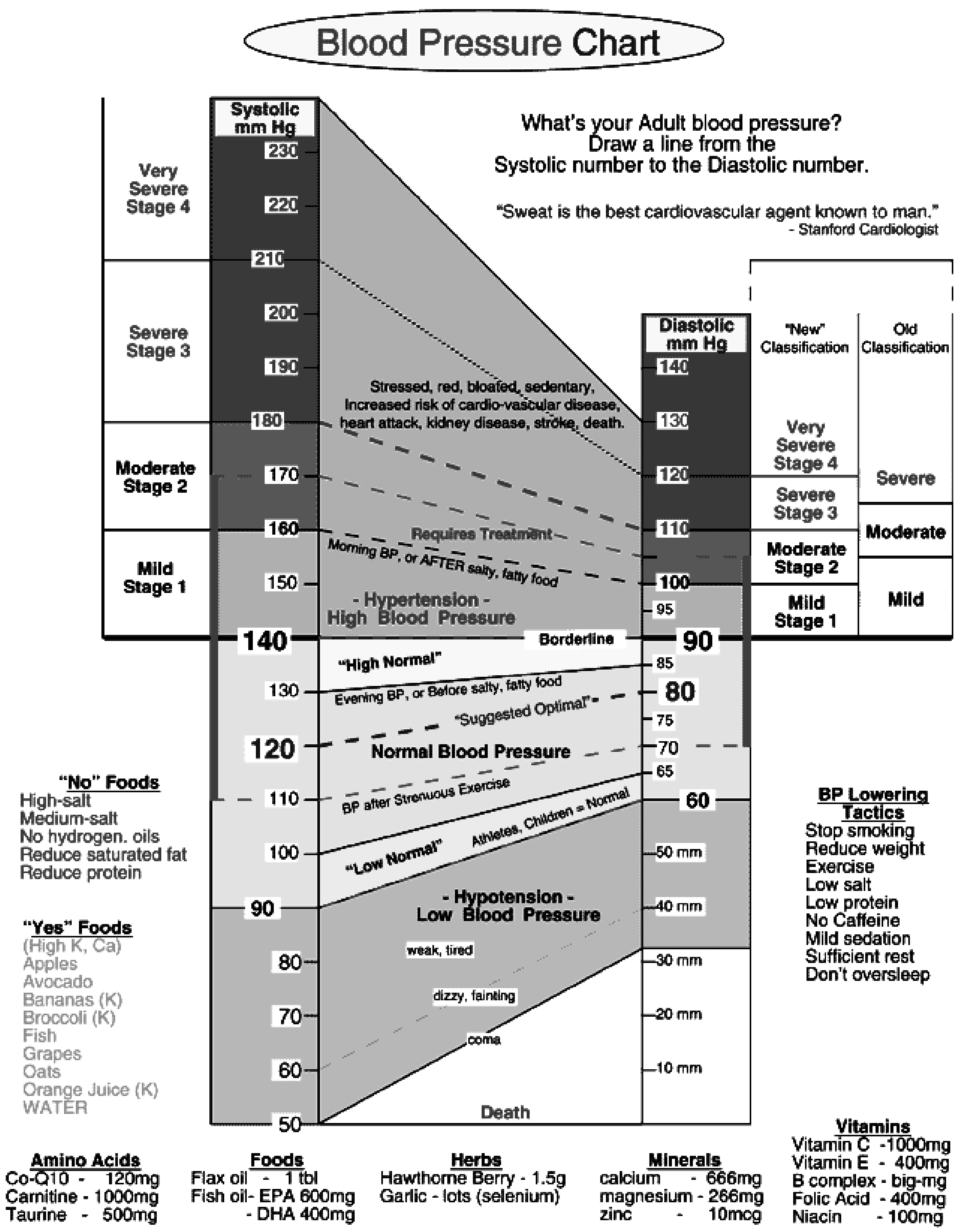
Cardiomyopathy. Cardiomyopathy (pronounced: kar-dee-oh-my-**ah**-puh-thee) is a long-lasting disease that causes the heart muscle (the myocardium) to become weakened. Usually, the disease first affects the lower chambers of the heart, the ventricles, and then progresses and damages the muscle cells and even the tissues surrounding the heart. Some kids and teens with cardiomyopathy may receive heart transplants to treat their condition.

Coronary artery disease. Coronary artery disease is the most common heart disorder in adults, and it's caused by **atherosclerosis** (pronounced: ah-thuh-ro-skluh-**ro**-sis). Deposits of fat, calcium, and dead cells form on the inner walls and clog up the body's arteries (the blood vessels that supply the heart) and get in the way of the smooth flow of blood. A clot of blood may even form, which can lead to a heart attack.



Hyperlipidemia/hypercholesterolemia (high cholesterol). Cholesterol is a waxy substance that is found in the body's cells, in the blood, and in some of the foods we eat. Having too much cholesterol in the blood, also known as hypercholesterolemia (pronounced: high-pur-kuh-les-tuh-ruh-**lee**-me-uh) or hyperlipidemia (pronounced: high-pur-lih-puh-**dee**-me-uh), is a major risk factor for heart disease and can lead to a heart attack. About one out of 10 teens between 12 and 19 years old have high cholesterol levels that put them at increased risk of cardiovascular disease.

Hypertension (high blood pressure). Hypertension (pronounced: high-pur-**ten**-shun) is when a person has blood pressure that's significantly higher than normal. Over time, it can cause damage to the heart and arteries and other body organs. Teens can have high blood pressure, which may be caused by genetic factors, excess body weight, diet, lack of exercise, and diseases such as heart disease or kidney disease.



Rheumatic heart disease. Teens who have had strep throat infection may develop rheumatic (pronounced: roo-**ma**-tik) fever. This type of infection can cause permanent heart problems, mostly in kids and teens between 5 and 15 years of age. People who've had strep throat and received antibiotics right away are unlikely to develop this problem.

So what can you do to halt heart and circulatory problems before they start? Getting plenty of exercise, eating a nutritious diet, maintaining a healthy weight, and seeing your doctor regularly for medical checkups are the best ways to help keep the heart healthy and avoid long-term problems like high blood pressure, high cholesterol, and heart disease.

REVIEW AND FACTS ABUT THE CVS

Heart: The heart is the muscular pump like organ that circulates blood through the body. The muscles of the heart contract periodically and cause the heart to pump blood. The heart contracts about 72 times a minute when an adult person is at rest, but this rate increases to 100 or more during activity or excitement. The total volume of blood in the system is about 5 to 6 litres. The heart pumps approximately 5 litres of blood out every minute.

Blood Vessels: The 3 types of blood vessels are arteries, veins and capillaries and they are all connected to form one continuous closed system.

Arteries are the widest blood vessels having thick and elastic walls; arteries branch out into thinner tubes called arterioles, which again branch into thinner capillaries. Capillaries are tiny blood vessels with walls that are just one cell thick. These walls are permeable to water and CO_2, which are exchanged with tissues surrounding the capillaries. Capillaries ultimately joint to form venules and at last veins return blood to the heart.

Thus, arteries take blood from the heart and supply it to various tissues via the capillaries and veins return blood from the tissue to the heart. For maintaining such a unidirectional flow of blood, large veins have valves in them. The pressure of blood flow opens them in the directional of flow and closes them otherwise.

Arterial blood is rich in oxygen and dissolved food, while venous blood carries CO_2 and waste material. However, pulmonary artery and pulmonary vein form two important exceptions to it. Pulmonary artery supplies lungs CO_2 - rich blood and pulmonary vein collects oxygen - rich blood from lungs and sends it to heart.

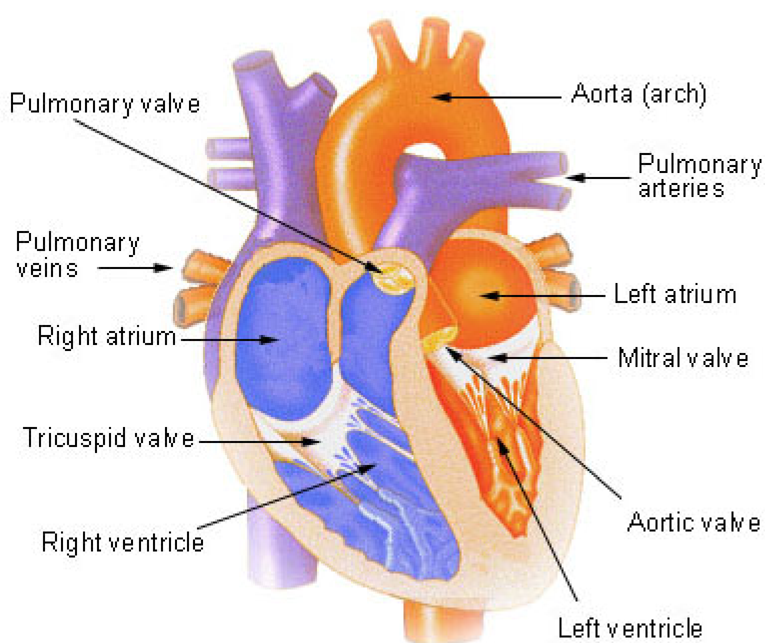
Interesting facts:

- The heart muscles will stop working only when we die.
- Every second, 15 million blood cells are destroyed in the human body.
- Platelets, which form a part of the blood cell component are produced at the rate of 200 billion per day.
- An adult human body contains five to six liters of blood and an infant has about one liter of blood.
- Except the heart and lungs, all the other parts of the body receive their blood supply from the largest artery of the body, the aorta.
- The Pulmonary vein is the only vein that carries oxygenated blood while all the other veins of the body carry de-oxygenated blood.
- Human blood is colorless. It is the hemoglobin; a pigment present in the red blood cells that is responsible for the red color of the blood.
- Heartbeat is nothing but the sound produced by the closure of valves of the heart when the blood is pushed through its chamber.
- A women's heart beat is faster than that of a man's.
- The human heart continues to beat even after it is taken out of the body or cut in to pieces.

- On an average, the human blood circulates through the whole body every 23 seconds.
- On an average an adult's heart pumps about 4,000 gallons of blood each day.
- The left side of human heart is much thicker and stronger than the right side.
- Human blood is a make up of Red Blood Cells carrying oxygen, White Blood Cells that fight disease, Platelets that help the blood to clot and a liquid called plasma.
- Red Blood Cells lasts only for about 4 months before they wear out.
- Red Blood Cells are the only cells in the body that do not have a nucleus.
- There are about 30 - 40 billion white blood cells present in our body to fight against infective and foreign organisms.
- Every day 440 Gallons of blood flow through the kidney.
- Capillaries are so small that it would take ten of them to equal the thickness of a human hair.
- The Human heart beats 30 million times a year.
- In human beings and other multicellular animals the transport of materials takes place by a fluid medium, the blood that circulates throughout the body by circulatory system

THE HEART

The heart is a muscular pump that provides the force necessary to circulate the blood to all the tissues in the body. Its function is vital because, to survive, the tissues need a continuous supply of oxygen and nutrients, and metabolic waste products have to be removed. Deprived of these necessities, cells soon undergo irreversible changes that lead to death. While blood is the transport medium, the heart is the organ that keeps the blood moving through the vessels. The normal adult heart pumps about 5 liters of blood every minute throughout life. If it loses its pumping effectiveness for even a few minutes, the individual's life is jeopardized.



Structure of the Heart: The human heart is a four-chambered muscular organ, shaped and sized roughly like a man's closed fist with two-thirds of the mass to the left of midline. The heart is enclosed in a pericardial sac that is lined with the parietal layers of a serous membrane. The visceral layer of the serous membrane forms the epicardium.

Layers of the Heart Wall: Three layers of tissue form the heart wall. The outer layer of the heart wall is the epicardium, the middle layer is the myocardium, and the inner layer is the endocardium.

Chambers of the Heart: The internal cavity of the heart is divided into four chambers:

- Right atrium
- Right ventricle

- Left atrium
- Left ventricle

The two atria are thin-walled chambers that receive blood from the veins. The two ventricles are thick-walled chambers that forcefully pump blood out of the heart. Differences in thickness of the heart chamber walls are due to variations in the amount of myocardium present, which reflects the amount of force each chamber is required to generate. The right atrium receives deoxygenated blood from systemic veins; the left atrium receives oxygenated blood from the pulmonary veins.

Valves of the Heart : Pumps need a set of valves to keep the fluid flowing in one direction and the heart is no exception. The heart has two types of valves that keep the blood flowing in the correct direction. The valves between the atria and ventricles are called atrioventricular valves (also called cuspid valves), while those at the bases of the large vessels leaving the ventricles are called semilunar valves.

The right atrioventricular valve is the tricuspid valve. The left atrioventricular valve is the bicuspid, or mitral, valve. The valve between the right ventricle and pulmonary trunk is the pulmonary semilunar valve. The valve between the left ventricle and the aorta is the aortic semilunar valve.

When the ventricles contract, atrioventricular valves close to prevent blood from flowing back into the atria. When the ventricles relax, semilunar valves close to prevent blood from flowing back into the ventricles.

Pathway of Blood through the Heart : While it is convenient to describe the flow of blood through the right side of the heart and then through the left side, it is important to realize that both atria contract at the same time and both ventricles contract at the same time. The heart works as two pumps, one on the right and one on the left, working simultaneously. Blood flows from the right atrium to the right ventricle, and then is pumped to the lungs to receive oxygen. From the lungs, the blood flows to the left atrium, then to the left ventricle. From there it is pumped to the systemic circulation.

Blood Supply to the Myocardium : The myocardium of the heart wall is a working muscle that needs a continuous supply of oxygen and nutrients to function with efficiency. For this reason, cardiac muscle has an extensive network of blood vessels to bring oxygen to the contracting cells and to remove waste products.

The right and left coronary arteries, branches of the ascending aorta, supply blood to the walls of the myocardium. After blood passes through the capillaries in the myocardium, it enters a system of cardiac (coronary) veins. Most of the cardiac veins drain into the coronary sinus, which opens into the right atrium.

PHYSIOLOGY OF THE HEART

The work of the heart is to pump blood to the lungs through pulmonary circulation and to the rest of the body through systemic circulation. This is accomplished by systematic contraction and relaxation of the cardiac muscle in the myocardium.

Conduction System : An effective cycle for productive pumping of blood requires that the heart be synchronized accurately. Both atria need to contract simultaneously, followed by contraction of both ventricles. Specialized cardiac muscle cells that make up the conduction system of the heart coordinate contraction of the chambers. The conduction system includes several components. The first part of the conduction system is the sinoatrial node. Without any neural stimulation, the sinoatrial node rhythmically initiates impulses 70 to 80 times per minute. Because it establishes the basic rhythm of the heartbeat, it is called the pacemaker of the heart. Other parts of the conduction system include the atrioventricular node, atrioventricular bundle, bundle branches, and conduction myofibers. All these components coordinate the contraction and relaxation of the heart chambers.

Cardiac Cycle : The cardiac cycle refers to the alternating contraction and relaxation of the myocardium in the walls of the heart chambers, coordinated by the conduction system, during one heartbeat. Systole is the contraction phase of the cardiac cycle, and diastole is the relaxation phase. At a normal heart rate, one cardiac cycle lasts for 0.8 second.

Heart Sounds : The sounds associated with the heartbeat are due to vibrations in the tissues and blood caused by closure of the valves. Abnormal heart sounds are called murmurs.

Heart Rate : The sinoatrial node, acting alone, produces a constant rhythmic heart rate. Regulating factors are reliant on the atrioventricular node to increase or decrease the heart rate to adjust cardiac output to meet the changing needs of the body. Most changes in the heart rate are mediated through the cardiac center in the medulla oblongata of the brain. The center has both sympathetic and parasympathetic components that adjust the heart rate to meet the changing needs of the body.

Peripheral factors such as emotions, ion concentrations, and body temperature may affect heart rate. These are usually mediated through the cardiac center.

BLOOD AND ITS COMPONENTS

Just about everyone knows that we can't live without blood. Without blood, our organs couldn't get the oxygen and nutrients they need to survive, we couldn't keep warm or cool off, we couldn't fight infections, and we couldn't get rid of our own waste products. Without enough blood, we'd weaken and die.

So how exactly does blood do these things? How is it made, and what's in it? How does blood clot? These questions and more are explained in this article about the mysterious, life-sustaining fluid called blood.

What Is Blood and What Does It Do?

Two types of blood vessels carry blood throughout our bodies: The arteries carry oxygenated blood (blood that has received oxygen from the lungs) from the heart to the rest of the body. The blood then travels through the veins back to the heart and lungs, where it receives more oxygen. As the heart beats, you can feel blood traveling through the body at your pulse points - like the neck and the wrist - where large, blood-filled arteries run close to the surface of the skin.

The blood that flows through this network of veins and arteries is called **whole blood**. Whole blood contains three types of blood cells, including:

- red blood cells
- white blood cells
- platelets

These three types of blood cells are mostly manufactured in the bone marrow (the soft tissue inside our bones), especially in the bone marrow of the vertebrae (the bones that make up the spine), ribs, pelvis, skull, and sternum (breastbone). These cells travel through the circulatory system suspended in a yellowish fluid called **plasma** (pronounced: **plaz**-muh). Plasma is 90% water and contains nutrients, proteins, hormones, and waste products. Whole blood is a mixture of blood cells and plasma.

Red blood cells (also called **erythrocytes**, pronounced: ih-**rith**-ruh-sytes) are shaped like slightly indented, flattened disks. Red blood cells contain an iron-rich protein called **hemoglobin** (pronounced: **hee**-muh-glow-bun). Blood gets its bright red color when hemoglobin in red blood cells picks up oxygen in the lungs. As the blood travels through the body, the hemoglobin releases oxygen to the tissues. The body contains more red blood cells than any other type of cell, and each red blood cell has a life span of about 4 months. Each day, the body produces new red blood cells to replace those that die or are lost from the body.

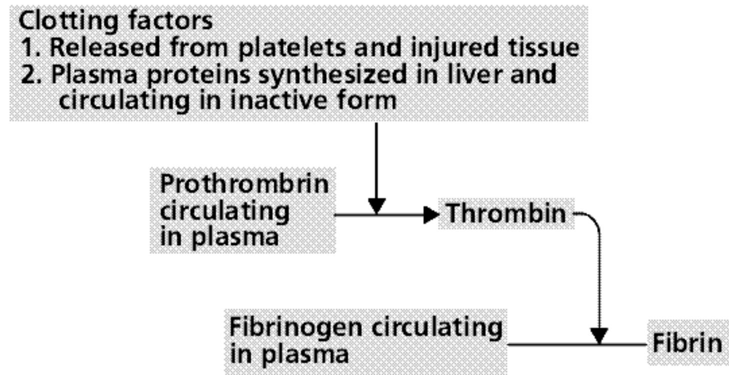
White blood cells (also called **leukocytes**, pronounced: **loo**-kuh-sytes) are a key part of the body's system for defending itself against infection. They can move in and out of the bloodstream to reach affected tissues. The blood contains far fewer white blood cells than red cells, although the body can increase production of white blood cells to fight infection. There are several types of white blood cells, and their life spans vary from a few days to months. New cells are constantly being formed in the bone marrow.

Several different parts of blood are involved in fighting infection. White blood cells called **granulocytes** (pronounced: **gran**-yuh-low-sytes) and **lymphocytes** (pronounced: **lim**-fuh-sytes) travel along the walls of blood vessels. They fight germs such as bacteria and viruses and may also attempt to destroy cells that have become infected or have changed into cancer cells.

Certain types of white blood cells produce antibodies, special proteins that recognize foreign materials and help the body destroy or neutralize them. When a person has an infection, his or her white cell count (the number of cells in a given amount of blood) often is higher than when he or she is well because more white blood cells are being produced or are entering the bloodstream to battle the infection. After the body has been challenged by some infections, lymphocytes "remember" how to make the specific antibodies that will quickly attack the same germ if it enters the body again.

Platelets (also called **thrombocytes**, pronounced: **throm**-buh-sytes) are tiny oval-shaped cells made in the bone marrow. They help in the clotting process. When a blood vessel breaks, platelets gather in the area and help seal off the leak. Platelets survive only about 9 days in the bloodstream and are constantly being replaced by new cells.

Blood also contains important proteins called **clotting factors**, which are critical to the clotting process. Although platelets alone can plug small blood vessel leaks and temporarily stop or slow bleeding, the action of clotting factors is needed to produce a strong, stable clot.



Platelets and clotting factors work together to form solid lumps to seal leaks, wounds, cuts, and scratches and to prevent bleeding inside and on the surfaces of our bodies. The process of clotting is like a puzzle with interlocking parts. When the last part is in place, the clot happens - but if only one piece is missing, the final pieces can't come together.

When large blood vessels are severed (or cut), the body may not be able to repair itself through clotting alone. In these cases, dressings or stitches are used to help control bleeding.

In addition to the cells and clotting factors, blood contains other important substances, such as nutrients from the food that has been processed by the digestive system. Blood also carries hormones released by the endocrine glands and carries them to the body parts that need them.

Blood is essential for good health because the body depends on a steady supply of fuel and oxygen to reach its billions of cells. Even the heart couldn't survive without blood flowing through the vessels that bring nourishment to its muscular walls! Blood also carries carbon dioxide and other waste materials to the lungs, kidneys, and digestive system, from where they are removed from the body.

An interesting thing about blood is that blood cells and some of the special proteins blood contains can be replaced or supplemented by giving a person blood from someone else. This process is called a transfusion. In addition to receiving whole blood transfusions, people can also receive transfusions of a particular component of blood that they need. For example, a person can receive only platelets, red blood cells, or a clotting factor. When a person donates blood, the whole blood can be separated into its different parts and used in this way.

THINGS THAT CAN GO WRONG WITH BLOOD

Most of the time, blood functions without problems, but sometimes, blood disorders or diseases can cause illness in children and teens. Diseases of the blood that commonly affect children can involve any or all of the three types of blood cells (red blood cells, white blood cells, or platelets). Other types of blood diseases affect the proteins and chemicals in the plasma that are responsible for clotting. Some of the diseases and conditions involving the blood include:

Diseases of the Red Blood Cells

The most common condition affecting the red blood cells of children and adolescents is **anemia** (pronounced: uh-**nee**-mee-uh), a lower-than-normal number of red cells in the blood. Anemia is accompanied by a decrease in the amount of hemoglobin present in the blood. The symptoms of anemia - such as pale skin, weakness, a fast heart rate, and poor growth in infants and children - happen because of the blood's reduced capacity for carrying oxygen. The causes of anemia can be grouped into two main categories: those due to inadequate production of red blood cells and those due to unusually rapid red blood cell destruction. In more severe cases of chronic anemia, as well as when a large amount of blood is lost, a child or teen may need a transfusion of red blood cells or whole blood.

- **Anemia resulting from inadequate red blood cell production** There are several conditions that can cause a reduced production of red blood cells, including:
    - **Iron deficiency anemia.** Iron deficiency anemia is the most common type of anemia and affects kids and teens of any age who have a diet low in iron or who've lost a lot of red blood cells (and the iron they contain) through bleeding. Premature babies, infants with poor nutrition, menstruating teenage girls, and those with ongoing blood loss due to illnesses such as inflammatory bowel disease are especially likely to have iron deficiency anemia.
    - **Lead poisoning.** When lead enters the body, most of it goes into red blood cells where it can interfere with the production of hemoglobin. This can result in anemia. Lead poisoning can also affect - and sometimes permanently damage - other body tissues including the brain and nervous system. Although lead poisoning is much less common than it once was in the United States, it still is a problem in many larger cities, especially where young children might ingest paint chips or the dust that comes from lead-containing paints peeling off the walls in older buildings.
    - **Anemia due to chronic disease.** Children with chronic diseases (such as cancer or human immunodeficiency virus infection) often develop anemia as a complication of their illness.
    - **Anemia due to kidney disease.** The kidneys produce erythropoietin, a hormone that stimulates production of red cells in the bone marrow. Kidney disease can interfere with the production of this hormone.
- **Anemia resulting from unusually rapid red blood cell destruction** When red blood cells are destroyed more quickly than normal by disease (this process is called **hemolysis**, pronounced: hih-**mah**-luh-sus), the bone marrow will make up for it by increasing production of new red cells to take their place. But if red blood cells are destroyed faster than they can be replaced, a person will develop anemia. There are several causes of increased red blood cell destruction that can affect teens:
    - **G6PD deficiency.** G6PD is an enzyme that helps to protect red blood cells from the destructive effects of certain chemicals found in foods and medications. When the enzyme is deficient, these chemicals can cause red cells to hemolyze, or burst. G6PD deficiency is a common hereditary disease among people of African, Mediterranean, and Southeast Asian descent.
    - **Hereditary spherocytosis** (pronounced: sfeer-o-sye-**toe**-sus) is an inherited condition in which red blood cells are misshapen (like tiny spheres, instead of disks) and especially fragile because of a genetic problem with a protein in the structure of the red blood cell. This fragility causes the cells to be easily destroyed.
    - **Autoimmune hemolytic anemia.** Sometimes - because of disease or for no known reason - the body's immune system mistakenly attacks and destroys red blood cells.
    - **Sickle cell anemia**, most common in people of African descent, is a hereditary disease that results in the production of abnormal hemoglobin. The red blood cells become sickle shaped, they cannot carry oxygen adequately, and they are easily destroyed. The sickle-shaped blood cells also tend to abnormally stick together, causing obstruction of blood vessels. This blockage in the blood vessels can seriously damage organs and cause bouts of severe pain.

Diseases of the White Blood Cells

- **Neutropenia** (pronounced: noo-truh-**pee**-nee-uh) occurs when there aren't enough of a certain type of white blood cell to protect the body against bacterial infections. People who take certain chemotherapy drugs to treat cancer may develop neutropenia.

- **Human immunodeficiency virus (HIV)** is a virus that attacks certain types of white blood cells (lymphocytes) that work to fight infection. Infection with the virus can result in AIDS (acquired immunodeficiency syndrome), leaving the body prone to infections and certain other diseases. Newborns can become infected with the virus from their infected mothers while in the uterus, during birth, or from breastfeeding, although HIV infection of the fetus and newborn is usually preventable with proper medical treatment of the mother during pregnancy and delivery. Teens and adults can get the disease from sexual intercourse with an infected person or from sharing contaminated needles used for injecting drugs or tattoo ink.
- **Leukemias** (pronounced: loo-**kee**-mee-uhz) are cancers of the cells that produce white blood cells. These cancers include acute myeloid leukemia (AML), chronic myeloid leukemia (CML), acute lymphocytic leukemia (ALL), and chronic lymphocytic leukemia (CLL). The most common types of leukemia affecting kids are ALL and AML. In the past 25 years, scientists have made great advances in treating several types of childhood leukemia, most notably certain types of ALL.

Diseases of Platelets

- **Thrombocytopenia** (pronounced: throm-buh-syte-uh-**pee**-nee-uh), or a lower than normal number of platelets, is usually diagnosed because a person has abnormal bruising or bleeding. Thrombocytopenia can happen when a person takes certain drugs or develops infections or leukemia or when the body uses up too many platelets. Idiopathic thrombocytopenic purpura (ITP) is a condition, which can occur in children, in which the person's immune system attacks and destroys his or her own platelets.

Diseases of the Clotting System

The body's clotting system depends on platelets as well as many clotting factors and other blood components. If a hereditary defect affects any of these components, a child can have a bleeding disorder. Some of the most common bleeding disorders are:

- **Hemophilia** (pronounced: hee-muh-**fil**-ee-uh), an inherited condition that almost exclusively affects boys, involves a lack of particular clotting factors in the blood. People with severe hemophilia are at risk for excessive bleeding and bruising after dental work, surgery, and trauma. They may experience episodes of life-threatening internal bleeding, even if they haven't been injured.
- **Von Willebrand disease**, the most common hereditary bleeding disorder, also involves a clotting-factor deficiency. It affects both males and females.

Other causes of clotting problems include chronic liver disease (clotting factors are produced in the liver) and vitamin K deficiency (the vitamin is necessary for the production of certain clotting factors).

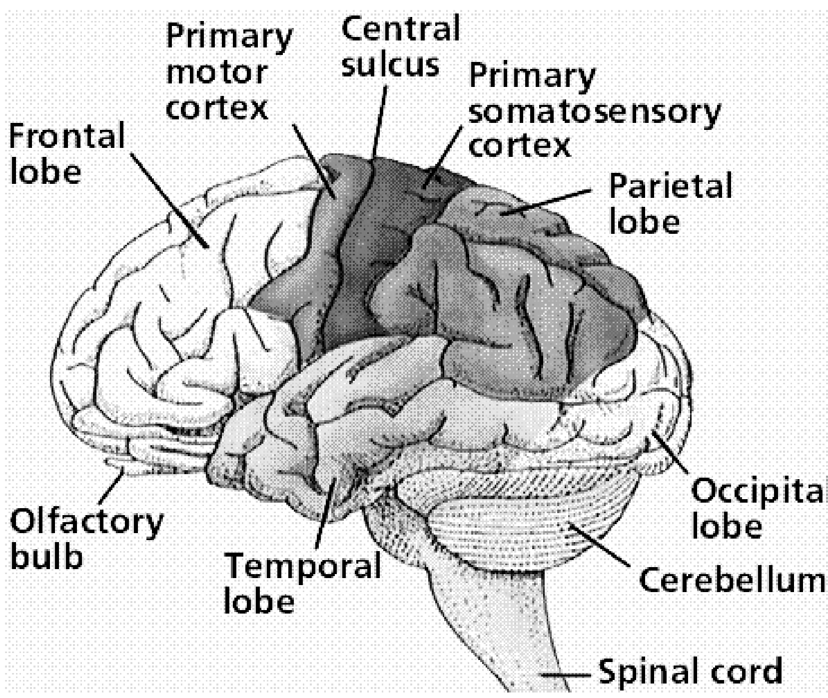
BRAIN AND NERVOUS SYSTEM

You're in the middle of a meeting at work, but your mind keeps drifting to the parent-teacher conference you have tonight ... and the car you have to pick up at the shop on the way home ... and how you wish you hadn't skipped lunch because the rumbling in your stomach is driving you nuts. You vaguely hear your boss ask you a question and for just a moment your heart races and you tap your pen nervously, trying to regain your focus. Then, suddenly, you're back in the moment, answering confidently and hoping nobody noticed your brief "departure."

With things so hectic these days, it may seem as if your brain is always on the go. And it is. The brain not only controls what you think and feel, how you learn and remember, and the way you move and talk, but also many things you're less aware of - such as the beating of your heart, the digestion of your food, and yes, even the amount of stress you feel. Like you, your brain is quite the juggler.

Anatomy of the Nervous System

If you think of the brain as a central computer that controls all the functions of your body, then the nervous system is like a network that relays messages back and forth from it to different parts of the body. It does this via the spinal cord, which runs from the brain down through the back and contains threadlike nerves that branch out to every organ and body part.



When a message comes into the brain from anywhere in the body, the brain tells the body how to react. For example, if you accidentally touch a hot stove, the nerves in your skin shoot a message of pain to your brain. The brain then sends a message back telling the muscles in your hand to pull away. Luckily, this neurological relay race takes a lot less time than it just took to read about it!

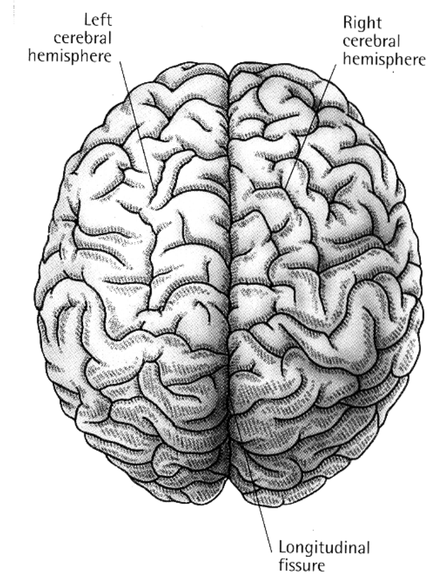
Considering everything it does, the human brain is incredibly compact, weighing just 3 pounds. Its many folds and grooves, though, provide it with the additional surface area necessary for storing all of the body's important information.

The spinal cord, on the other hand, is a long bundle of nerve tissue about 18 inches long and 3/4 inch thick. It extends from the lower part of the brain down through spine. Along the way, various nerves branch out to the entire body. These are called the peripheral nervous system.

Both the brain and the spinal cord are protected by bone: the brain by the bones of the skull, and the spinal cord by a set of ring-shaped bones called vertebrae. They're both cushioned by layers of membranes called meninges as well as a special fluid called cerebrospinal fluid. This fluid helps protect the nerve tissue, keep it healthy, and remove waste products.

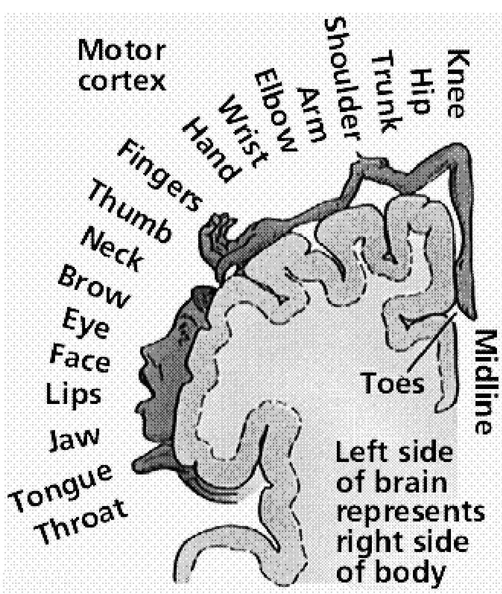
The brain is made up of three main sections: the forebrain, the midbrain, and the hindbrain.

The Forebrain: The forebrain is the largest and most complex part of the brain. It consists of the cerebrum - the area with all the folds and grooves typically seen in pictures of the brain - as well as some other structures beneath it.



The cerebrum contains the information that essentially makes us who we are: our intelligence, memory, personality, emotion, speech, and ability to feel and move. Specific areas of the cerebrum are in charge of processing these different types of information. These are called lobes, and there are four of them: the frontal, parietal, temporal, and occipital.

The cerebrum has right and left halves, called hemispheres, which are connected in the middle by a band of nerve fibers (the corpus collosum) that enables the two sides to communicate. Though these halves may look like mirror images of each other, many scientists believe they have different functions. The left side is considered the logical, analytical, objective side. The right side is thought to be more intuitive, creative, and subjective. So when you're balancing the checkbook, you're using the left side; when you're listening to music, you're using the right side. It's believed that some people are more "right-brained" or "left-brained" while others are more "whole-brained," meaning they use both halves of their brain to the same degree.

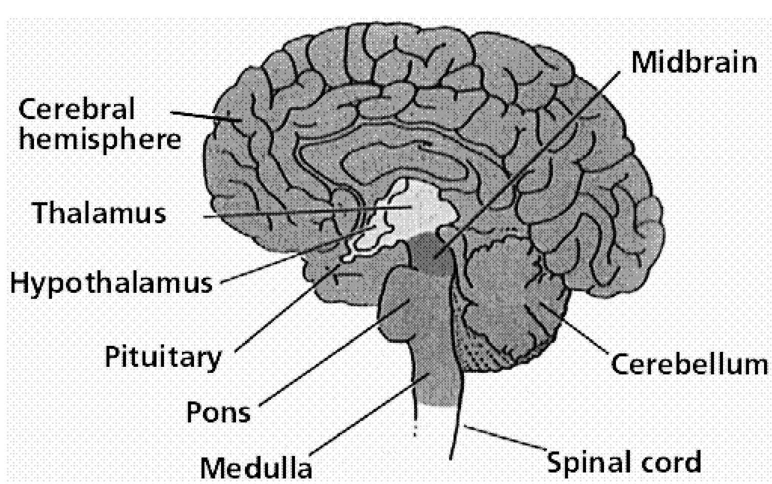


The outer layer of the cerebrum is called the cortex (also known as "gray matter"). Information collected by the five senses comes into the brain from the spinal cord to the cortex. This information is then directed to other parts of the nervous system for further processing. For example, when you touch the hot stove, not only does a message go out to move your hand but one also goes to another part of the brain to help you remember not to do that again.

In the inner part of the forebrain sits the thalamus, hypothalamus, and pituitary gland. The thalamus carries messages from the sensory organs like the eyes, ears, nose, and fingers to the cortex. The hypothalamus controls the pulse, thirst, appetite, sleep patterns, and other processes in our bodies that happen automatically. It also controls the pituitary gland, which makes the hormones that control our growth, metabolism, digestion, sexual maturity, and response to stress.

The Midbrain:

The midbrain, located underneath the middle of the forebrain, acts as a master coordinator for all the messages going in and out of the brain to the spinal cord.



The Hindbrain:

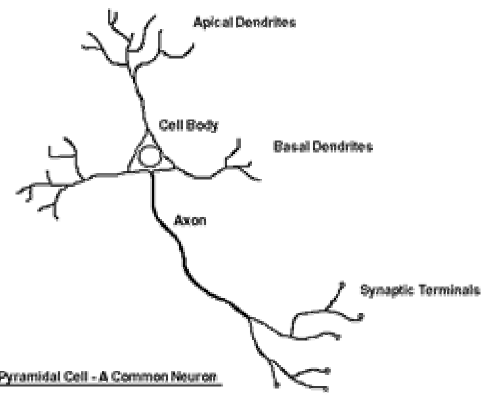
The hindbrain sits underneath the back end of the cerebrum, and it consists of the cerebellum, pons and medulla.

The cerebellum - also called the "little brain" because it looks like a small version of the cerebrum - is responsible for balance, movement, and coordination.

The pons and the medulla, along with the midbrain, are often called the brainstem. The brainstem takes in, sends out, and coordinates all of the brain's messages. It is also controls many of the body's automatic functions, like breathing, heart rate, blood pressure, swallowing, digestion, and blinking.

How the Nervous System Works

The basic functioning of the nervous system depends a lot on tiny cells called neurons. The brain has billions of them, and they have many specialized jobs. For example, sensory neurons take information from the eyes, ears, nose, tongue, and skin to the brain. Motor neurons carry messages away from the brain and back to the rest of the body. All neurons, however, relay information to each other through a complex electrochemical process, making connections that affect the way we think, learn, move, and behave.



The Pyramidal Cell - A Common Neuron

Intelligence, learning, and memory. At birth, your nervous system contains all the neurons you will ever have, but many of them are not connected to each other. As you grow and learn, messages travel from one neuron to another over and over, creating connections, or pathways, in the brain. It's why driving seemed to take so much concentration when you first learned but now is second nature: The pathway became established.

In young children, the brain is highly adaptable; in fact, when one part of a young child's brain is injured, another part can often learn to take over some of the lost function. But as we age, the brain has to work harder to make new neural pathways, making it more difficult to master new tasks or change established behavior patterns. That's why many scientists believe it's important to keep challenging your brain to learn new things and make new connections - it helps keeps the brain active over the course of a lifetime. Memory is another complex function of the brain. The things we've done, learned, and seen are first processed in the cortex, and then, if we sense that this information is important enough to remember permanently, it's passed inward to other regions of the brain (such as the hippocampus and amygdala) for long-term storage and retrieval. As these messages travel through the brain, they too create pathways that serve as the basis of our memory.

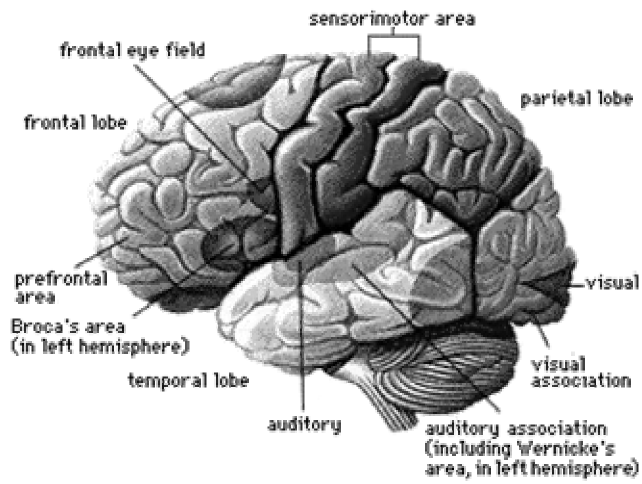
Movement. Different parts of the cerebrum are responsible for moving different body parts. The left side of the brain controls the movements of the right side of the body, and the right side of the brain controls the movements of the left side of the body. When you press the accelerator with your right foot, for example, it's the left side of your brain that sends the message allowing you to do it.

Basic body functions. A part of the peripheral nervous system called the autonomic nervous system is responsible for controlling many of the body processes we almost never need to think about, like breathing, digestion, sweating, and shivering. The autonomic nervous system has two parts: the sympathetic and the parasympathetic nervous systems.

The sympathetic nervous system prepares the body for sudden stress, like if you see a robbery taking place. When something frightening happens, the sympathetic nervous system makes the heart beat faster so that it sends blood more quickly to the different body parts that might need it. It also causes the adrenal glands at the top of the kidneys to release adrenaline, a hormone that helps give extra power to the muscles for a quick getaway. This process is known as the body's "fight or flight" response.

The parasympathetic nervous system does the exact opposite: It prepares the body for rest. It also helps the digestive tract move along so our bodies can efficiently take in nutrients from the food we eat.

The senses. Your spouse may be a sight for sore eyes at the end of a long day - but without the brain, you wouldn't even recognize him or her. Pepperoni pizza sure is delicious - but without the brain, your taste buds wouldn't be able to tell if you were eating pizza or the box it came in. None of your senses would be useful without the processing that occurs in the brain.



- **Sight.** Sight probably tells us more about the world than any other sense. Light entering the eye forms an upside-down image on the retina. The retina transforms the light into nerve signals for the brain. The brain then turns the image right-side up and tells us what we are seeing.
- **Hearing.** Every sound we hear is the result of sound waves entering our ears and causing our eardrums to vibrate. These vibrations are then transferred along the tiny bones of the middle ear and converted into nerve signals. The cortex then processes these signals, telling us what we are hearing.
- **Taste.** The tongue contains small groups of sensory cells called taste buds that react to chemicals in foods. Taste buds react to sweet, sour, salty, and bitter. Messages are sent from the taste buds to the areas in the cortex responsible for processing taste.
- **Smell.** Olfactory cells in the mucous membranes lining each nostril react to chemicals we breathe in and send messages along specific nerves to the brain - which, according to experts, can distinguish between more than 10,000 different smells. With that kind of sensitivity, it's no wonder research suggests that smells are very closely linked to our memories.
- **Touch.** The skin contains more than 4 million sensory receptors - mostly concentrated in the fingers, tongue, and lips - that gather information related to touch, pressure, temperature, and pain and send it to the brain for processing and reaction.

THINGS THAT CAN GO WRONG WITH THE BRAIN

Because the brain controls just about everything, when something goes wrong with it, it's often serious and can affect many different parts of the body. Inherited diseases, brain disorders associated with mental illness, and head injuries can all affect the way the brain works and upset the daily activities of the rest of the body.

Problems that can affect the brain include:

Brain tumors. A tumor is a swelling caused by overgrown tissue. A tumor in the brain may grow slowly and produce few symptoms until it becomes large, or it can grow and spread rapidly, causing severe and quickly worsening symptoms. Brain tumors in children can be benign or malignant. Benign tumors usually grow in one place and may be curable through surgery if they're located in a place where they can be removed without damaging the normal tissue near the tumor. A malignant tumor is cancerous and more likely to grow rapidly and spread.

Cerebral palsy. Cerebral palsy is the result of a developmental defect or damage to the brain before or during birth. It affects the motor areas of the brain. A person with cerebral palsy may have average intelligence or can have severe developmental delays or mental retardation. Cerebral palsy can affect body movement in many different ways. In mild cases of cerebral palsy, there may be minor muscle weakness of the arms and legs. In other cases, there may be more severe motor impairment - a child may have trouble talking and performing basic movements like walking.

Epilepsy. This condition is made up of a wide variety of seizure disorders. Partial seizures involve specific areas of the brain, and symptoms vary depending on the location of the seizure activity. Other seizures, called generalized seizures, involve a larger portion of the brain and usually cause uncontrolled movements of the entire body and loss of consciousness when they occur. Although the specific cause is unknown in many cases, epilepsy can be related to brain injury, tumors, or infections. The tendency to develop epilepsy may be inherited in families.

Headaches. Of the many different types of headaches, the most frequently occurring include tension headache (the most common type), caused by muscle tension in the head, neck, and shoulders; migraine, an intense, recurring headache with an unclear cause; and cluster headache, considered by some to be a form of migraine. Migraines occur with or without warning and may last for several hours or days. There seems to be an inherited predisposition to migraines as well as certain triggers that can lead to them. People with migraines may experience dizziness, numbness, sensitivity to light, and nausea, and may see flashing zigzag lines before their eyes.

Meningitis and encephalitis. These are infections of the brain and spinal cord that are usually caused by bacteria or viruses. Meningitis is an inflammation of the coverings of the brain and spinal cord, and encephalitis is an inflammation of the brain tissue. Both conditions may result in permanent injury to the brain.

Mental illness. Mental illnesses are psychological and behavioral in nature and involve a wide range of problems in thought and function. Certain mental illnesses are now known to be linked to structural abnormalities or chemical dysfunction of the brain. Some mental illnesses are inherited, but often the cause is unknown. Injuries to the brain and chronic drug or alcohol abuse also can trigger some mental illnesses. Signs of chronic mental illnesses such as bipolar disorder or schizophrenia may first show up in childhood. Mental illnesses that can be seen in younger people include depression, eating disorders such as bulimia or anorexia nervosa, obsessive-compulsive disorder (OCD), and phobias.

Head Injuries. Head injuries fit into two categories: external (usually scalp) injuries and internal head injuries. Internal injuries may involve the skull, the blood vessels within the skull, or the brain. Fortunately, most childhood falls or blows to the head result in injury to the scalp only, which is usually more frightening than threatening. An internal head injury could have more serious implications because the skull serves as the protective helmet for the delicate brain.

Concussions are also a type of internal head injury. A concussion is the temporary loss of normal brain function as a result of an injury. Repeated concussions can result in permanent injury to the brain. One of the most common reasons kids get concussions is through sports, so it's important to make sure they wear appropriate protective gear and don't continue to play if they've had a head injury.

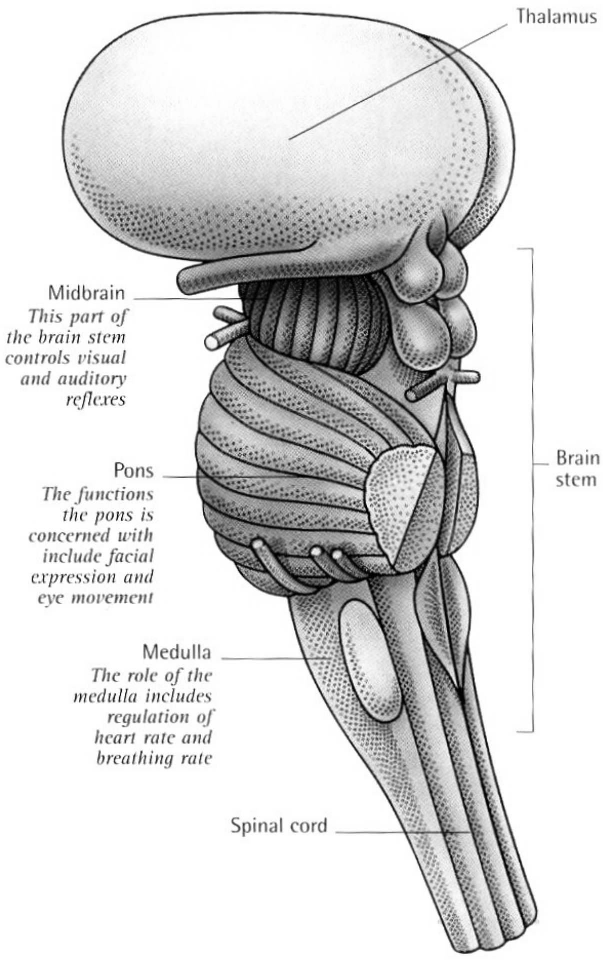
REVIEW AND FACTS ABOUT THE NERVOUS SYSTEM

The Central nervous system consists of the brain, the spinal cord, and the body's nerve network. This complex system is based on one kind of cell the neurons. The brain, the mass of tissue inside the head, has the greatest number of these cells, most of which are in its outer part, the cerebrum. Below the cerebrum is the cerebellum and the brain stem, which is linked to the spinal cord.

The Brain: The brain has been compared to a giant telephone exchange or to a computer. It functions as both, handling incoming and out going calls, and making decisions, as diverse as whether to laugh or cry and whether the temperature of the body should be higher or lower, on the basis of information fed into it.

Cerebrum: The brain's most obvious external features are two soft hemispheres, which make up the cerebrum. These hemispheres make up 70% of the whole brain and nervous system. They are "mirror images" of each other, and each is chiefly concerned with the movements and sensations of only one side of the body. Sensations on the right side of the body and the control of the muscles on that side are functions of the left hemisphere, and vice versa. It consists of 2 layers: (1) outer cortex or grey matter - which is the decision maker of the brain, (2) Inner layer of white matter - made up of nerve fibers.

Cerebellum: The cerebellum functions below the level of consciousness. It is concerned with balance, and is the center for the co-ordination of complex muscular movements



Brain Stem: Links the spinal cord to the brain. They lie below the cerebral hemispheres.

The Spinal Cord: The spinal cord is the body's main nerve trunk-a cylinder of nerve tissue 18 inches long about as thick as a man's little finger. It runs down the back from the medulla oblongata, at the base of the brain. It is enclosed in a set of 3 membranes, similar to those surrounding the brain. Between the layers of membranes, Cerebro-spinal fluid acts as a cushion, to protect the cord from damage.

Nerve Fibres: The spinal cord is a column of nervous tissue, which is spread throughout the body; they carry impulses to and from the brain. Nerve fibres from the brain and spinal cord are bundled together to form 12 pairs of cranial nerves, connected to the brain and 31 pairs of spinal nerves

Spinal Nerves:

CERVICAL NERVES - (8 pairs) serve mainly the arms.

THORACIC NERVES - (12 pairs) lead to the sternum, internal organs and muscles of the chest.

LUMBAR NERVES - (5 pairs) serve the abdominal wall and legs.

SACRAL & COCCYGEAL NERVES - (6 pairs) lead mainly to the legs.

Cranial Nerves: The brain has links with the sense organs and the muscles of the head by means of 12 pairs of cranial nerves

1) OLFACTORY: - sense of smell

2) OPTIC: - sense of sight balance

3) OCULOMOTOR: - Focusing, regulating the size of the pupil, balance

4) TROCHLEAR: - movement of the eyeball.

5) TRIGEMINAL: - Chewing, sensation from the face

6) ABDUCENT: - movement of eye, sense of taste

7) FACIAL: - movements of facial expression

8) VESTIBULOCOCHLEAR: - maintenance of balance, sense of hearing

9) GLOSSOPHARYNGEAL: - secretion of saliva, sense of taste, movement of pharynx

10) VAGUS: - movement and secretion

11) ACCESSORY: - movement of the head, shoulders, pharynx and larynx

12) HYPOGLOSSAL: - movement of tongue.

Autonomic Nervous System: The autonomic system controls glands, such as the salivary glands, and the internal organs-the bladder, heart, intestines, liver, lungs and sexual organs. Nearly all the actions of the autonomic system are outside voluntary control e.g. you cannot normally "will" your heart to beat faster; but if you are given a fight, your pulse involuntarily speeds up. The autonomic division of the nervous system consists of two opposing parts, the sympathetic and the parasympathetic which operate below the level of consciousness

The sympathetic nerves: - Through the sympathetic nerves, the brain mobilizes the body for action to meet possible danger.

1) IRIS- Changes size, when someone is frightened or angry, the brain stimulates the sympathetic nerves to their part of the eye, causing the pupils to open wide.

2) SALIVARY GLANDS- produces less saliva, so that the mouth goes dry.

3) LUNGS & WINDPIPE- are affected under stress; breathing becomes faster, so that the body gets more oxygen.

4) HEART- pumps faster, during times of fear & anger. Normally you are unaware of the beating of the heart, but its increased activity in times of excitement raises the blood pressure, pumping more blood to supply energy for muscles.

5) ADRENAL GLANDS- at the top of the kidneys secrete the hormone adrenaline, which prepares the body to fight or run away

6) LIVER-releases glucose under emotional stress, providing extra energy for muscles.

7) STOMACH & INTESTINES- have their blood diverted to the heart, CNS and muscles, so that they can operate under stress. The wave like movements of the intestinal walls stop, and the various sphincters close. ·

Parasympathetic Nerves: - are concerned with restoring the body to peaceful activity after an emergency

Heart - slows down & the blood pressure falls after the danger is over.

Bladder - can be contracted and it's sphincter may open, causing urination.

Interesting facts:

- A newborn baby's brain grows almost 3 times during its first year.
- The left side of human brain controls the right side of the body and the right side of the brain controls the left side of the body.
- A New born baby loses about half of their nerve cells before they are born.
- As we get older, the brain loses almost one gram per year.
- There are about 13, 500, 00 neurons in the human spinal cord.
- The total surface area of the human brain is about 25, 000 square cm.
- The base of the spinal cord has a cluster of nerves, which are very sensitive.
- An average adult male brain weighs about 1375 grams.
- An average adult female brain is about 1275 grams.
- Only four percent of the brain's cells work while the remaining cells are kept in reserve.
- The Brain utilizes 20 % of our body's energy i.e., it uses 20% of one's blood and oxygen and makes up only 2 % of our body weight.
- The Human brain stops growing by18 years of age.

- The human brain is very soft like butter.
- Sixty percent of the human body's nerve ends in the forehead and the hands.
- The brain continues to send out electric wave signals until approximately 37 hours after death
- It is estimated that there are over 1, 000,000,000,000,000 connections in the human brain.
- Human brain constitutes 60 % of white matter and 40 % of grey matter.
- The average length of the human brain is about 167 mm and its average height is 93mm.
- On an average, 100, 000 to 1000, 000 chemical reactions take place in our brain.
- The Nervous system transmits messages to the brain at the speed of 180 miles
- The spinal cord, which controls over 10 billion nerve cells, is less than two feet in length and its diameter is same as that of the index finger.
- Reading aloud to children helps to stimulate brain development.
- The right side of the human brain is responsible for self-recognition.
- Men listen with the left side of the brain and women use both sides of the brain.

ENDOCRINE SYSTEM

Ever dozed through chemistry class and wondered what chemistry had to do with you? A lot! Your body produces its own chemicals and uses them to control certain functions, and the main system that coordinates these chemicals is called the endocrine system**.**

Although we rarely think about the endocrine system, it influences almost every cell, organ, and function of our bodies. The endocrine system is instrumental in regulating mood, growth and development, tissue function, metabolism, and sexual function and reproductive processes.

In general, the endocrine system is in charge of body processes that happen slowly, such as cell growth. Faster processes like breathing and body movement are monitored by the nervous system. But even though the nervous system and endocrine system are separate systems, they often work together to help the body function properly.

What Is the Endocrine System?

The foundations of the endocrine system are the hormones and glands. As the body's chemical messengers, **hormones** (pronounced: **hor**-moanz) transfer information and instructions from one set of cells to another. Many different hormones move through the bloodstream, but each type of hormone is designed to affect only certain cells.

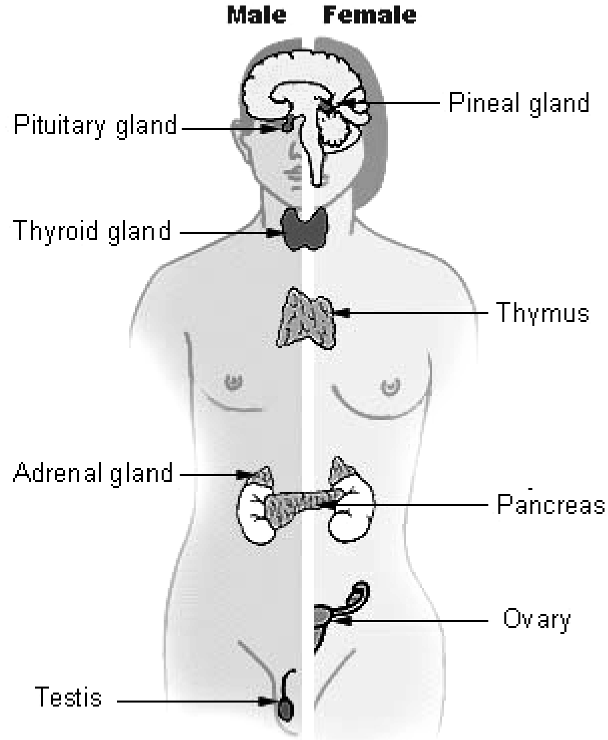
A **gland** is a group of cells that produces and secretes, or gives off, chemicals. A gland selects and removes materials from the blood, processes them, and secretes the finished chemical product for use somewhere in the body.

Some types of glands release their secretions in specific areas. For instance, **exocrine** (pronounced: **ek**-suh-krin) **glands**, such as the sweat and salivary glands, release secretions in the skin or inside the mouth. **Endocrine glands**, on the other hand, release more than 20 major hormones directly into the bloodstream where they can be transported to cells in other parts of the body.

The major glands that make up the human endocrine system include the:

- hypothalamus
- pituitary gland
- thyroid
- parathyroids
- adrenal glands
- pineal body
- reproductive glands
    - ovaries
    - testes

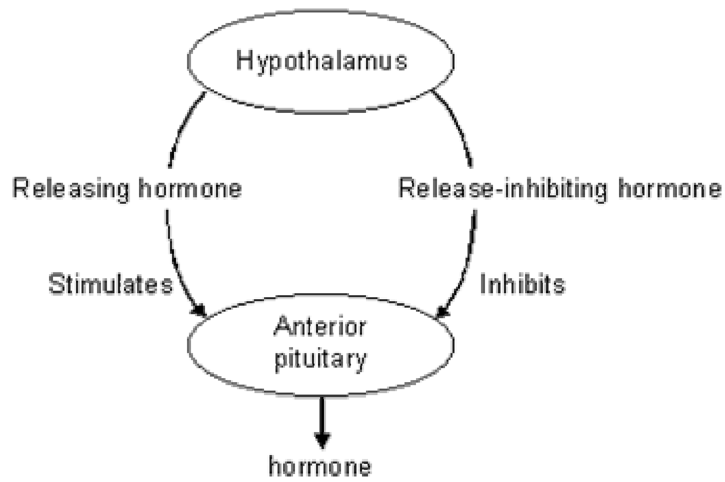
Major Endocrine Glands



The **hypothalamus** (pronounced: hi-po-**tha**-luh-mus), a collection of specialized cells that is located in the lower central part of the brain, is the main link between the endocrine and nervous systems. Nerve cells in the hypothalamus control the pituitary gland by producing chemicals that either stimulate or suppress hormone secretions from the pituitary.

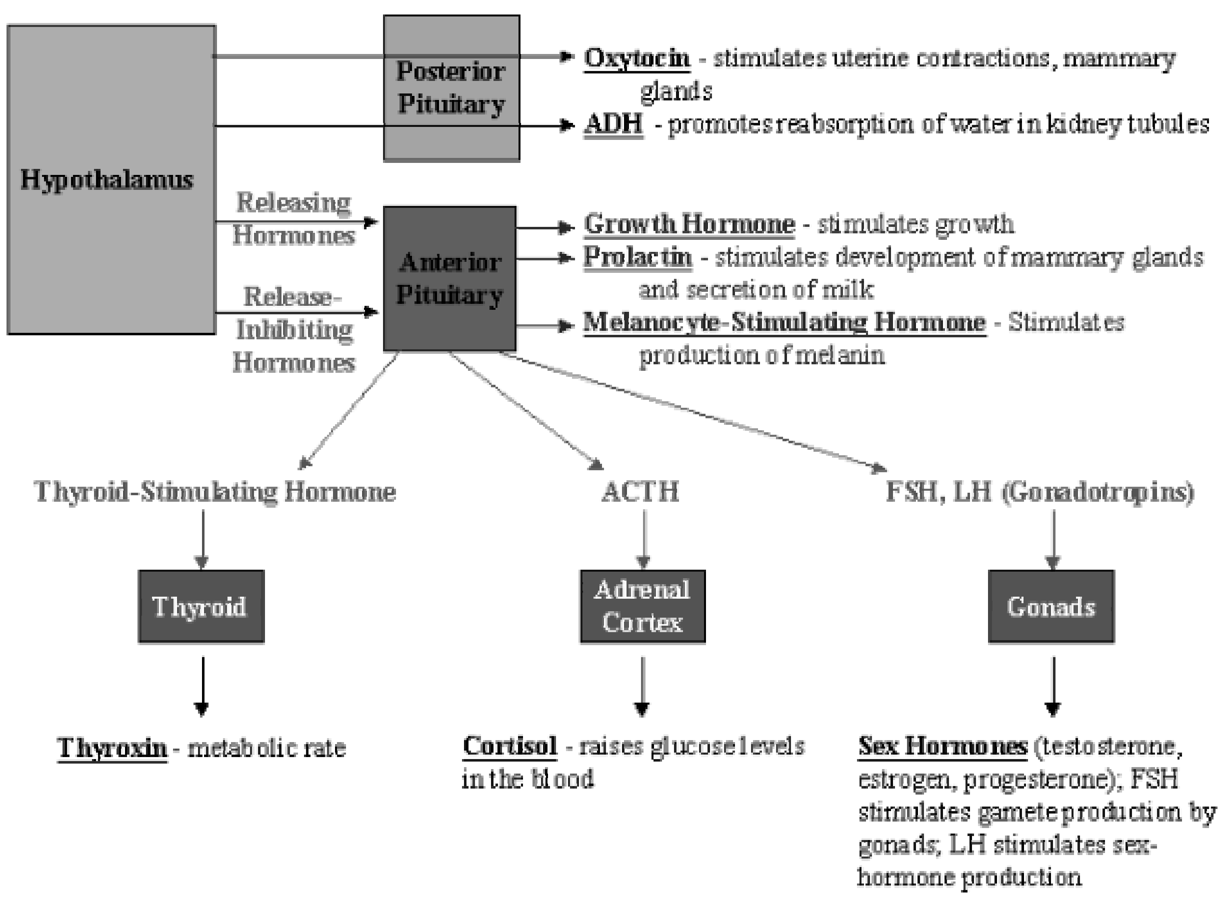
Although it is no bigger than a pea, the **pituitary** (pronounced: puh-**too**-uh-ter-ee) **gland**, located at the base of the brain just beneath the hypothalamus, is considered the most important part of the endocrine system.

It's often called the "master gland" because it makes hormones that control several other endocrine glands. The production and secretion of pituitary hormones can be influenced by factors such as emotions and changes in the seasons. To accomplish this, the hypothalamus provides information sensed by the brain (such as environmental temperature, light exposure patterns, and feelings) to the pituitary.



The tiny pituitary is divided into two parts: the anterior lobe and the posterior lobe. The **anterior lobe** regulates the activity of the thyroid, adrenals, and reproductive glands. The anterior lobe produces hormones such as:

- **growth hormone**, which stimulates the growth of bone and other body tissues and plays a role in the body's handling of nutrients and minerals
- **prolactin** (pronounced: pro-**lak**-tin), which activates milk production in women who are breastfeeding
- **thyrotropin** (pronounced: thy-ruh-**tro**-pin), which stimulates the thyroid gland to produce thyroid hormones
- **corticotropin** (pronounced: kor-tih-ko-**tro**-pin), which stimulates the adrenal gland to produce certain hormones



The pituitary also secretes **endorphins** (pronounced: en-**dor**-fin), chemicals that act on the nervous system and reduce feelings of pain. In addition, the pituitary secretes hormones that signal the reproductive organs to make sex hormones. The pituitary gland also controls ovulation and the menstrual cycle in women.

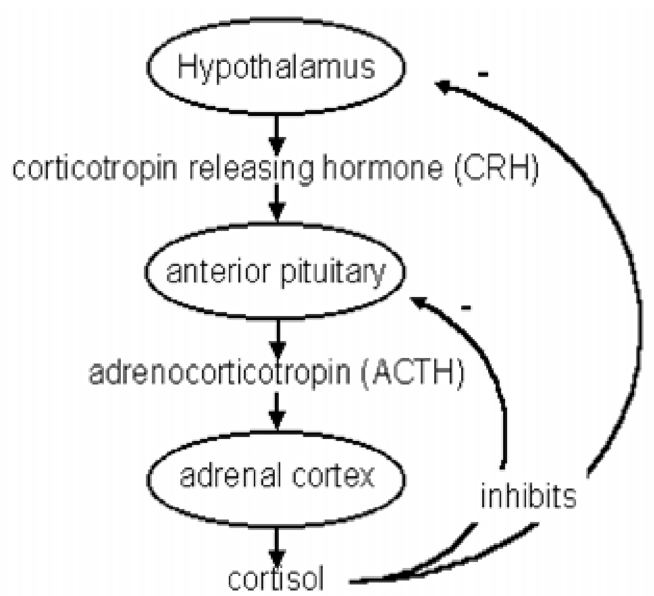
The **posterior lobe** of the pituitary releases **antidiuretic** (pronounced: an-ty-dy-uh-**reh**-tik) **hormone**, which helps control the balance of water in the body. Antidiuretic hormone also affects the production of **oxytocin** (pronounced: ahk-see-**toe**-sin), which triggers the contractions of the uterus in a woman having a baby.

The **thyroid** (pronounced: **thy**-royd), located in the front part of the lower neck, is shaped like a bow tie or butterfly and produces the thyroid hormones

thyroxine (pronounced: thy-**rahk**-seen) and **triiodothyronine** (pronounced: try-eye-uh-doe-**thy**-ruh-neen). These hormones control the rate at which cells burn fuels from food to produce energy. The production and release of thyroid hormones is controlled by **thyrotropin** (pronounced: thigh-ruh-**tro**-pin), which is secreted by the pituitary gland. The more thyroid hormone there is in a person's bloodstream, the faster chemical reactions occur in the body.

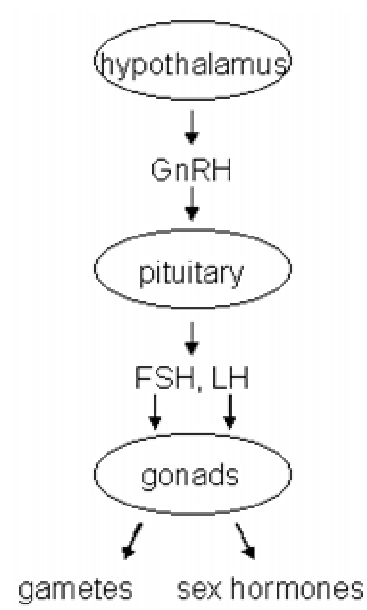
Why are thyroid hormones so important? There are several reasons - for example, they help kids and teens develop strong bones, and they also play a role in the development of the brain and nervous system in kids.

Attached to the thyroid are four tiny glands that function together called the **parathyroids** (pronounced: par-uh-**thy**-roydz). They release **parathyroid hormone**, which regulates the level of calcium in the blood with the help of **calcitonin** (pronounced: kal-suh-**toe**-nin), which is produced in the thyroid.



The body also has two triangular **adrenal** (pronounced: uh-**dree**-nul) **glands**, one on top of each kidney. The adrenal glands have two parts, each of which produces a set of hormones and has a different function. The outer part, the **adrenal cortex**, produces hormones called **corticosteroids** (pronounced: kor-tih-ko-**ster**-oydz) that influence or regulate salt and water balance in the body, the body's response to stress, metabolism, the immune system, and sexual development and function. The inner part, the **adrenal medulla** (pronounced: muh-**duh**-luh), produces **catecholamines (**pronounced: kah-tuh-**ko**-luh-meenz), such as **epinephrine** (pronounced: eh-puh-**neh**-frun). Also called adrenaline, epinephrine increases blood pressure and heart rate when the body experiences stress.

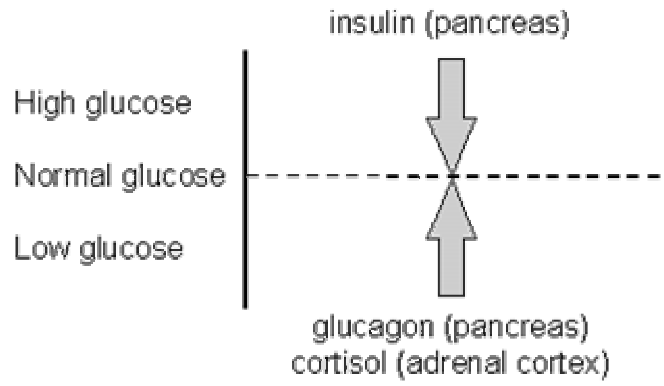
The **pineal** (pronounced: pih-**nee**-ul) **body**, also called the pineal gland, is located in the middle of the brain. It secretes **melatonin** (pronounced: meh-luh-**toe**-nin), a hormone that may help regulate when you sleep at night and when you wake in the morning.



The **gonads** are the main source of sex hormones. Most people don't realize it, but both guys and girls have gonads. In guys the male gonads, or **testes** (pronounced: **tes**-teez), are located in the scrotum. They secrete hormones called **androgens** (pronounced: **an**-druh-junz), the most important of which is **testosterone** (pronounced: teh-**stass**-tuh-rone). These hormones tell a guy's body when it's time to make the changes associated with puberty, like penis and height growth, deepening voice, and growth in facial and pubic hair. Working with hormones from the pituitary gland, testosterone also tells a guy's body when it's time to produce sperm in the testes.

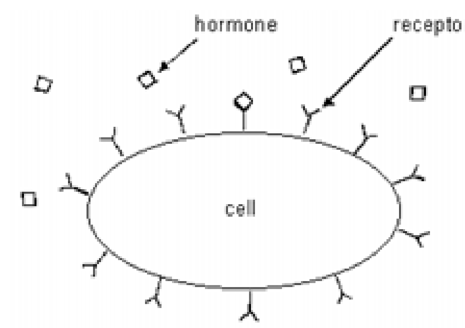
A girl's gonads, the **ovaries** (pronounced: **oh**-vuh-reez), are located in her pelvis. They produce eggs and secrete the female hormones **estrogen** (pronounced: **es**-truh-jen) and **progesterone** (pronounced: pro-**jes**-tuh-rone). Estrogen is involved when a girl begins to go through puberty. During puberty, a girl will experience breast growth, will begin to accumulate body fat around the hips and thighs, and will have a growth spurt. Estrogen and progesterone are also involved in the regulation of a girl's menstrual cycle. These hormones also play a role in pregnancy.

Although the endocrine glands are the body's main hormone producers, some other organs not in the endocrine system - such as the brain, heart, lungs, kidneys, liver, and skin - also produce and release hormones. The **pancreas** (pronounced: **pan**-kree-us) is also part of the body's hormone-secreting system, even though it is also associated with the digestive system because it produces and secretes digestive enzymes. The **pancreas** produces (in addition to others) two important hormones, **insulin** (pronounced: **in**-suh-lin) and **glucagon** (pronounced: **gloo**-kuh-gawn). They work together to maintain a steady level of glucose, or sugar, in the blood and to keep the body supplied with fuel to produce and maintain stores of energy.



What Does the Endocrine System Do?

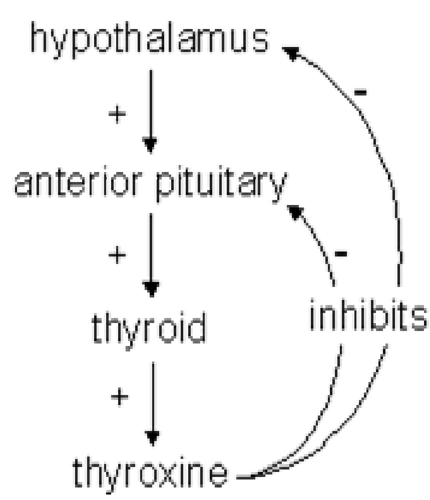
Once a hormone is secreted, it travels from the endocrine gland that produced it through the bloodstream to the cells designed to receive its message. These cells are called target cells. Along the way to the target cells, special proteins bind to some of the hormones. These proteins act as carriers that control the amount of hormone that is available for the cells to use. The target cells have receptors that latch onto only specific hormones, and each hormone has its own receptor, so that each hormone will communicate only with specific target cells that have receptors for that hormone. When the hormone reaches its target cell, it locks onto the cell's specific receptors and these hormone-receptor combinations transmit chemical instructions to the inner workings of the cell.

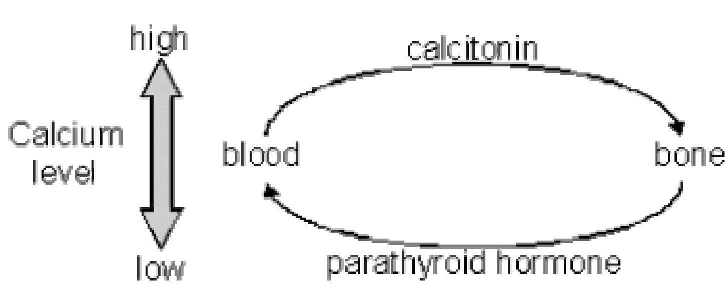


When hormone levels reach a certain normal amount, the endocrine system helps the body to keep that level of hormone in the blood.

For example, if the thyroid gland has secreted the right amount of thyroid hormones into the blood, the pituitary gland senses the normal levels of thyroid hormone in the bloodstream. Then the pituitary gland adjusts its release of thyrotropin, the hormone that stimulates the thyroid gland to produce thyroid hormones.

Another example of this process is parathyroid hormone. Parathyroid hormone increases the level of calcium in the blood. When the blood calcium level rises, the parathyroid glands sense the change and reduce their secretion of parathyroid hormone. This turnoff process is called a negative feedback system.



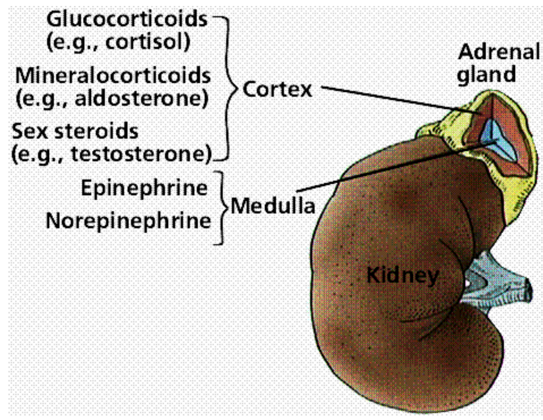


SUMMARY OF THE ENDOCRINE GLANDS AND THEIR ACTIONS

Sl. No.	Endocrine Glands	Location	Hormone	Action
1	Pituitary (Master Gland)	Base of fore brain, pea shaped	Growth Hormone	Regulates the growth of bone and tissue.
			Anti-diuretic hormone	Controls amount of water reabsorbed by the kidney
			Adreno corticotrophic hormone	Defending the body against physiological stress eg. exposure to cold Follicle stimulating hormone Stimulates ovary to produce female hormone
			Thyroid stimulating hormone	Stimulates thyroid to produce its hormone
2	Thyroid	Neck of lower extremity of larynx, butterfly shaped	Thyroxine	Regulates rate of growth and metabolism. Too little over weight and sluggishness. Too much-thinning and over activity.
3	Adrenals	A Pair of cap shaped organs above each kidney	Cortisone	Aids in conversion of proteins to sugar, cortex of this gland produces the hormone.
4	Pancreas	It's a double gland	Insulin	Regulates Sugar metabolism. Too little insulin leads to high sugar level in blood and weakness (a condition called diabetes).
5	Ovary	Lie on the lateral walls of the pelvis	Estrogen	Development of Secondary sexual characters. Eg. Development of breasts in female.
6	Testis	In the scrotum	Testosterone	Development of many masculine features such as growth of moustaches and beard.

THINGS THAT CAN GO WRONG WITH THE ENDOCRINE SYSTEM

Too much or too little of any hormone can be harmful to your body. For example, if the pituitary gland produces too much growth hormone, a teen may grow excessively tall. If it produces too little, a teen may be unusually short. Doctors can often treat problems with the endocrine system by controlling the production of hormones or replacing certain hormones with medication. Some endocrine problems that affect teens include:



Adrenal insufficiency. This condition occurs when the adrenal glands don't work properly or don't produce enough corticosteroids. The symptoms of adrenal insufficiency may include weakness, fatigue, abdominal pain, nausea, dehydration, and skin changes. Doctors treat adrenal insufficiency with medications to replace corticosteroid hormones.

Type 1 diabetes. When the pancreas fails to produce enough insulin, type 1 diabetes (pronounced: dy-uh-**be**-teez and previously known as juvenile diabetes) occurs. In kids and teens, type 1 diabetes is usually an autoimmune disorder, which means that some parts of the body's immune system attack and destroy the cells of the pancreas that produce insulin. To control their blood sugar levels and reduce the risk of developing diabetes problems, kids and teens with this condition need regular injections of insulin.

Type 2 diabetes. Unlike type 1 diabetes, in which the body can't produce normal amounts of insulin, in type 2 diabetes the body can't respond to insulin normally. Kids and teens with the condition tend to be overweight. Some kids and teens can control their blood sugar level with dietary changes, exercise, and oral medications, but many will need to take insulin injections like people with type 1 diabetes.

Growth hormone problems. Too much growth hormone in kids and teens who are still growing will make their bones and other body parts grow excessively. This rare condition (sometimes called gigantism) is usually caused by a pituitary tumor and can be treated by removing the tumor. The opposite can happen when a kid or teen has a pituitary glad that doesn't produce enough growth hormone. Doctors may treat these growth problems with medication.

Hyperthyroidism. Hyperthyroidism (pronounced: hi-per-**thy**-roy-dih-zum) is a condition in which the levels of thyroid hormones in the blood are very high. In kids and teens, the condition is usually caused by Graves' disease, an immune system problem that causes the thyroid gland to become very active. Doctors may treat hyperthyroidism with medications, surgery, or radiation treatments.

Hypothyroidism. Hypothyroidism (pronounced: hi-po-**thy**-roy-dih-zum) is a condition in which the levels of thyroid hormones in the blood are very low. Thyroid hormone deficiency slows body processes and may lead to fatigue, a slow heart rate, dry skin, weight gain, constipation. Kids and teens with this condition may also grow more slowly and reach puberty at a later age. Hashimoto's thyroiditis is an immune system problem that often causes problems with the thyroid and blocks the production of thyroid hormone. Doctors often treat this problem with medication.

Precocious puberty. If the pituitary glands release hormones that stimulate the gonads to produce sex hormones too early, some kids may begin to go through puberty at a very young age. This condition is called precocious puberty. Kids and teens who are affected by precocious puberty can be treated with medication that will help them develop at a normal rate.

CENTRES OF CONSCIOUSNESS

Relationship between the Physical (Annamaya Kosha), Energy (Pranamaya Kosha) and Mental (Manomaya Kosha) Bodies

Chakra	Centre	Location	Petals	Element	Sound	Plexus	Gland	Shape
SAHASRARA 1000 Petalled Lotus	Crown Consciousness	Top of the Head	1000	Atman Soul	Om	Forebrain Hypothalamus	Pineal	1000 Petalled Lotus
AJNA Lotus of Intuition	Brow Understanding	Between Eyebrows	2	Manas Mind	Aung	Cavernous Plexus	Pituitary	Orange Circle
VISHUDDHA Lotus of Great Purity	Throat Creativity	Throat Region	16	Akash Ether	Hung	Pharyngeal Plexus	Thyroid	Magenta Oval
ANAHATHA Lotus of Unstruck Sound	Heart Compassion	Heart Region	12	Vayu Air	Yang	Cardiac Plexus	Thymus	Blue Hexagon
MANIPURA Gem City Lotus	Solar Power	Navel Region	10	Tejas Fire	Rung	Solar Plexus	Pancreas	Inverted Red Triangle
SWADHISTHANA Lotus of One's Own Self	Sacral Sensuality	Pelvic Region	6	Apas Water	Vung	Hypogastric Plexus	Adrenals	Silver Crescent
MOOLADHARA Root Support Lotus	Root Stability	Base of Spine	4	Prithvi Earth	Lung	Sacral Plexus	Gonads	Yellow Square

CENTRES OF CONSCIOUSNESS

Sense Organs (Jnanendriyas), Subtle Elements (Tanmatras), Action Organs (Karmendriyas) and Psychological Qualities Associated with the Five Spinal Chakras

Chakra	Jnane-ndriya	Tan-matra	Karme-ndriya	Qualities
MOOLADHARA	**Grahna** Nose	**Gandha** Smell	**Pada** Locomotion Feet	Solidarity Integration Cohesiveness
SWADHISTHANA	**Jihva** Tongue	**Rasana** Taste	**Pani** Dexterity Hands	Diplomacy Flexibility Equanimity
MANIPURA	**Chakshu** Eyes	**Rupa** Sight	**Payu** Excretion Anus	Power Passion Motivation
ANAHATHA	**Tvak** Skin	**Sparsha** Touch	**Upastha** Reproduction Genitals	Compassion Tolerance Understanding
VISHUDDHA	**Shotra** Ears	**Shabda** Hearing	**Vak** Mouth Speech	Empathy Freedom Communication

CENTRES OF CONSCIOUSNESS

Asanas For Creating Awareness and Energy In The Chakras

Chakra	Recommended Asanas
MOOLADHARA	Vajrasana, Sukhasana, Siddasana, Padmasana
SWADHISTHANA	Supta Vajrasana, Matsyasana
MANIPURA	Dharmikasana
ANAHATHA	Ardha Matsyendrasana, Brahmadandasana, Vakrasana, Gomukasana
VISHUDDHA	Sarvangasana
AJNA	Shirshasana or Kapalasana with Padmasana
SAHASRARA	Yoga Mudrasana and Baddha Padmasana

Chakra	Devatha	Gayatri	Loka
MOOLADHARA	Brahma	Ganesha	Bhurloka
SWADHISTHANA	Rudra	Brahma	Bhuvarloka
MANIPURA	Vishnu	Vishnu	Svarloka
ANAHATA	Ishwara	Rudra	Janaloka
VISHUDDHA	Sadasiva	Shiva	Tapaloka
AJNA	Shambu	Hamsa	Maharloka
SAHASRARA	Param Siva	Sukshma	Satya Loka

Chakra	Prana Vayu	Upa Prana Vayu
MOOLADHARA	Apana	-
SWADHISTHANA	Apana	Dhananjaya Nourishing the body
MANIPURA	Samana	Krikara Sneezing
ANAHATHA	Prana	Devadutta Yawning
VISHUDDHA	Udana	Kurma Opening eyes
AJNA	Prana	Devadutta Yawning
SAHASRARA	Vyana	Naga Belching

FEMALE REPRODUCTIVE SYSTEM

All living things reproduce. Reproduction - the process by which organisms make more organisms like themselves - is one of the things that sets living things apart from nonliving matter. But even though the reproductive system is essential to keeping a species alive, unlike other body systems, it's not essential to keeping an individual alive.

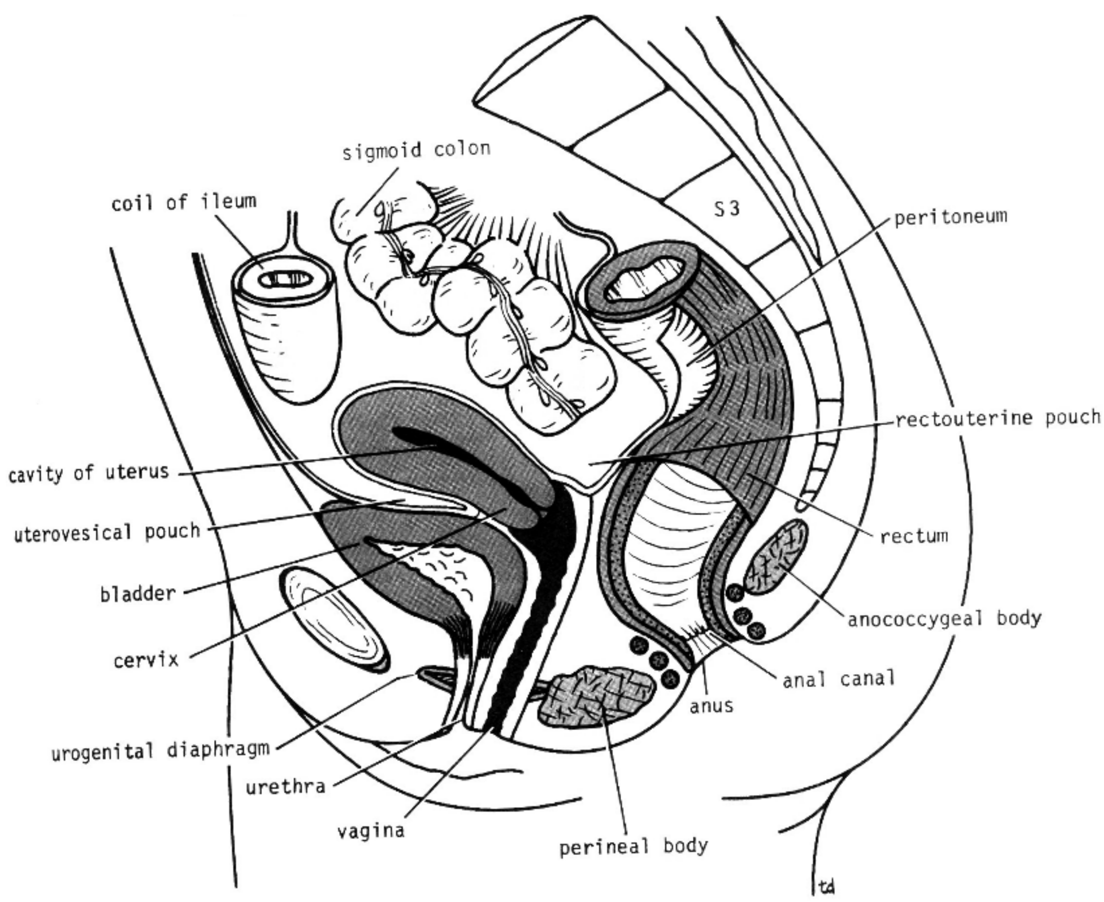
In the human reproductive process, two kinds of **sex cells**, or **gametes** (pronounced: **gah**-meetz), are involved. The male gamete, or **sperm**, and the female gamete, the **egg** or **ovum**, meet in the female's reproductive system to create a new individual. Both the male and female reproductive systems are essential for reproduction. The female needs a male to fertilize her egg, even though it is she who carries offspring through pregnancy and childbirth.

Humans, like other organisms, pass certain characteristics of themselves to the next generation through their **genes**, the special carriers of human traits. The genes that parents pass along to their children are what make children similar to others in their family, but they are also what make each child unique. These genes come from the father's sperm and the mother's egg, which are produced by the male and female reproductive systems.

What Is the Female Reproductive System?

Most species have two sexes: male and female. Each sex has its own unique reproductive system. They are different in shape and structure, but both are specifically designed to produce, nourish, and transport either the egg or sperm.

Unlike the male, the human female has a reproductive system located entirely in the pelvis (that's the lowest part of the abdomen). The external part of the female reproductive organs is called the **vulva**, which means covering. Located between the legs, the vulva covers the opening to the **vagina** (pronounced: vuh-**jigh**-nuh) and other reproductive organs located inside the body.



The fleshy area located just above the top of the vaginal opening is called the **mons pubis** (pronounced: **manz pyoo**-bis). Two pairs of skin flaps called the **labia** (which means lips and is pronounced: **lay**-bee-uh) surround the vaginal opening. The **clitoris** (pronounced: **klih**-tuh-rus), a small sensory organ, is located toward the front of the vulva where the folds of the labia join.

Between the labia are openings to the **urethra** (the canal that carries urine from the bladder to the outside of the body, which is pronounced: yoo-**ree**-thruh) and vagina. Once girls become sexually mature, the outer labia and the mons pubis are covered by pubic hair.

A female's internal reproductive organs are the vagina, uterus, fallopian tubes, and ovaries.

The vagina is a muscular, hollow tube that extends from the vaginal opening to the uterus. The vagina is about 3 to 5 inches (8 to 12 centimeters) long in a grown woman. Because it has muscular walls it can expand and contract. This ability to become wider or narrower allows the vagina to accommodate something as slim as a tampon and as wide as a baby. The vagina's muscular walls are lined with mucous membranes, which keep it protected and moist. The vagina has several functions: for sexual intercourse, as the pathway that a baby takes out of a woman's body during childbirth, and as the route for the menstrual blood (the period) to leave the body from the uterus.

A thin sheet of tissue with one or more holes in it called the **hymen** (pronounced: **hi**-mun) partially covers the opening of the vagina. Hymens are often different from person to person. Most women find their hymens have stretched or torn after their first sexual experience, and the hymen may bleed a little (this usually causes little, if any, pain). Some women who have had sex don't have much of a change in their hymens, though.

The vagina connects with the **uterus** (pronounced: **yoo**-tuh-rus), or womb, at the **cervix** (which means neck and is pronounced: **sir**-viks). The cervix has strong, thick walls. The opening of the cervix is very small (no wider than a straw), which is why a tampon can never get lost inside a girl's body. During childbirth, the cervix can expand to allow a baby to pass.

The uterus is shaped like an upside-down pear, with a thick lining and muscular walls - in fact, the uterus contains some of the strongest muscles in the female body. These muscles are able to expand and contract to accommodate a growing fetus and then help push the baby out during labor. When a woman isn't pregnant, the uterus is only about 3 inches (7.5 centimeters) long and 2 inches (5 centimeters) wide.

At the upper corners of the uterus, the **fallopian** (pronounced: fuh-**lo**-pee-un) tubes connect the uterus to the **ovaries** (pronounced: **o**-vuh-reez). The ovaries are two oval-shaped organs that lie to the upper right and left of the uterus. They produce, store, and release eggs into the fallopian tubes in the process called **ovulation** (pronounced: av-yoo-**lay**-shun). Each ovary measures about 1 1/2 to 2 inches (4 to 5 centimeters) in a grown woman.

There are two fallopian tubes, each attached to a side of the uterus. The fallopian tubes are about 4 inches (10 centimeters) long and about as wide as a piece of spaghetti. Within each tube is a tiny passageway no wider than a sewing needle. At the other end of each fallopian tube is a fringed area that looks like a funnel. This fringed area wraps around the ovary but doesn't completely attach to it. When an egg pops out of an ovary, it enters the fallopian tube. Once the egg is in the fallopian tube, tiny hairs in the tube's lining help push it down the narrow passageway toward the uterus.

The ovaries are also part of the endocrine system because they produce female sex hormones such as **estrogen** (pronounced: **es**-truh-jun) and **progesterone** (pronounced: pro-**jes**-tuh-rone).

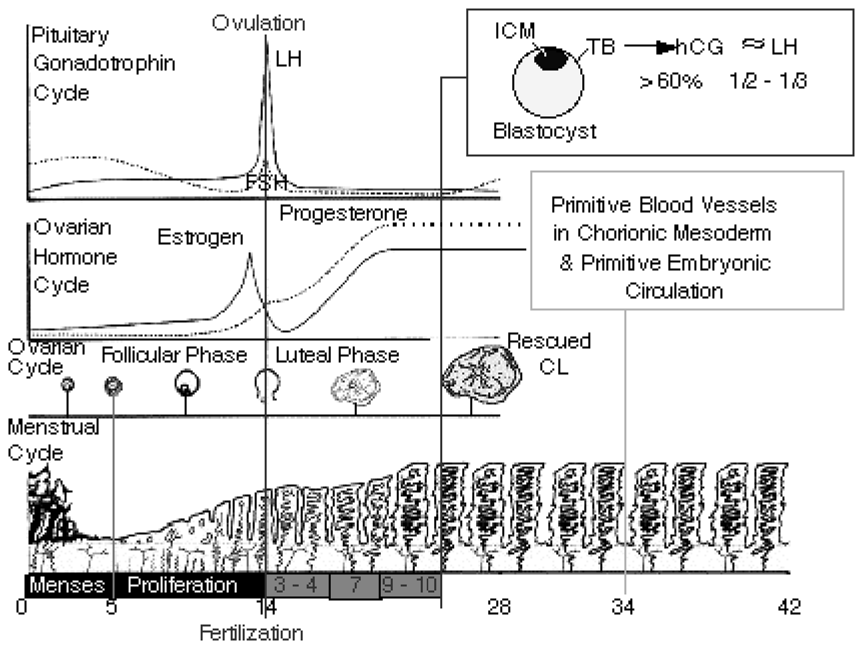
What Does the Female Reproductive System Do?

The female reproductive system enables a woman to:

- produce eggs (ova)
- have sexual intercourse
- protect and nourish the fertilized egg until it is fully developed
- give birth

Sexual reproduction couldn't happen without the sexual organs called the **gonads** (pronounced: **go**-nadz). Although most people think of the gonads as the male testicles, both sexes actually have gonads: In females the gonads are the ovaries. The female gonads produce female gametes (eggs); the male gonads produce male gametes (sperm). After an egg is fertilized by the sperm, the fertilized egg is called the **zygote** (pronounced: **zi**-gote).

When a baby girl is born, her ovaries contain hundreds of thousands of eggs, which remain inactive until puberty begins. At puberty, the pituitary gland, located in the central part of the brain, starts making hormones that stimulate the ovaries to produce female sex hormones, including estrogen. The secretion of these hormones causes a girl to develop into a sexually mature woman.



Toward the end of puberty, girls begin to release eggs as part of a monthly period called the **menstrual cycle**. Approximately once a month, during ovulation, an ovary sends a tiny egg into one of the fallopian tubes. Unless the egg is fertilized by a sperm while in the fallopian tube, the egg dries up and leaves the body about 2 weeks later through the uterus. This process is called **menstruation** (pronounced: men-**stray**-shun). Blood and tissues from the inner lining of the uterus combine to form the menstrual flow, which in most girls lasts from 3 to 5 days. A girl's the first period is called **menarche** (pronounced: **meh**-nar-kee).

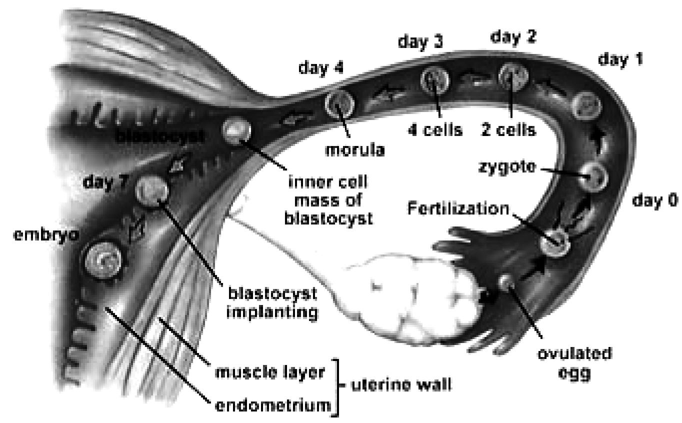
It's common for women and girls to experience some discomfort in the days leading to their periods. **Premenstrual syndrome** (PMS) includes both physical and emotional symptoms that many girls and women get right before their periods, such as acne, bloating, fatigue, backaches, sore breasts, headaches, constipation, diarrhea, food cravings, depression, irritability, or difficulty concentrating or handling stress. PMS is usually at its worst during the 7 days before a girl's period starts and disappears once it begins.

Many girls also experience abdominal cramps during the first few days of their periods. They are caused by prostaglandin, a chemical in the body that makes the smooth muscle in the uterus contract. These involuntary contractions can be either dull or sharp and intense.

It can take up to 2 years from menarche for a girl's body to develop a regular menstrual cycle. During that time, her body is adjusting to the hormones puberty brings. On average, the monthly cycle for an adult woman is 28 days, but the range is from 23 to 35 days.

If a female and male have sex within several days of the female's ovulation (egg release), fertilization can occur. When the male ejaculates (which is when semen leaves a man's penis), between 0.05 and 0.2 fluid ounces (1.5 to 6.0 milliliters) of **semen** is deposited into the vagina. Between 75 and 900 million sperm are in this small amount of semen, and they "swim" up from the vagina through the cervix and uterus to meet the egg in the fallopian tube. It takes only one sperm to fertilize the egg.

About a week after the sperm fertilizes the egg, the fertilized egg (zygote) has become a multi-celled **blastocyst** (pronounced: **blas**-tuh-sist). A blastocyst is about the size of a pinhead, and it's a hollow ball of cells with fluid inside. The blastocyst burrows itself into the lining of the uterus, called the **endometrium** (pronounced: en-doh-**mee**-tree-um). The hormone estrogen causes the endometrium to become thick and rich with blood. Progesterone, another hormone released by the ovaries, keeps the endometrium thick with blood so that the blastocyst can attach to the uterus and absorb nutrients from it. This process is called **implantation** (pronounced: im-plan-**tay**-shun).



As cells from the blastocyst take in nourishment, another stage of development, the embryonic stage, begins. The inner cells form a flattened circular shape called the embryonic disk, which will develop into a baby. The outer cells become thin membranes that form around the baby. The cells multiply thousands of times and move to new positions to eventually become the **embryo** (pronounced: **em**-bree-o). After approximately 8 weeks, the embryo is about the size of an adult's thumb, but almost all of its parts - the brain and nerves, the heart and blood, the stomach and intestines, and the muscles and skin - have formed.

During the fetal stage, which lasts from 9 weeks after fertilization to birth, development continues as cells multiply, move, and change. The **fetus** (pronounced: **fee**-tus) floats in **amniotic** (pronounced: am-nee-**ah**-tik) **fluid** inside the **amniotic sac**. The fetus receives oxygen and nourishment from the mother's blood via the **placenta** (pronounced: pluh-**sen**-tuh), a disk-like structure that sticks to the inner lining of the uterus and connects to the fetus via the **umbilical** (pronounced: um-**bih**-lih-kul) **cord**. The amniotic fluid and membrane cushion the fetus against bumps and jolts to the mother's body.

Pregnancy lasts an average of 280 days - about 9 months. When the baby is ready for birth, its head presses on the cervix, which begins to relax and widen to get ready for the baby to pass into and through the vagina. The mucus that has formed a plug in the cervix loosens, and with amniotic fluid, comes out through the vagina when the mother's water breaks.

When the contractions of **labor** begin, the walls of the uterus contract as they are stimulated by the pituitary hormone **oxytocin** (pronounced: ahk-see-**toh**-sin). The contractions cause the cervix to widen and begin to open. After several hours of this widening, the cervix is dilated (opened) enough for the baby to come through. The baby is pushed out of the uterus, through the cervix, and along the birth canal. The baby's head usually comes first; the umbilical cord comes out with the baby and is cut after the baby is delivered. The last stage of the birth process involves the delivery of the placenta, which is now called the afterbirth. After it has separated from the inner lining of the uterus, contractions of the uterus push it out, along with its membranes and fluids.

Things That Can Go Wrong With the Female Reproductive System

Girls and women may sometimes experience reproductive system problems. Below are some examples of disorders that affect the female reproductive system.

Things That Can Go Wrong With the Vulva and Vagina

- **Vulvovaginitis** (pronounced: vul-vo-vah-juh-**ni**-tus) is an inflammation of the vulva and vagina. It may be caused by irritating substances (such as laundry soaps or bubble baths). Poor personal hygiene (such as wiping from back to front after a bowel movement) may also cause this problem. Symptoms include redness and itching in the vaginal and vulvar areas and sometimes vaginal discharge. Vulvovaginitis can also be caused by an overgrowth of candida, a fungus normally present in the vagina.

- **Nonmenstrual vaginal bleeding** is most commonly due to the presence of a **vaginal foreign body**, often wadded-up toilet paper. It may also be due to **urethral prolapse**, a condition in which the mucous membranes of the urethra protrude into the vagina and form a tiny, donut-shaped mass of tissue that bleeds easily. It can also be due to a straddle injury (such as when falling onto a beam or bicycle frame) or vaginal trauma from sexual abuse.

Things That Can Go Wrong With the Ovaries and Fallopian Tubes

- **Ectopic** (pronounced: ek-**tah**-pik) **pregnancy** occurs when a fertilized egg, or zygote, doesn't travel into the uterus, but instead grows rapidly in the fallopian tube. Girls with this condition can develop severe abdominal pain and should see a doctor because surgery may be necessary.
- **Endometriosis** (pronounced: en-doh-mee-tree-**o**-sus) occurs when tissue normally found only in the uterus starts to grow outside the uterus - in the ovaries, fallopian tubes, or other parts of the pelvic cavity. It can cause abnormal bleeding, painful periods, and general pelvic pain.
- **Ovarian tumors**, although they're rare, can occur. Girls with ovarian tumors may have abdominal pain and masses that can be felt in the abdomen. Surgery may be needed to remove the tumor.
- **Ovarian cysts** are noncancerous sacs filled with fluid or semi-solid material. Although they are common and generally harmless, they can become a problem if they grow very large. Large cysts may push on surrounding organs, causing abdominal pain. In most cases, cysts will disappear on their own and treatment is unnecessary. If the cysts are painful, a doctor may prescribe birth control pills to alter their growth, or they may be removed by a surgeon.
- **Polycystic** (pronounced: pah-lee-**sis**-tik) **ovary syndrome** is a hormone disorder in which too many male hormones (androgens) are produced by the ovaries. This condition causes the ovaries to become enlarged and develop many fluid-filled sacs, or cysts. It often first appears during the teen years. Depending on the type and severity of the condition, it may be treated with drugs to regulate hormone balance and menstruation.

Menstrual Problems

There are a variety of menstrual problems that can affect girls. Some of the more common conditions are:

- **Dysmenorrhea** (pronounced: dis-meh-nuh-**ree**-uh) is when a girl has painful periods.
- **Menorrhagia** (pronounced: meh-nuh-**rah**-zhuh) is when a girl has a very heavy periods with excess bleeding.
- **Oligomenorrhea** (pronounced: o-lih-go-meh-nuh-**ree**-uh) is when a girl misses or has infrequent periods, even though she's been menstruating for a while and isn't pregnant.
- **Amenorrhea** (pronounced: **a**-meh-nuh-ree-uh) is when a girl has not started her period by the time she is 16 years old or 3 years after starting puberty, has not developed signs of puberty by age 14, or has had normal periods but has stopped menstruating for some reason other than pregnancy.

Infections of the Female Reproductive System

- **Sexually transmitted diseases.** These include infections and diseases such as pelvic inflammatory disease (PID), human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), human papilloma virus (HPV, or genital warts), syphilis, chlamydia, gonorrhea, and genital herpes. Most are spread from one person to another by sexual intercourse.
- **Toxic shock syndrome.** This uncommon illness is caused by toxins released into the body during a type of bacterial infection that is more likely to develop if a tampon is left in too long. It can produce high fever, diarrhea, vomiting, and shock.

MALE REPRODUCTIVE SYSTEM

Most species have two sexes: male and female. Each sex has its own unique reproductive system. They are different in shape and structure, but both are specifically designed to produce, nourish, and transport either the egg or sperm.

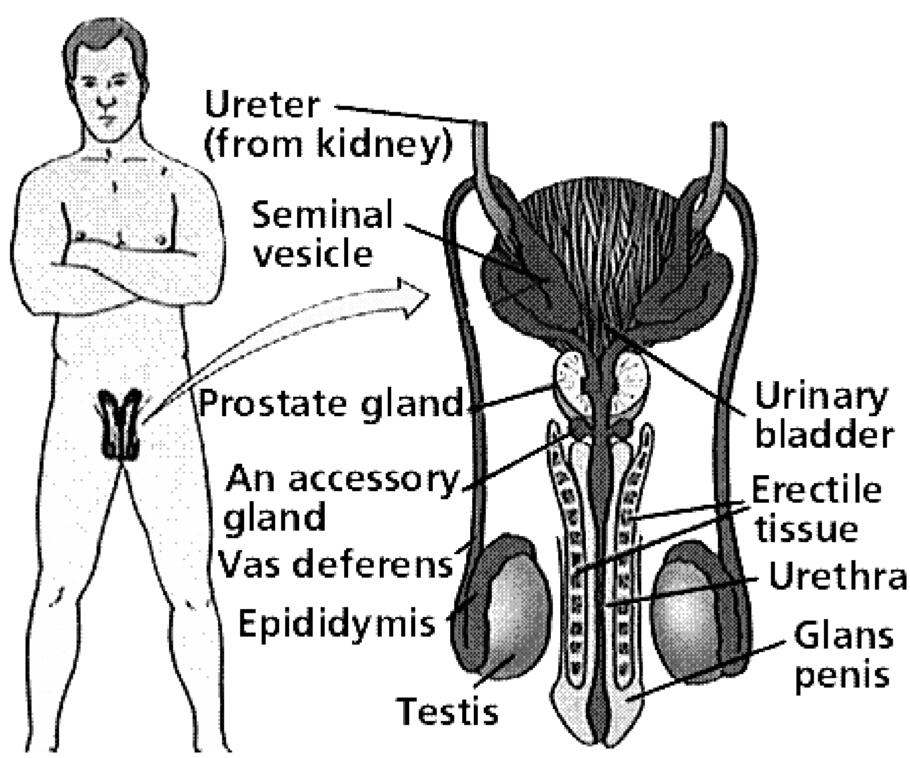
Unlike the female, whose sex organs are located entirely within the pelvis, the male has reproductive organs, or **genitals** (pronounced: **jeh**-nuh-tulz), that are both inside and outside the pelvis. The male genitals include:

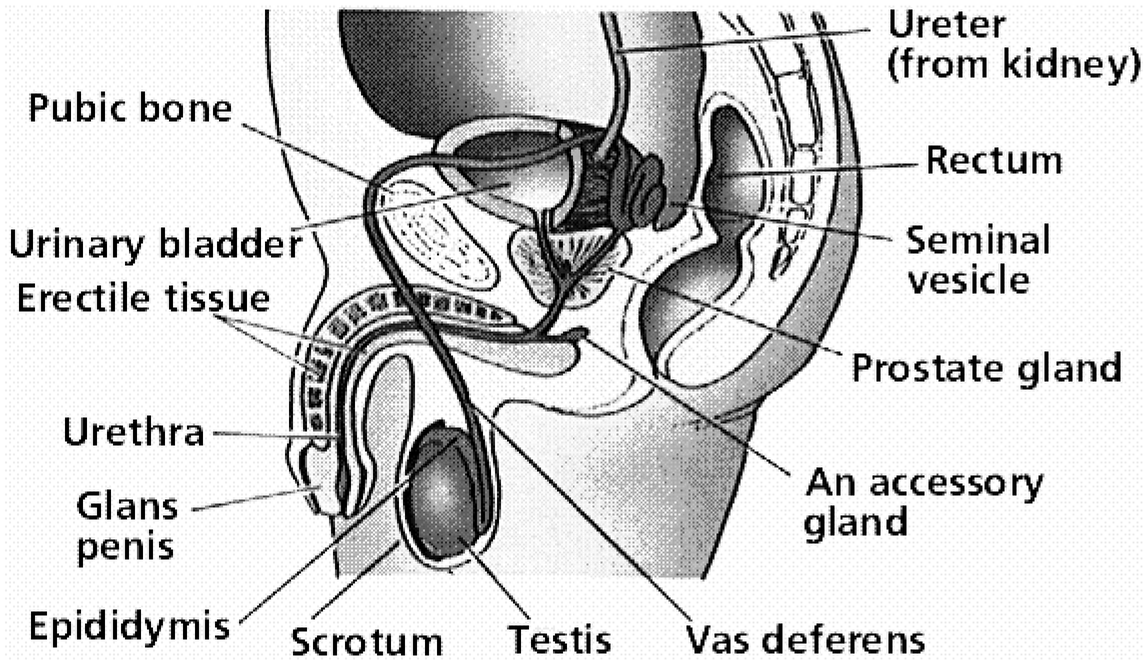
- the testicles
- the duct system, which is made up of the epididymis and the vas deferens
- the accessory glands, which include the seminal vesicles and prostate gland
- the penis

In a guy who's reached sexual maturity, the two **testicles** (pronounced: **tes**-tih-kulz), or **testes** (pronounced: **tes**-teez), produce and store millions of tiny sperm cells. The testicles are oval-shaped and grow to be about 2 inches (5 centimeters) in length and 1 inch (3 centimeters) in diameter. The testicles are also part of the endocrine system because they produce hormones, including **testosterone** (pronounced: teh-**stass**-tuh-rone). Testosterone is a major part of puberty in guys, and as a guy makes his way through puberty, his testicles produce more and more of it. Testosterone is the hormone that causes guys to develop deeper voices, bigger muscles, and body and facial hair, and it also stimulates the production of sperm.

Alongside the testicles are the **epididymis** (pronounced: eh-puh-dih-duh-**mus**) and the **vas deferens** (pronounced: **vass de**-fuh-runz), which make up the duct system of the male reproductive organs. The vas deferens is a muscular tube that passes upward alongside the testicles and transports the sperm-containing fluid called **semen** (pronounced: **see**-mun). The epididymis is a set of coiled tubes (one for each testicle) that connects to the vas deferens.

The epididymis and the testicles hang in a pouch-like structure outside the pelvis called the **scrotum**. This bag of skin helps to regulate the temperature of testicles, which need to be kept cooler than body temperature to produce sperm. The scrotum changes size to maintain the right temperature. When the body is cold, the scrotum shrinks and becomes tighter to hold in body heat. When it's warm, the scrotum becomes larger and more floppy to get rid of extra heat. This happens without a guy ever having to think about it. The brain and the nervous system give the scrotum the cue to change size.





The **accessory glands**, including the seminal vesicles and the prostate gland, provide fluids that lubricate the duct system and nourish the sperm. The **seminal vesicles** (pronounced: **seh**-muh-nul **veh**-sih-kulz) are sac-like structures attached to the vas deferens to the side of the bladder. The **prostate gland**, which produces some of the parts of semen, surrounds the ejaculatory ducts at the base of the **urethra** (pronounced: yoo-**ree**-thruh), just below the bladder. The urethra is the channel that carries the semen to the outside of the body through the penis. The urethra is also part of the urinary system because it is also the channel through which urine passes as it leaves the bladder and exits the body.

The **penis** is actually made up of two parts: the **shaft** and the **glans** (pronounced: **glanz**). The shaft is the main part of the penis and the glans is the tip (sometimes called the head). At the end of the glans is a small slit or opening, which is where semen and urine exit the body through the urethra. The inside of the penis is made of a spongy tissue that can expand and contract.

All boys are born with a **foreskin**, a fold of skin at the end of the penis covering the glans. Some boys have a **circumcision** (pronounced: sur-kum-**sih**-zhun), which means that a doctor or clergy member cuts away the foreskin. Circumcision is usually performed during a baby boy's first few days of life. Although circumcision is not medically necessary, parents who choose to have their children circumcised often do so based on religious beliefs, concerns about hygiene, or cultural or social reasons. Boys who have circumcised penises and those who don't are no different: All penises work and feel the same, regardless of whether the foreskin has been removed.

What Does the Male Reproductive System Do?

The male sex organs work together to produce and release semen into the reproductive system of the female during sexual intercourse. The male reproductive system also produces sex hormones, which help a boy develop into a sexually mature man during **puberty** (pronounced: **pyoo**-bur-tee).

When a baby boy is born, he has all the parts of his reproductive system in place, but it isn't until puberty that he is able to reproduce. When puberty begins, usually between the ages of 10 and 14, the **pituitary** (pronounced: puh-**too**-uh-ter-ee) **gland** - which is located in the brain - secretes hormones that stimulate the testicles to produce testosterone. The production of testosterone brings about many physical changes. Although the timing of these changes is different for every guy, the stages of puberty generally follow a set sequence.

- During the first stage of male puberty, the scrotum and testes grow larger.
- Next, the penis becomes longer, and the seminal vesicles and prostate gland grow.

- Hair begins to appear in the pubic area and later it grows on the face and underarms. During this time, a male's voice also deepens.
- Boys also undergo a growth spurt during puberty as they reach their adult height and weight.

Once a guy has reached puberty, he will produce millions of sperm cells every day. Each sperm is extremely small: only 1/600 of an inch (0.05 millimeters long). Sperm develop in the testicles within a system of tiny tubes called the **seminiferous tubules** (pronounced: seh-muh-**nih**-fuh-rus **too**-byoolz). At birth, these tubules contain simple round cells, but during puberty, testosterone and other hormones cause these cells to transform into sperm cells. The cells divide and change until they have a head and short tail, like tadpoles. The head contains genetic material (genes). The sperm use their tails to push themselves into the epididymis, where they complete their development. It takes sperm about 4 to 6 weeks to travel through the epididymis.

The sperm then move to the vas deferens, or sperm duct. The seminal vesicles and prostate gland produce a whitish fluid called **seminal fluid**, which mixes with sperm to form semen when a male is sexually stimulated. The penis, which usually hangs limp, becomes hard when a male is sexually excited. Tissues in the penis fill with blood and it becomes stiff and erect (an erection). The rigidity of the erect penis makes it easier to insert into the female's vagina during sexual intercourse. When the erect penis is stimulated, muscles around the reproductive organs contract and force the semen through the duct system and urethra. Semen is pushed out of the male's body through his urethra - this process is called **ejaculation** (pronounced: ih-jah-kyuh-**lay**-shun). Each time a guy ejaculates, it can contain up to 500 million sperm.

When the male ejaculates during intercourse, semen is deposited into the female's vagina. From the vagina the sperm make their way up through the cervix and move through the uterus with help from uterine contractions. If a mature egg is in one of the female's fallopian tubes, a single sperm may penetrate it, and **fertilization**, or **conception**, occurs.

This fertilized egg is now called a **zygote** (pronounced: **zy**-goat) and contains 46 chromosomes - half from the egg and half from the sperm. The genetic material from the male and female has combined so that a new individual can be created. The zygote divides again and again as it grows in the female's uterus, maturing over the course of the pregnancy into an embryo, a fetus, and finally a newborn baby.

Things That Can Go Wrong With the Male Reproductive System

- **Testicular injury.** Even a mild injury to the testicles can cause severe pain, bruising, or swelling. Most testicular injuries occur when the testicles are struck, hit, kicked, or crushed, usually during sports or due to other trauma. Testicular torsion (pronounced: **tor**-zhun), when one of the testicles twists around, cutting off the blood supply, is also a problem that some teen guys experience - although it's not common.
- **Varicocele** (pronounced: **var**-uh-koh-seal). This is a varicose vein (an abnormally swollen vein) in the network of veins that run from the testicles. Varicoceles commonly develop while a guy is going through puberty. A varicocele is usually not harmful, although in some people it may damage the testicle or decrease sperm production, so it helps for a guy to see his doctor if he's concerned about changes in his testicles.
- **Testicular cancer.** This is one of the most common cancers in men younger than 40. It occurs when cells in the testicle divide abnormally and form a tumor. Testicular cancer can spread to other parts of the body, but if it's detected early, the cure rate is excellent. All guys should perform testicular self-examinations regularly to help with early detection.
- **Epididymitis** (pronounced: eh-puh-dih-duh-**my**-tus) is inflammation of the epididymis, the coiled tubes that connect the testes with the vas deferens. It is usually caused by an infection, such as the sexually transmitted

disease chlamydia, and results in pain and swelling next to one of the testicles.

- **Hydrocele.** A hydrocele (pronounced: **high**-druh-seel) occurs when fluid collects in the membranes surrounding the testes. Hydroceles may cause swelling of the testicle but are generally painless. In some cases, surgery may be needed to correct the condition.
- **Inguinal hernia.** When a portion of the intestines pushes through an abnormal opening or weakening of the abdominal wall and into the groin or scrotum, it is known as an inguinal hernia (pronounced: **in**-gwuh-nul **her**-nee-uh). The hernia may look like a bulge or swelling in the groin area. It can be corrected with surgery.
- **Inflammation of the penis.** Symptoms of penile inflammation include redness, itching, swelling, and pain. Balanitis occurs when the glans (the head of the penis) becomes inflamed. Posthitis is foreskin inflammation, which is usually due to a yeast or bacterial infection.
- **Hypospadius** is a disorder in which the urethra opens on the underside of the penis, not at the tip.
- **Sexually transmitted diseases.** Sexually transmitted diseases (STDs) that can affect guys include human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), human papilloma virus (HPV, or genital warts), syphilis, chlamydia, gonorrhea, herpes genitalis, and hepatitis B. They are spread from one person to another mainly through sexual intercourse.

IMMUNE SYSTEM

Whether you're stomping through the showers in your bare feet after gym class or touching the bathroom doorknob, you're being exposed to germs. Fortunately for most of us, the immune system is constantly on call to do battle with bugs that could put us out of commission.

The immune (pronounced: ih-**myoon**) system, which is made up of special cells, proteins, tissues, and organs, defends people against germs and microorganisms every day. In most cases, the immune system does a great job of keeping people healthy and preventing infections. But sometimes problems with the immune system can lead to illness and infection.

What Is the Immune System and What Does It Do?

The immune system is the body's defense against infectious organisms and other invaders. Through a series of steps called the **immune response**, the immune system attacks organisms and substances that invade our systems and cause disease. The immune system is made up of a network of cells, tissues, and organs that work together to protect the body.

The cells that are part of this defense system are white blood cells or **leukocytes** (pronounced: **loo**-kuh-sytes). They come in two basic types (more on these below), which combine to seek out and destroy the organisms or substances that cause disease.

Leukocytes are produced or stored in many locations throughout the body, including the thymus, spleen, and bone marrow. For this reason, they are called the **lymphoid** (pronounced: **lim**-foyd) organs. There are also clumps of lymphoid tissue throughout the body, primarily in the form of lymph nodes, that house the leukocytes.

The leukocytes circulate through the body between the organs and nodes by means of the **lymphatic** (pronounced: lim-**fah**-tik) **vessels**. (You can think of the lymphatic vessels as a type of highway between the rest stops that are the lymphoid organs and lymph nodes). Leukocytes can also circulate through the blood vessels. In this way, the immune system works in a coordinated manner to monitor the body for substances that might cause problems.

There are two basic types of leukocytes:

- The **phagocytes** (pronounced: **fah**-guh-sytes) are cells that chew up invading organisms.
- The **lymphocytes** (pronounced: **lim**-fuh-sytes) are cells that allow the body to remember and recognize previous invaders.

There are a number of different cells that are considered phagocytes. The most common type is the **neutrophil** (pronounced: **noo**-truh-fil). Neutrophils primarily fight bacteria. So when doctors are worried about a bacterial infection, sometimes they order a blood test to see if a patient has an increased number of neutrophils triggered by the infection. Other types of phagocytes have their own jobs to make sure that the body responds appropriately to a specific type of invader.

There are two kinds of lymphocytes: the **B lymphocytes** and the **T lymphocytes**. Lymphocytes start out in the bone marrow and either stay and mature there to become B cells or leave for the thymus gland, where they mature to become T cells. B lymphocytes and T lymphocytes have separate jobs to do: B lymphocytes are like the body's military intelligence system, seeking out their targets and sending defenses to lock onto them. T cells are like the soldiers, destroying the invaders that the intelligence system has identified. Here's how it works.

A foreign substance that invades the body is called an **antigen** (pronounced: **an**-tih-jun). When an antigen is detected, several types of cells work together to recognize and respond to it. These cells trigger the B lymphocytes to produce **antibodies** (pronounced: **an**-tye-bah-deez). Antibodies are specialized proteins that lock onto specific antigens. Antibodies and antigens fit together like a key and a lock.

Once the B lymphocytes have produced antibodies, these antibodies continue to exist in a person's body. That means if the same antigen is presented to the immune system again, the antibodies are already there to do their job. That's why if someone gets sick with a certain disease, like chickenpox, that person typically doesn't get sick from it again. This is also why we use immunizations to prevent certain diseases. The immunization introduces the body to the antigen in a way that doesn't make a person sick, but it does allow the body to produce antibodies that will then protect that person from future attack by the germ or substance that produces that particular disease.

Although antibodies can recognize an antigen and lock onto it, they are not capable of destroying it without help. That is the job of the T cells. The T cells are part of the system that destroys antigens that have been tagged by antibodies or cells that have been infected or somehow changed. (There are actually T cells that are called "killer cells"). T cells are also involved in helping signal other cells (like phagocytes) to do their jobs.

Antibodies can also neutralize toxins (poisonous or damaging substances) produced by different organisms. Lastly, antibodies can activate a group of proteins called **complement** that are also part of the immune system. Complement assists in killing bacteria, viruses, or infected cells.

All of these specialized cells and parts of the immune system offer the body protection against disease. This protection is called immunity. Humans have three types of immunity - innate, adaptive, and passive.

Innate Immunity: Everyone is born with innate (or natural) immunity, a type of general protection that humans have. Many of the germs that affect other species don't harm us. For example, the viruses that cause leukemia in cats or distemper in dogs don't affect humans. Innate immunity works both ways because some viruses that make humans ill - such as the virus that causes HIV/AIDS - don't make cats or dogs sick either. Innate immunity also includes the external barriers of the body, like the skin and mucous membranes (like those that line the nose, throat, and gastrointestinal tract), which are our first line of defense in preventing diseases from entering the body. If this outer defensive wall is broken (like if you get a cut), the skin attempts to heal the break quickly and special immune cells on the skin attack invading germs.

Adaptive Immunity: We also have a second kind of protection called adaptive (or active) immunity. This type of immunity develops throughout our lives. Adaptive immunity involves the lymphocytes (as in the process described above) and develops as children and adults are exposed to diseases or immunized against diseases through vaccination.

Passive Immunity: Passive immunity is "borrowed" from another source and it lasts for a short time. For example, antibodies in a mother's breast milk provide an infant with temporary immunity to diseases that the mother has been exposed to. This can help protect the infant against infection during the early years of childhood.

Everyone's immune system is different. Some people never seem to get infections, whereas others seem to be sick all the time. As a person gets older, he or she usually becomes immune to more germs as the immune system comes into contact with more and more of them. That's why adults and teens tend to get fewer colds than children - their bodies have learned to recognize and immediately attack many of the viruses that cause colds.

Things That Can Go Wrong With the Immune System

Disorders of the immune system can be broken down into four main categories:

- immunodeficiency disorders (primary or acquired)
- autoimmune disorders (in which the body's own immune system attacks its own tissue as foreign matter)
- allergic disorders (in which the immune system overreacts in response to an antigen)
- cancers of the immune system

Immunodeficiency Disorders

Immunodeficiencies (pronounced: ih-myoon-o-dih-**fih**-shun-seez) occur when a part of the immune system is not present or is not working properly. Sometimes a person is born with an immunodeficiency - these are called primary immunodeficiencies. (Although primary immunodeficiencies are conditions that a person is born with, symptoms of the disorder sometimes may not show up until later in life.) Immunodeficiencies can also be acquired through infection or produced by drugs. These are sometimes called secondary immunodeficiencies.

Immunodeficiencies can affect B lymphocytes, T lymphocytes, or phagocytes. An example of the most common immunodeficiency disorder is **IgA deficiency**. IgA is an immunoglobulin that is found primarily in the saliva and other body fluids that help guard the entrances to the body. IgA deficiency is a disorder in which the body doesn't produce enough of the antibody IgA. People with IgA deficiency tend to have allergies or get more colds and other respiratory infections, but the condition is usually not severe.

Acquired immunodeficiencies usually develop after a person has a disease, although they can also be the result of malnutrition, burns, or other medical problems. Certain medicines also can cause problems with the functioning of the immune system. Some examples of secondary immunodeficiencies:

- **HIV (human immunodeficiency virus) infection and AIDS (acquired immunodeficiency syndrome).** This disease slowly and steadily destroys the immune system. It is caused by HIV, a virus which wipes out certain types of lymphocytes called T-helper cells. Without T-helper cells, the immune system is unable to defend the body against normally harmless organisms, which can cause life-threatening infections in people who have AIDS. Newborns can get HIV infection from their mothers while in the uterus, during the birth process, or during breastfeeding. Teens and adults can get HIV infection by having unprotected sexual intercourse with an infected person or from sharing contaminated needles for drugs, steroids, or tattoos.
- **Immunodeficiencies caused by medications.** There are several medicines that suppress the immune system. One of the drawbacks of chemotherapy treatment for cancer, for example, is that it not only attacks cancer cells, but other fast-growing, healthy cells, including those found in the bone marrow and other parts of the immune system. In addition, people with autoimmune disorders or who have had organ transplants may need to take immunosuppressant medications. These medicines can also reduce the immune system's ability to fight infections and can cause secondary immunodeficiency.

Autoimmune Disorders

In autoimmune disorders, the immune system mistakenly attacks the body's healthy organs and tissues as though they were foreign invaders. Some examples of autoimmune diseases:

- **Lupus** is a chronic disease marked by muscle and joint pain and inflammation. The abnormal immune response may also involve attacks on the kidneys and other organs.
- **Juvenile rheumatoid arthritis** is a disease in which the body's immune system acts as though certain body parts such as the joints of the knee, hand, and foot are foreign tissue and attacks them.
- **Scleroderma** is a chronic autoimmune disease that can lead to inflammation and damage of the skin, joints, and internal organs.
- **Ankylosing spondylitis** is a disease that involves inflammation of the spine and joints, causing stiffness and pain.
- **Juvenile dermatomyositis** is a disorder marked by inflammation and damage of the skin and muscles.

Allergic Disorders

Allergic disorders occur when the immune system overreacts to exposure to antigens in the environment. The substances that provoke such attacks are called allergens. The immune response can cause symptoms such as swelling, watery eyes, and sneezing, and even a life-threatening reaction called anaphylaxis. Taking medications called antihistamines can relieve most symptoms. Some examples of allergic disorders:

- **Asthma**, a respiratory disorder that can cause breathing problems, frequently involves an allergic response by the lungs. If the lungs are oversensitive to certain allergens (like pollen, molds, animal dander, or dust mites), it can trigger breathing tubes in the lungs to become narrowed, leading to reduced airflow and making it hard for a teen to breathe.
- **Eczema** is a scaly, itchy rash also known as atopic dermatitis. Although atopic dermatitis is not necessarily caused by an allergic reaction, it more often occurs in kids and teens who have allergies, hay fever, or asthma or who have a family history of these conditions.
- **Allergies** of several types can occur in teens. Environmental allergies (to dust mites, for example), seasonal allergies (such as hay fever), drug allergies (reactions to specific medications or drugs), food allergies (such as to nuts), and allergies to toxins (bee stings, for example) are the common conditions people usually refer to as allergies.

Cancers of the Immune System

Cancer occurs when cells grow out of control. This can also happen with the cells of the immune system. Lymphoma involves the lymphoid tissues and is one of the more common childhood cancers. Leukemia, which involves abnormal overgrowth of leukocytes, is the most common childhood cancer. With current medications most cases of both types of cancer in kids and teens are curable.

Although immune system disorders usually can't be prevented, you can help your immune system stay strong and fight illnesses by staying informed about your condition and working closely with the doctor. And if you're lucky enough to be healthy, you can help your immune system keep you that way by washing your hands often to avoid infection, eating right, getting plenty of exercise, and getting regular medical checkups.

KIDNEYS AND URINARY TRACT

Our bodies produce several kinds of wastes, including sweat, carbon dioxide gas, feces (also known as stool), and urine (pee). These wastes exit the body in different ways: Sweat is released through pores (tiny holes) in the skin. Water vapor and carbon dioxide are exhaled (breathed out) from the lungs. And undigested food materials are formed into feces in the intestines and excreted from the body as solid waste in bowel movements.

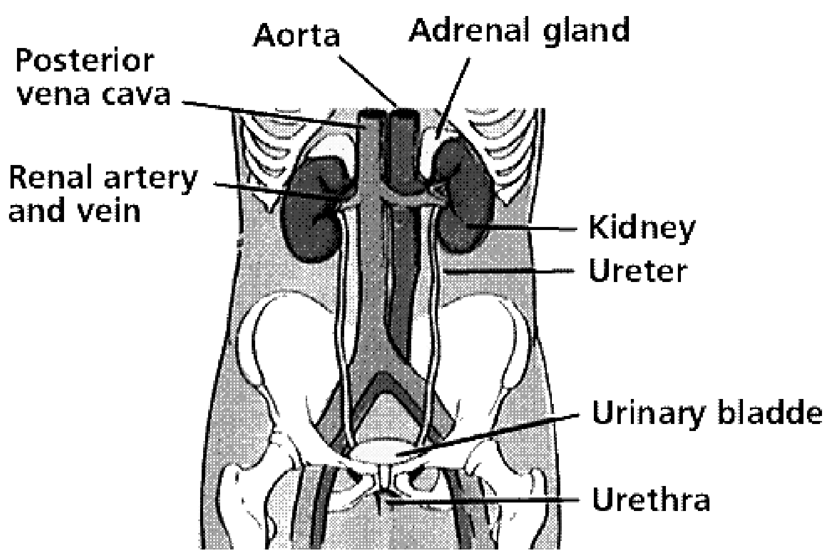
Urine, which is produced by the **kidneys**, contains the by-products of our body's metabolism - salts, toxins, and water - that end up in our blood. The kidneys and **urinary tract** (which includes the ureters, bladder, and urethra) filter and eliminate these waste substances from our blood. Without the kidneys, waste products and other toxins would soon build up in the blood to dangerous levels.

In addition to eliminating wastes, the kidneys and urinary tract also regulate many important body functions. For example, the kidneys monitor and maintain the body's balance of water, ensuring that our tissues receive enough water to function properly and be healthy.

When you're asked to give a urine sample during a doctor's visit, the results reveal how well your two kidneys are working. For example, blood, protein, or white blood cells in the urine may indicate injury, infection, or inflammation of the kidneys, and glucose in the urine may be an indication of diabetes.

What Do the Kidneys and Urinary Tract Do?

Although the two kidneys work together to perform many vital functions, people can live a normal, healthy life with just one kidney. In fact, some people are born with just one of these bean-shaped organs. If one kidney is removed, the remaining one will enlarge within a few months to take over the role of filtering blood on its own.



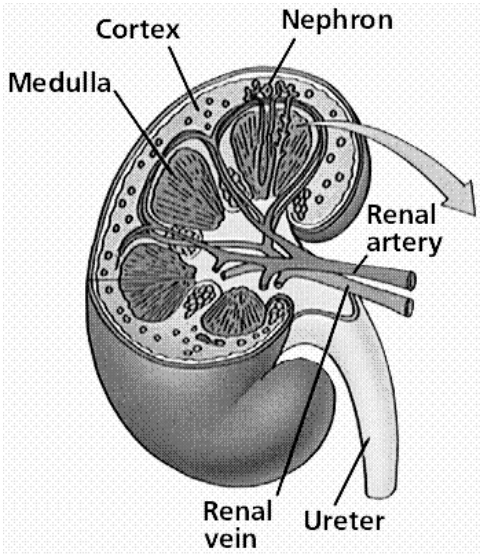
Every minute, more than 1 quart (about 1 liter) of blood passes through the kidneys, adding up to about 425 gallons (1,609 liters) of blood each day. About a quarter of our blood is in our kidneys at any one time, and the kidneys cleanse all of the blood in the body about every 50 minutes.

In addition to filtering blood, producing urine, and ensuring that body tissues receive enough water, the kidneys also regulate blood pressure and the level of vital salts in the blood. By regulating salt levels through production of an enzyme called **renin** (as well as other substances), the kidneys ensure that blood pressure is regulated.

The kidneys also secrete a hormone called **erythropoietin** (pronounced: eh-rith-ro-**po**-uh-ten), which stimulates and controls the body's red blood cell production (red blood cells carry oxygen throughout the body). In addition, the kidneys help regulate the acid-base balance (or the pH) of the blood and body fluids, which is necessary for the body to function normally.

Where Are the Kidneys and Urinary Tract and How Do They Work?

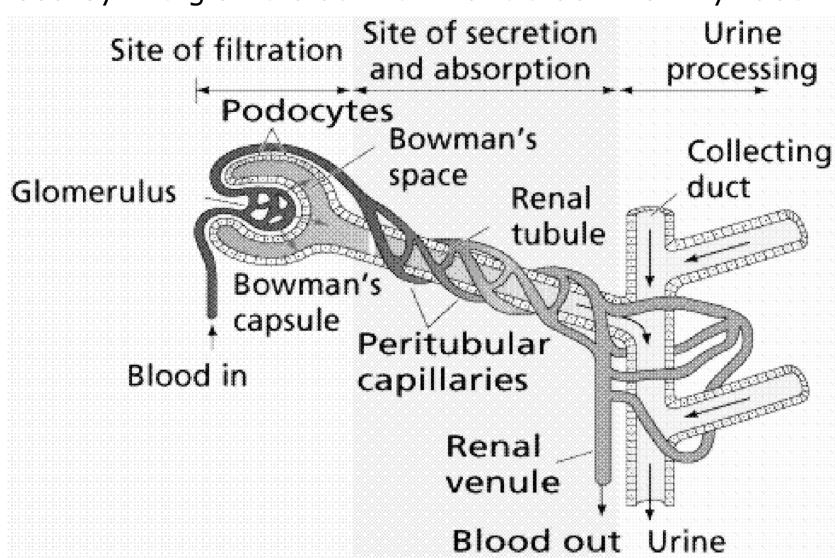
The kidneys are located just under the rib cage in the back, one on each side. The right kidney is located below the liver, so it's a little lower than the left one. Each adult kidney is about 5 inches (127 millimeters) long, 3 inches (76 millimeters) wide, and 1 inch (25 millimeters) thick. Each has an outer layer called the **cortex**,



which contains the filtering units. The center part of the kidney, the **medulla** (pronounced: **muh**-duh-luh) has 10 to 15 fan-shaped structures called **pyramids**. These drain urine into cup-shaped tubes called **calyxes** (pronounced: **kay**-luh-seez). A layer of fat surrounds the kidneys to cushion and help hold them in place.

Here's how the kidneys filter blood: Blood travels to each kidney through the **renal artery**, which enters the kidney at the **hilus** (pronounced: **hy**-luss), the indentation in the kidney that gives it its bean shape. As it enters the cortex, the artery branches out; each branch envelops the **nephrons** (pronounced: **neh**-fronz) - 1 million tiny filtering units in each kidney that remove the harmful substances from the blood.

Each of the nephrons contains a filter called the **glomerulus** (pronounced: gluh-**mer**-yuh-lus), which contains a network of tiny blood vessels known as capillaries. The fluid filtered from the blood by the glomerulus then travels down a tiny tube-like structure called a **tubule** (pronounced: **tu**-byool) that adjusts the level of salts, water, and wastes that are excreted in the urine.



Filtered blood leaves the kidney through the **renal vein** and flows back to the heart.

The continuous blood supply entering and leaving the kidneys gives the kidneys their dark red color. While the blood is in the kidneys, water and some of the other blood components (such as acids, glucose, and other nutrients) are reabsorbed back into the bloodstream. Left behind is urine. Urine is a concentrated solution of waste material containing water, **urea** (pronounced: yoo-**ree**-uh, a waste product that forms when proteins are broken down), salts, amino acids, by-products of bile from the liver, ammonia, and any substances that cannot be reabsorbed into the blood. Urine also contains **urochrome** (pronounced: **yur**-uh-krome), a pigmented blood product that gives urine its yellowish color.

The **renal pelvis**, located near the hilus, collects the urine flowing from the calyxes. From the renal pelvis, urine is transported out of the kidneys through the **ureters** (pronounced: **yur**-uh-ters), tubes that carry the urine out of each kidney to be stored in the urinary **bladder** - a muscular collection sac in the lower abdomen.

The bladder expands as it fills and can hold about half a liter (2 cups) of urine at any given time (an average adult produces about 1 1/2 liters, or 6 cups, of urine per day). An adult needs to excrete at least one third of this amount to adequately clear waste products from the body. Producing too much or not enough urine may be a sign of illness.

When the bladder is full, nerve endings in its wall send impulses to the brain. When a person is ready to urinate, the bladder walls contract and the **sphincter** (pronounced: **sfink**-ter, a ring-like muscle that guards the exit from the bladder to the urethra) relaxes. The urine is ejected from the bladder and out of the body through the **urethra** (pronounced: yoo-**ree**-thruh), another tube-like structure. The male urethra ends at the tip of the penis; the female urethra ends just above the vaginal opening.

THINGS THAT CAN GO WRONG WITH THE KIDNEYS AND URINARY TRACT

Like other systems in the body, the entire urinary tract is subject to diseases and disorders. In kids and teens, the more common kidney and urinary tract problems include:

Congenital problems of the urinary tract. As a fetus develops in the womb, any part of the urinary tract can grow to an abnormal size or in an abnormal shape or position. One of the more common congenital abnormalities (meaning abnormalities that exist at birth) is **duplication of the ureters**, in which a kidney has two ureters instead of one. This defect occurs in about one out of every 125 births and can cause the kidney to develop problems with infection and scarring over time.

Another congenital problem is **horseshoe kidney**, where the two kidneys are fused (connected) into one arched kidney that usually functions normally, but is more prone to develop problems later in life. This condition is found in one out of every 500 births.

Glomerulonephritis is an inflammation of the glomeruli, the parts of the filtering units (nephrons) of the kidney that contain a network of capillaries (tiny blood vessels). The most common form of this condition is post-streptococcal glomerulonephritis, which usually occurs in young children.

Hypertension (high blood pressure) can result when the kidneys are impaired by disease. The kidneys control blood pressure by regulating the amount of salt in the body and by producing the enzyme **renin** that, along with other substances, controls the constriction of muscle cells in the walls of the blood vessels.

Kidney (renal) failure can be **acute** (which means sudden) or **chronic** (occurring over time and usually long lasting or permanent). In either form of kidney failure, the kidneys slow down or stop filtering blood effectively, causing waste products and toxic substances to build up in the blood.

Acute kidney failure may be due to bacterial infection, injury, shock, heart failure, poisoning, or drug overdose. Treatment includes correcting the problem that led to the failure and sometimes requires surgery or **dialysis** (which involves using a machine or other artificial device to remove the excess salts and water and other wastes from the body when the kidneys are unable to perform this function).

Chronic kidney failure involves a deterioration of kidney function over time. In kids and teens, it can result from acute kidney failure that fails to improve, birth defects of the kidney, chronic kidney diseases, or chronic severe high blood pressure. If diagnosed early, chronic kidney failure can be treated, but usually not reversed, and may require a kidney transplant at some point in the future.

Kidney stones (or nephrolithiasis) result from the buildup of crystallized salts and minerals such as calcium in the urinary tract. Stones (also called **calculi**) can also form after an infection. If kidney stones are large enough to block the kidney or ureter, they can cause severe abdominal pain. But the stones usually pass through the urinary tract on their own. In some cases, they may need to be removed surgically.

Nephritis is any inflammation of the kidney. It can be caused by infection, an autoimmune disease (such as lupus), or it may be **idiopathic** (which means the exact cause may not be known or understood). Nephritis is generally detected by high levels of protein and blood in the urine.

Urinary tract infection (UTI) is infection of a part of or throughout the urinary tract, usually caused by bacteria. UTIs are most commonly caused by intestinal bacteria, such as E. coli, that are normally found in feces. These bacteria can cause infections anywhere in the urinary tract, including the kidneys. Most UTIs occur in the lower urinary tract, especially in the bladder and urethra. Teen girls are more likely to develop UTIs than boys; this may be because girls have shorter urethras than boys.

Vesicoureteral reflux (VUR) is a condition in which urine abnormally flows backward (or refluxes) from the bladder into the ureters. It may even reach the kidneys, where infection and scarring can occur over time. VUR occurs in 1% of children and tends to run in families. It's often detected after a young infant or child has a first urinary tract infection

METABOLISM

Every time you swallow a bite of sandwich or slurp a smoothie, your body works hard to process the nutrients you've eaten. Long after the dishes are cleared and the food is digested, the nutrients you've taken in become the building blocks and fuel needed by your body. Your body gets the energy it needs from food through a process called metabolism.

What Is Metabolism and What Does It Do?

Metabolism (pronounced: muh-**tah**-buh-lih-zum) is a collection of chemical reactions that takes place in the body's cells. Metabolism converts the fuel in the food we eat into the energy needed to power everything we do, from moving to thinking to growing. Specific proteins in the body control the chemical reactions of metabolism, and each chemical reaction is coordinated with other body functions. In fact, thousands of metabolic reactions happen at the same time - all regulated by the body - to keep our cells healthy and working.

Metabolism is a constant process that begins when we're conceived and ends when we die. It is a vital process for all life forms - not just humans. If metabolism stops, living things die.

Here's an example of how the process of metabolism works in humans - and it begins with plants. First, a green plant takes in energy from sunlight. The plant uses this energy and a molecule called cholorophyll (which gives plants their green color) to build sugars from water and carbon dioxide. This process is called **photosynthesis**, and you probably learned about it in biology class.

When people and animals eat the plants (or, if they're carnivores, they eat animals that have eaten the plants), they take in this energy (in the form of sugar), along with other vital cell-building chemicals. The body's next step is to break the sugar down so that the energy released can be distributed to, and used as fuel by, the body's cells.

After food is eaten, molecules in the digestive system called **enzymes** break proteins down into amino acids, fats into fatty acids, and carbohydrates into simple sugars (e.g., glucose). In addition to sugar, both amino acids and fatty acids can be used as energy sources by the body when needed. These compounds are absorbed into the blood, which transports them to the cells. After they enter the cells, other enzymes act to speed up or regulate the chemical reactions involved with "metabolizing" these compounds. During these processes, the energy from these compounds can be released for use by the body or stored in body tissues, especially the liver, muscles, and body fat.

In this way, the process of metabolism is really a balancing act involving two kinds of activities that go on at the same time - the building up of body tissues and energy stores and the breaking down of body tissues and energy stores to generate more fuel for body functions:

- **Anabolism** (pronounced: uh-**nah**-buh-lih-zum), or **constructive metabolism**, is all about building and storing: It supports the growth of new cells, the maintenance of body tissues, and the storage of energy for use in the future. During anabolism, small molecules are changed into larger, more complex molecules of carbohydrate, protein, and fat.
- **Catabolism** (pronounced: kuh-**tah**-buh-lih-zum), or **destructive metabolism**, is the process that produces the energy required for all activity in the cells. In this process, cells break down large molecules (mostly carbohydrates and fats) to release energy. This energy release provides fuel for anabolism, heats the body, and enables the muscles to contract and the body to move. As complex chemical units are broken down into more simple substances, the waste products released in the process of catabolism are removed from the body through the skin, kidneys, lungs, and intestines.

Several of the hormones of the endocrine system are involved in controlling the rate and direction of metabolism. **Thyroxine** (pronounced: thigh-**rahk**-sun), a hormone produced and released by the **thyroid** (pronounced: **thigh**-royd) gland, plays a key role in determining how fast or slow the chemical reactions of metabolism proceed in a person's body.

Another gland, the **pancreas** (pronounced: **pan**-kree-us) secretes (gives off) hormones that help determine whether the body's main metabolic activity at a particular time will be anabolic or catabolic. For example, after eating a meal, usually more anabolic activity occurs because eating increases the level of glucose - the body's most important fuel - in the blood. The pancreas senses this increased level of glucose and releases the hormone **insulin** (pronounced: **in**-suh-lin), which signals cells to increase their anabolic activities.

Metabolism is a complicated chemical process, so it's not surprising that many people think of it in its simplest sense: as something that influences how easily our bodies gain or lose weight. That's where calories come in. A **calorie** is a unit that measures how much energy a particular food provides to the body. A chocolate bar has more calories than an apple, so it provides the body with more energy - and sometimes that can be too much of a good thing. Just as a car stores gas in the gas tank until it is needed to fuel the engine, the body stores calories - primarily as fat. If you overfill a car's gas tank, it spills over onto the pavement. Likewise, if a person eats too many calories, they "spill over" in the form of excess fat on the body.

The number of calories a person burns in a day is affected by how much that person exercises, the amount of fat and muscle in his or her body, and the person's basal metabolic rate. The **basal metabolic rate**, or BMR, is a measure of the rate at which a person's body "burns" energy, in the form of calories, while at rest. The BMR can play a role in a person's tendency to gain weight. For example, a person with a low BMR (who therefore burns fewer calories while at rest or sleeping) will tend to gain more pounds of body fat over time, compared with a similar-sized person with an average BMR who eats the same amount of food and gets the same amount of exercise.

What factors influence a person's BMR? To a certain extent, a person's basal metabolic rate is inherited - passed on through the genes the person gets from his or her parents. Sometimes health problems can affect a person's BMR (see below). But people can actually change their BMR in certain ways. For example, exercising more will not only cause a person to burn more calories directly from the extra activity itself, but becoming more physically fit will increase BMR as well. BMR is also influenced by body composition - people with more muscle and less fat generally have higher BMRs.

THINGS THAT CAN GO WRONG WITH METABOLISM

Most of the time your metabolism works effectively without you giving any thought to it. But sometimes a person's metabolism can cause major mayhem in the form of a metabolic disorder. In a broad sense, a metabolic disorder is any disease that is caused by an abnormal chemical reaction in the body's cells. Most disorders of metabolism involve either abnormal levels of enzymes of hormones or problems with the functioning of those enzymes or hormones. When the metabolism of body chemicals is blocked or defective, it can cause a buildup of toxic substances in the body or a deficiency of substances needed for normal body function, either of which can lead to serious symptoms.

Some metabolic diseases and conditions include:

Hyperthyroidism (pronounced: hi-per-**thigh**-roy-dih-zum). Hyperthyroidism is caused by an overactive thyroid gland. The thyroid releases too much of the hormone thyroxine, which increases the person's basal metabolic rate (BMR). It causes symptoms such as weight loss, increased heart rate and blood pressure, protruding eyes, and a swelling in the neck from an enlarged thyroid (goiter). The disease may be controlled with medications or through surgery or radiation treatments.

Hypothyroidism (pronounced: hi-po-**thigh**-roy-dih-zum)**.** Hypothyroidism is caused by a nonexistent or underactive thyroid gland, and it results from a developmental problem or a destructive disease of the thyroid. The thyroid releases too little of the hormone thyroxine, so a person's basal metabolic rate (BMR) is low. Not getting treatment for hypothyroidism can lead to brain and growth problems. Hypothyroidism slows body processes and causes fatigue, slow heart rate, excessive weight gain, and constipation. Teens with this condition can be treated with oral thyroid hormone to achieve normal levels in the body.

Inborn errors of metabolism. Some metabolic diseases are inherited. These conditions are called inborn errors of metabolism. When babies are born, they're tested for many of these metabolic diseases. Inborn errors of metabolism can sometimes lead to serious problems if they're not controlled with diet or medication from an early age. Examples of inborn errors of metabolism include **galactosemia** (babies born with this inborn error of metabolism do not have enough of the enzyme that breaks down the sugar in milk called galactose) and **phenylketonuria** (this problem is due to a defect in the enzyme that breaks down the amino acid phenylalanine, which is needed for normal growth and protein production). Teens may need to follow a certain diet or take medications to control metabolic problems they've had since birth.

Type 1 diabetes mellitus (pronounced: dye-uh-**bee**-teez **meh**-luh-tus)**.** Type 1 diabetes occurs when the pancreas doesn't produce and secrete enough insulin. Symptoms of this disease include excessive thirst and urination, hunger, and weight loss. Over the long term, the disease can cause kidney problems, pain due to nerve damage, blindness, and heart and blood vessel disease. Teens with type 1 diabetes need to receive regular injections of insulin and control blood sugar levels to reduce the risk of developing problems from diabetes.

Type 2 diabetes. Type 2 diabetes happens when the body can't respond normally to insulin. The symptoms of this disorder are similar to those of type 1 diabetes. Many children and teens who develop type 2 diabetes are overweight, and this is thought to play a role in their decreased responsiveness to insulin. Some teens can be treated successfully with dietary changes, exercise, and oral medication, but insulin injections are necessary in other cases. Controlling blood sugar levels reduces the risk of developing the same kinds of long-term health problems that occur with type 1 diabetes.

MOUTH AND TEETH

The first thing that comes to mind when you think of your mouth is probably eating - or kissing! But your mouth's a lot more than an input slot for food or a tool for smooching your sweetie. Your mouth and teeth form your smile, which is often the first thing people notice when they look at you. The mouth is also essential for speech: The tongue (which also allows us to taste) enables us to form words with the help of our lips and teeth. The tongue hits the teeth to make certain sounds. The th sound, for example, is produced when the tongue brushes against the upper row of teeth. If a person has a lisp, that means the tongue touches the teeth instead of directly behind them when saying words with the s sound.

Without our teeth, we'd have to live on a liquid diet or a diet of soft, mashed food. The hardest substances in the body, the teeth are necessary for **mastication** - a fancy way of saying chewing - the process by which we tear, cut, and grind food in preparation for swallowing. Chewing allows enzymes and lubricants released in the mouth to further digest, or break down, food. This makes the mouth one of the first steps in the digestive process. Read on to find out how each aspect of the mouth and teeth plays a role in our daily lives.

Basic Anatomy of the Mouth and Teeth

The mouth is lined with **mucous membranes** (pronounced: **myoo**-kus **mem**-branes). Just as skin lines and protects the outside of the body, mucous membranes line and protect the inside. Mucous membranes make mucus, which keeps them moist.

The membrane-covered roof of the mouth is called the **palate**. The front part consists of a bony portion called the hard palate, with a fleshy rear part called the soft palate. The hard palate divides the mouth from the nose above. The soft palate forms a curtain between the mouth and the throat (or **pharynx -** pronounced: **fa**-rinks) to the rear. The soft palate contains the **uvula** (pronounced: **yoo**-vyoo-luh), the dangling fleshy object at the back of the mouth. The **tonsils** are located on either side of the uvula and look like twin pillars holding up the opening to the pharynx.

A bundle of muscles extends from the floor of the mouth to form the **tongue**. The upper surface of the tongue is covered with tiny projections called papillae. Our taste buds are located here. The four types of taste buds - sweet, salty, sour, and bitter - are grouped in different parts of the tongue.

Three pairs of **salivary glands** in the walls and floor of the mouth secrete saliva, which contains a digestive enzyme called amylase that starts the breakdown of carbohydrates even before food enters the stomach.

The **lips** are covered with skin on the outside and with slippery mucous membranes on the inside of the mouth. The major lip muscle, called the **orbicularis oris** (pronounced: or-**bik**-yoo-lar-iss or-iss), allows for the lips' mobility. The reddish tint of the lips comes from underlying blood vessels, which is why the lips can bleed so easily with injury. The inside part of the lips connects to the gums.

There are several types of teeth:

- **Incisors** are the squarish, sharp-edged teeth at the front and middle of the mouth. There are four on the bottom and four on the top.
- To the sides of the incisors are the long, sharp **canines,** two on the bottom and two on the top. The upper canines are sometimes called eyeteeth.
- Behind the canines are the **premolars**, or bicuspids. There are two sets, or a total of four premolars, in each jaw - one behind each of the canines on the bottom and one behind each canine on the top.
- The **molars**, situated behind the premolars, have points and grooves. There are 12 molars in the adult mouth - two sets each of first, second, and third molars in both the upper and lower jaw. The third molars are called **wisdom teeth**. Wisdom teeth get their name because, as the last teeth to erupt, they break through when a person is becoming an adult and is

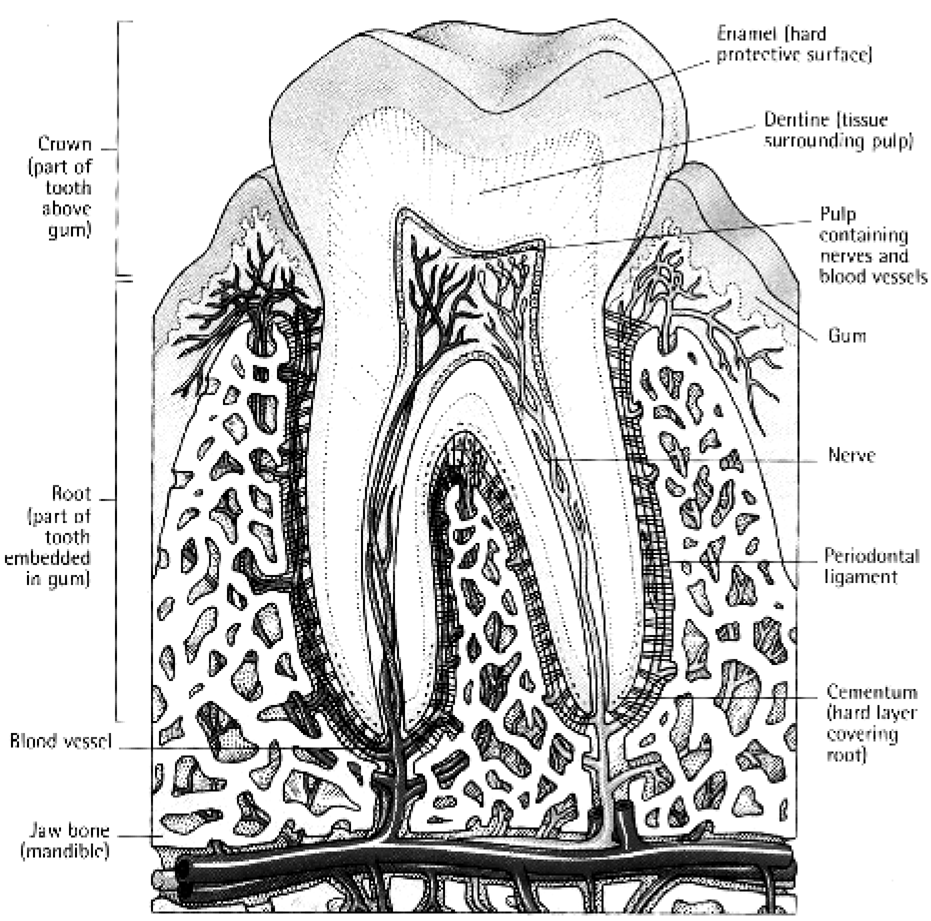
supposedly wiser. Wisdom teeth are not essential today, but some people believe they evolved thousands of years ago when human diets consisted of mostly raw foods that required extra chewing power. Because wisdom teeth can crowd out the other teeth, a dentist may need to remove them. This often happens during a person's teenage years.

Each tooth is made of four types of tissue: pulp, dentin, enamel, and cementum. The **pulp** is the innermost portion of the tooth. Unlike the outer parts of the tooth, the pulp is soft. It is made of connective tissue, nerves, and blood vessels, which nourish the tooth. The pulp has two parts: the pulp chamber, which lies in the crown (or top part of the tooth) and the root canal, which is in the bottom part of the tooth that lies beneath the gums. Blood vessels and nerves enter the root through a small hole at the very bottom of the tooth and extend through the canal into the pulp chamber. **Dentin** surrounds the pulp. A hard yellow substance that is mostly made up of mineral salts and water, dentin makes up most of the tooth. It is the dentin that gives the tooth its slightly yellowish tint.

Both the dentin and pulp cover the whole tooth from the crown into the root. But the outermost layer covering the tooth is different, depending on whether it sits above the gum or below it. **Enamel**, the hardest tissue in the body, covers the crown. Under the gum line, a bony layer of **cementum** covers the outside of the root and holds the tooth in place within the jawbone. Cementum is as hard as bone but not as hard as enamel, which enables the tooth to withstand the pressure of chewing and protects it from harmful bacteria and changes in temperature from hot and cold foods.

Tooth structure

The teeth are encased in sockets in the jaw bone and held in place by ligaments and shock-absorbent gums. At the center of each tooth there is a soft pulp which contains blood vessels and nerves; this is surrounded by a layer of sensitive tissue called dentine. Above the gum, the tooth has an outer covering of hard enamel. Below the gum, a bonelike tissue called cementum forms the tooth's outer layer.



Normal Development of the Mouth and Teeth

Humans are **diphyodont** (pronounced: dy-**fy**-uh-dant), meaning that they develop two sets of teeth. The first set of teeth, the **deciduous** (pronounced: duh-**sid**-you-wus) teeth are also called the milk, primary, temporary, falling-off, or baby teeth. These teeth begin to develop before birth, push through the gums between the ages of 6 months and 1 year (this process is called **eruption**), and usually start to fall out when a kid is around 6 years old. They are replaced by a set of 32 **permanent** teeth, which are also called secondary or adult teeth.

Although teeth aren't visible at birth, both the deciduous and permanent teeth are forming beneath the gums. By the time a child is 3 years old, he or she has a set of 20 deciduous teeth, 10 in the lower and 10 in the upper jaw. Each jaw has four incisors, two canines, and four molars.

The deciduous teeth help the permanent teeth erupt in their normal positions; most of the permanent teeth form just beneath the roots of the deciduous teeth above them. When a primary tooth is preparing to fall out, its root begins to dissolve. This root has completely dissolved by the time the permanent tooth below it is ready to erupt.

The phase during which permanent teeth develop usually lasts for about 15 years as the jaw steadily grows into its adult form. From ages 6 to 9, the incisors and first molars start to come in. Between ages 10 and 12, the first and second premolars, as well as the canines, erupt. From 12 to 13, the second molars come in. The wisdom teeth (third molars) erupt between the ages of 17 and 21. Sometimes there isn't room in a person's mouth for all the permanent teeth. If this happens, the wisdom teeth may not come through at all. Overcrowding of the teeth is one of the reasons people get braces during their teenage years.

What Do the Mouth and Teeth Do?

The mouth and teeth play an important role in digesting food. Food is torn, ground, and moistened in the mouth. Each type of tooth serves a different function in the chewing process. Incisors cut foods when you bite into them. The sharper, longer canines tear food. The premolars grind and mash food. Molars, with their points and grooves, are responsible for the most vigorous grinding. All the while, the tongue helps to push the food up against our teeth.

As we chew, the salivary glands secrete saliva, which moistens the food and helps break it down further. As well as containing digestive enzymes, saliva makes it easier to chew and swallow foods (especially dry foods).

Once food has been converted into a soft, moist mass, it's pushed into the pharynx at the back of the mouth and is swallowed. When we swallow, the soft palate closes off the nasal passages from the throat to prevent food from entering the nose.

THINGS THAT CAN GO WRONG WITH THE MOUTH AND TEETH

Proper dental care is essential to maintaining healthy teeth and avoiding tooth decay and gum disease. A good diet, brushing and flossing after eating, and regular dental checkups are all necessary in taking good care of your teeth. Some common mouth and dental diseases and conditions are listed below.

Diseases and Conditions of the Mouth:

- Aphthous stomatitis (canker sores). Canker sores are a common form of mouth ulcer that girls get more often than guys. Although their cause is not completely understood, mouth injuries, stress, dietary deficiencies, hormonal changes (as with the menstrual cycle), or food allergies can trigger them. They usually appear on the inner surface of the cheeks, lips, tongue, soft palate, or the base of the gums, and begin with a tingling or burning sensation followed by a painful sore called an ulcer. Pain subsides in 7 to 10 days, with complete healing in 1 to 3 weeks.
- Cleft lip and cleft palate are birth defects in which the tissues of the mouth and/or lip don't form properly as a fetus is developing in the womb. Children born with cleft lip or cleft palate can have reconstructive surgery in infancy - and sometimes later - to repair the cleft. This surgery can prevent or lessen the severity of speech problems later in life.

- **Enteroviral stomatitis** is a common type of infection. People with this condition have small, painful ulcers inside their mouths that may decrease their desire to eat and drink, putting them at risk of dehydration.
- **Herpetic stomatitis (oral herpes).** Oral herpes causes painful, clustered blisters inside the mouth or on a person's lip. People can get this infection when they have direct contact (such as kissing!) with someone with the herpes simplex virus.
- **Periodontal disease.** Periodontal (pronounced: pare-ee-oh-**don**-tul) disease affects the gums and tissues supporting the teeth. **Gingivitis** (pronounced: jin-jih-**vy**-tus), an inflammation of the gums characterized by redness, swelling, and sometimes bleeding, is one common form of periodontal disease. It's usually caused by the accumulation of tartar (a hardened film of food particles and bacteria that builds up on teeth). Gingivitis is almost always the result of not brushing and flossing the teeth properly. When gingivitis isn't treated, it can lead to **periodontitis**, in which the gums loosen around the teeth and pockets of bacteria and pus form, sometimes damaging the supporting bone and causing tooth loss.

Diseases and Conditions of the Teeth:

- **Cavities and tooth decay.** When bacteria and food particles are allowed to settle on the teeth, plaque forms. The bacteria digest the carbohydrates in the food and produce acid, which dissolves the tooth's enamel and causes a cavity. If the cavity is not treated, the decay process progresses to involve the dentin. The most common ways to treat cavities and more serious tooth decay problems are filling the cavity with silver amalgam; performing a root canal procedure, which involves the removal of the pulp of a tooth; crowning a tooth with a cap that looks like a tooth made of metal, porcelain, or plastic; or removing or replacing the tooth. To avoid tooth decay and cavities, get in the habit of good dental care - including proper tooth brushing techniques.
- **Malocclusion** is the failure of the upper and lower teeth to meet properly when you bite down. The types of malocclusion include overbite, underbite, and crowding. Most of these conditions can be corrected with braces. Braces are metal or clear ceramic brackets bonded to the front of each tooth. Wires connecting the brackets are tightened periodically to force the teeth to move into the correct position.
- **Impacted wisdom teeth.** In many people, the wisdom teeth are unable to erupt normally so they either remain below the jawline or don't grow in properly. Dentists call these teeth impacted. Wisdom teeth usually become impacted because the jaw is not large enough to accommodate all the teeth that are growing in and the mouth becomes overcrowded. Impacted teeth can damage other teeth or become painful and infected. Dentists can check if a person has impacted wisdom teeth by taking X-rays of the teeth. If, after looking at the X-rays, a dentist thinks there's a chance that impacted teeth may cause problems, he or she will usually recommend that the tooth or teeth be removed (extracted).

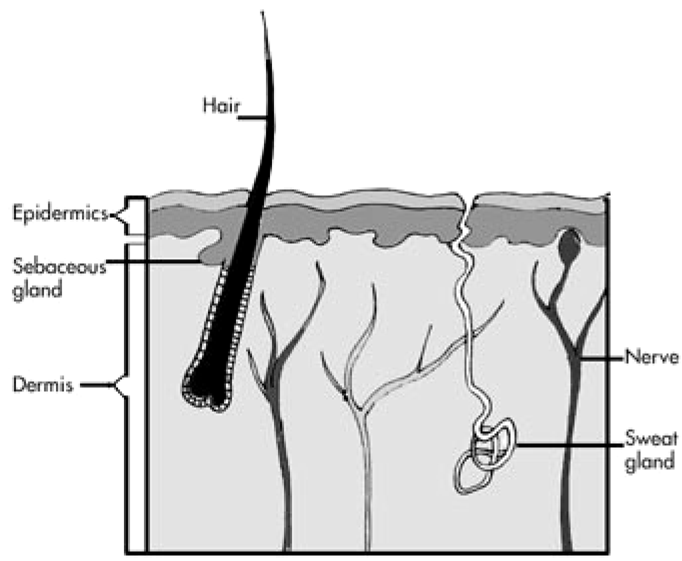
SKIN, HAIR, AND NAILS

Skin is our largest organ. If the skin of a typical 150-pound (68-kilogram) adult male were stretched out flat, it would cover about 2 square yards (1.7 square meters) and weigh about 9 pounds (4 kilograms). Our skin protects the network of muscles, bones, nerves, blood vessels, and everything else inside our bodies. Our eyelids have the thinnest skin, the soles of our feet the thickest.

Hair is actually a modified type of skin. Hair grows everywhere on the human body except the palms of the hands, soles of the feet, eyelids, and lips. Hair grows more quickly in summer than winter, and more slowly at night than during the day.

Like hair, nails are a type of modified skin. Nails protect the sensitive tips of fingers and toes. Human nails aren't necessary for living, but they do provide support for the tips of the fingers and toes, protect them from injury, and aid in picking up small objects. Without them, we'd have a hard time scratching an itch or untying a knot. Nails can be an indicator of a person's general health, and illness often affects their growth.

Skin Basics



Skin is essential in many ways. It forms a barrier that prevents harmful substances and microorganisms from entering the body. It protects body tissues against injury. It also controls the loss of life-sustaining fluids like blood and water, helps regulate body temperature through perspiration, and protects from the sun's damaging ultraviolet rays.

Without the nerve cells in skin, people couldn't feel warmth, cold, or other sensations. For instance, goosebumps form when the erector pili muscles contract to make hairs on the skin stand up straight when someone is cold or frightened — the blood vessels keep the body from losing heat by narrowing as much as possible and keeping the warm blood away from the skin's surface, offering insulation and protection.

Every square inch of skin contains thousands of cells and hundreds of sweat glands, oil glands, nerve endings, and blood vessels. Skin is made up of three layers: the **epidermis**, **dermis**, and the **subcutaneous tissue**.

The upper layer of our skin, the epidermis, is the tough, protective outer layer. It's about as thick as a sheet of paper over most parts of the body. The epidermis has four layers of cells that are constantly flaking off and being renewed. In these four layers are three special types of cells:

- **Melanocytes** produce melanin, the pigment that gives skin its color. All people have roughly the same number of melanocytes; those of dark-skinned people produce more melanin. Exposure to sunlight increases the production of melanin, which is why people get suntanned or freckled.
- **Keratinocytes** produce keratin, a type of protein that is a basic component of hair, skin, nails, and helps create an intact barrier.
- **Langerhans** cells help protect the body against infection.

Because the cells in the epidermis are completely replaced about every 28 days, cuts and scrapes heal quickly.

Below the epidermis is the next layer of our skin, the dermis, which is made up of blood vessels, nerve endings, and connective tissue. The dermis nourishes the epidermis. Two types of fibers in the dermis — collagen and elastin — help the skin stretch when we bend and reposition itself when we straighten up. Collagen is strong and hard to stretch, and elastin, as its name suggests, is elastic. In older people, some of the elastin-containing fibers degenerate, which is one reason why the skin looks wrinkled.

The dermis also contains a person's **sebaceous glands**. These glands, which surround and empty into hair follicles and pores, produce the oil sebum that lubricates the skin and hair. Sebaceous glands are found mostly in the skin on the face, upper back, shoulders, and chest.

Most of the time, the sebaceous glands make the right amount of sebum. As a person's body begins to mature and develop during the teenage years, though, hormones stimulate the sebaceous glands to make more sebum. When pores become clogged by too much sebum and too many dead skin cells, this contributes to acne. Later in life, these glands produce less sebum, which contributes to dry skin as people age.

The bottom layer of our skin, the **subcutaneous tissue**, is made up of connective tissue, sweat glands, blood vessels, and cells that store fat. This layer helps protect the body from blows and other injuries and helps it hold in body heat.

There are two types of sweat glands. The **eccrine glands** are found everywhere, although they're mostly in the forehead, palms, and soles of the feet. By producing sweat, these glands help regulate body temperature, and waste products are excreted through them.

The **apocrine glands** develop at puberty and are concentrated in the armpits and pubic region. The sweat from the apocrine glands is thicker than that produced by the eccrine glands. Although this sweat doesn't smell, when it mixes with bacteria on the skin's surface, it can cause body odor. A normal, healthy adult secretes about 1 pint (about half a liter) of sweat daily, but this may be increased by physical activity, fever, or a hot environment.

Hair Basics

The hair on our heads isn't just there for looks. It keeps us warm by preserving heat. The hair in the nose, ears, and around the eyes protects these sensitive areas from dust and other small particles. Eyebrows and eyelashes protect eyes by decreasing the amount of light and particles that go into them. The fine hair that covers the body provides warmth and protects the skin. Hair also cushions the body against injury.

Human hair consists of the hair shaft, which projects from the skin's surface, and the root, a soft thickened bulb at the base of the hair embedded in the skin. The root ends in the hair bulb, which sits in a sac-like pit in the skin called the follicle, from which the hair grows.

At the bottom of the follicle is the papilla, where hair growth actually takes place. The papilla contains an artery that nourishes the root of the hair. As cells multiply and produce keratin to harden the structure, they're pushed up the follicle and through the skin's surface as a shaft of hair. Each hair has three layers: the **medulla** at the center, which is soft; the **cortex**, which surrounds the medulla and is the main part of the hair; and the **cuticle**, the hard outer layer that protects the shaft.

Hair grows by forming new cells at the base of the root. These cells multiply to form a rod of tissue in the skin. The rods of cells move upward through the skin as new cells form beneath them. As they move up, they're cut off from their supply of nourishment and start to form a hard protein called keratin in a process called **keratinization**. As this process occurs, the hair cells die. The dead cells and keratin form the shaft of the hair.

Each hair grows about ¼ inch (about 6 millimeters) every month and keeps on growing for up to 6 years. The hair then falls out and another grows in its place. The length of a person's hair depends on the length of the growing phase of the follicle. Follicles are active for 2 to 6 years; they rest for about 3 months after that. A person becomes bald if the scalp follicles become inactive and no longer produce new hair. Thick hair grows out of large follicles; narrow follicles produce thin hair.

The color of a person's hair is determined by the amount and distribution of melanin in the cortex of each hair (the same melanin that's found in the epidermis). Hair also contains a yellow-red pigment; people who have blonde or red hair have only a small amount of melanin in their hair. Hair becomes gray when people age because pigment no longer forms.

Nail Basics

Nails grow out of deep folds in the skin of the fingers and toes. As epidermal cells below the nail root move up to the surface of the skin, they increase in number, and those closest to the nail root become flattened and pressed tightly together. Each cell is transformed into a thin plate; these plates are piled in layers to form the nail. As with hair, nails are formed by keratinization. When the nail cells accumulate, the nail is pushed forward.

The skin below the nail is called the matrix. The larger part of the nail, the nail plate, looks pink because of the network of tiny blood vessels in the underlying dermis. The whitish crescent-shaped area at the base of the nail is called the **lunula**.

Fingernails grow about three or four times as quickly as toenails. Like hair, nails grow more rapidly in summer than in winter. If a nail is torn off, it will regrow if the matrix isn't severely injured. White spots on the nail are sometimes due to temporary changes in growth rate.

THINGS THAT CAN GO WRONG WITH THE SKIN, HAIR, AND NAILS

Some of the things that can affect the skin, nails, and hair are described below.

Dermatitis

The term dermatitis refers to any inflammation (swelling, itching, and redness) possibly associated with the skin. There are many types of dermatitis, including:

- **Atopic dermatitis (eczema).** It's a common, hereditary dermatitis that causes an itchy rash primarily on the face, trunk, arms, and legs. It commonly develops in infancy, but can also appear in early childhood. It may be associated with allergic diseases such as asthma and seasonal, environmental, and food allergies.
- **Contact dermatitis.** This occurs when the skin comes into contact with an irritating substance or one that the person is allergic or sensitive to. The best-known cause of contact dermatitis is poison ivy, but there are many others, including chemicals found in laundry detergent, cosmetics, and perfumes, and metals like nickel plating on jewelry, belt buckles, and the back of a snap.
- **Seborrheic dermatitis.** This oily rash, which appears on the scalp, face, chest, and back, is related to an overproduction of sebum from the sebaceous glands. This condition is common in infants and adolescents.

Bacterial Skin Infections

- **Impetigo.** Impetigo is a bacterial infection that results in a honey-colored, crusty rash, often on the face near the mouth and nose.
- **Cellulitis.** Cellulitis is an infection of the skin and subcutaneous tissue that typically occurs when bacteria are introduced through a puncture, bite, or other break in the skin. The area with cellulitis is usually warm, tender, and has some redness.
- **Streptococcal and staphylococcal infections.** These two kinds of bacteria are the main causes of cellulitis and impetigo. Certain types of these bacteria are also responsible for distinctive rashes on the skin, including the rashes associated with scarlet fever and toxic shock syndrome.

Fungal Infections of the Skin and Nails

- **Candidal dermatitis.** A warm, moist environment, such as that found in the folds of the skin in the diaper area of infants, is perfect for growth of the yeast Candida. Yeast infections of the skin in older children, teens, and adults are less common.

- **Tinea infection (ringworm).** Ringworm, which isn't a worm at all, is a fungus infection that can affect the skin, nails, or scalp. Tinea fungi can infect the skin and related tissues of the body. The medical name for ringworm of the scalp is tinea capitis; ringworm of the body is called tinea corporis; and ringworm of the nails is called tinea unguium. With tinea corporis, the fungi can cause scaly, ring-like lesions anywhere on the body.
- **Tinea pedis (athlete's foot).** This infection of the feet is caused by the same types of fungi that cause ringworm. Athlete's foot is commonly found in adolescents and is more likely to occur during warm weather.

Other Skin Problems

- **Parasitic infestations.** Parasites (usually tiny insects or worms) can feed on or burrow into the skin, often resulting in an itchy rash. Scabies and lice are examples of parasitic infestations. Both are contagious and can be easily caught from other people.
- **Viral infections.** Many viruses cause characteristic rashes on the skin, including varicella, the virus that causes chickenpox and shingles; herpes simplex, which causes cold sores; human papillomavirus, the virus that causes warts; and a host of others.
- **Acne (acne vulgaris).** Acne is most common in teens. Some degree of acne is seen in 85% of adolescents, and nearly all teens have the occasional pimple, blackhead, or whitehead.
- **Skin cancer.** Skin cancer is rare in children and teens, but good sun protection habits established during these years can help prevent skin cancers such as **melanoma** (a serious form of skin cancer that can spread to other parts of the body) later in life, especially among fair-skinned people who sunburn easily.

In addition to these diseases and conditions, the skin can be injured in a number of ways. Minor scrapes, cuts, and bruises heal quickly on their own, but other injuries — severe cuts and burns, for example — require medical treatment.

Disorders of the Scalp and Hair

- **Tinea capitis**, a type of ringworm, is a fungal infection that forms a scaly, ring-like lesion in the scalp. It's contagious and common among school-age children.
- **Alopecia** is an area of hair loss. Ringworm is a common cause of temporary alopecia in children. Alopecia can also be caused by tight braiding that pulls on the hair roots (called tension alopecia). Alopecia areata (when hair falls out in round or oval patches on the scalp) is a less common condition that can affect children and teens.

SPLEEN AND LYMPHATIC SYSTEM

The lymphatic system is an extensive drainage network that helps keep bodily fluid levels in balance and defends the body against infections. The lymphatic system is made up of a network of **lymphatic vessels**. These vessels carry **lymph -** a clear, watery fluid containing protein molecules, salts, glucose, urea, and other substances - throughout the body.

The spleen is located in the upper left part of the abdomen under the ribcage. It works as part of the lymphatic system to protect the body, clearing worn out red blood cells and other foreign bodies from the bloodstream to help fight off infection.

Why Are the Spleen and Lymphatic System Necessary?

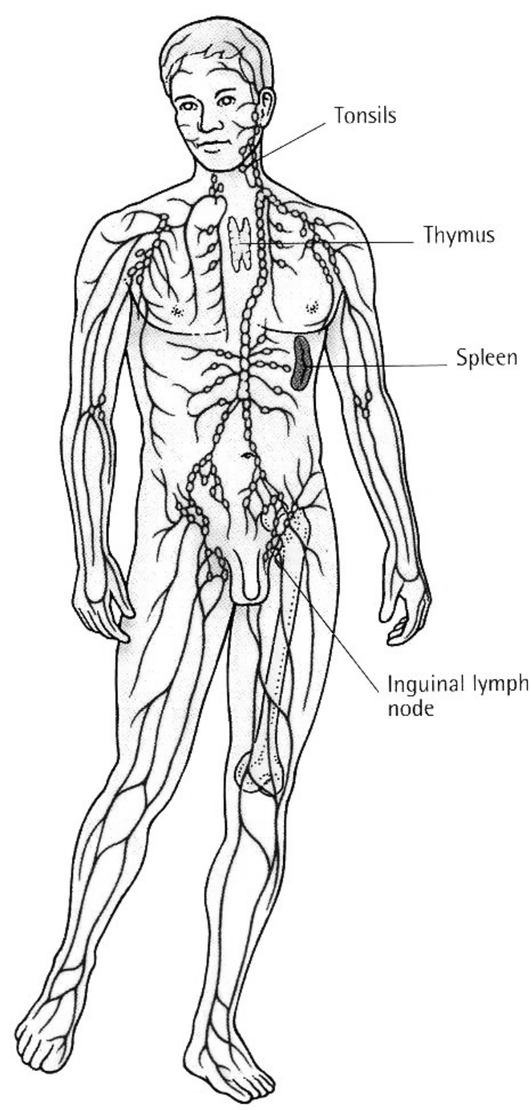
One of the lymphatic system's major jobs is to collect extra lymph fluid from body tissues and return it to the blood. This process is important because water, proteins, and other substances are continuously leaking out of tiny blood capillaries into the surrounding body tissues. If the lymphatic system didn't drain the excess fluid from the tissues, the lymph fluid would build up in the body's tissues, and they would swell.

The lymphatic system also helps defend the body against germs like viruses, bacteria, and fungi that can cause illnesses. Those germs are filtered out in the **lymph nodes**, which are small masses of tissue located along the network of lymph vessels. The nodes house **lymphocytes**, a type of white blood cell. Some of those lymphocytes make **antibodies**, special proteins that fight off germs and stop infections from spreading by trapping disease-causing germs and destroying them.

The spleen also helps the body fight infection. The spleen contains lymphocytes and another kind of white blood cell called **macrophages**, which engulf and destroy bacteria, dead tissue, and foreign matter and remove them from the blood passing through the spleen.

Basic Anatomy

The lymphatic system is a network of very small tubes (vessels) that drain lymph fluid from all over the body. The major parts of the lymph tissue are located in the bone marrow, spleen, thymus gland, lymph nodes, and the tonsils. The heart, lungs, intestines, liver, and skin also contain lymphatic tissue.



One of the major lymphatic vessels is the **thoracic duct**, which begins near the lower part of the spine and collects lymph from the pelvis, abdomen, and lower chest. The thoracic duct runs up through the chest and empties into the blood through a large vein near the left side of the neck. The **right lymphatic duct** is the other major lymphatic vessel. It collects lymph from the right side of the neck, chest, and arm, and empties into a large vein near the right side of the neck.

Lymph nodes are round or kidney shaped. They can be up to 1 inch in diameter. Most of the lymph nodes are found in clusters in the neck, armpit, and groin area. Nodes are also located along the lymphatic pathways in the chest, abdomen, and pelvis, where they filter the blood. Inside the lymph nodes, lymphocytes called **T-cells** and **B-cells** help the body fight infection. Lymphatic tissue is also scattered throughout the body in different major organs and in and around the gastrointestinal tract.

The spleen helps control the amount of blood and blood cells that circulate through the body and helps destroy damaged cells.

How A Healthy Lymph System Typically Works

Carrying Away Waste: Lymph fluid drains into lymph capillaries, which are tiny vessels. The fluid is then pushed along through the capillaries when a person breathes or the muscles contract. The lymph capillaries are very thin, and they have many tiny openings that allow gases, water, and nutrients to pass through to the surrounding cells, nourishing them and taking away waste products. When lymph fluid leaks through in this way it is called interstitial fluid. Lymph vessels collect the interstitial fluid and then return it to the bloodstream by emptying it into large veins in the upper chest, near the neck.

Fighting Infection: Lymph fluid enters the lymph nodes, where macrophages fight off foreign bodies like bacteria, removing them from the bloodstream. After these substances have been filtered out, the lymph fluid leaves the lymph nodes and returns to the veins, where it re-enters the bloodstream. When a person has an infection, germs collect in the lymph nodes. If the throat is infected, for example, the lymph nodes of the neck may swell. That's why doctors check for swollen lymph glands in the neck when your throat is infected.

THINGS THAT CAN GO WRONG WITH THE LYMPHATIC SYSTEM

Certain diseases can affect the lymph nodes, the spleen, or the collections of lymphoid tissue in certain areas of the body.

- **Lymphadenopathy.** This is a condition where the lymph nodes become swollen or enlarged, usually because of a nearby infection. Swollen lymph glands in the neck, for example, can be caused by a throat infection. Once the infection is treated, the swelling usually goes away. If several lymph node groups throughout the body are swollen, that can indicate a more serious disease that needs further investigation by a doctor.
- **Lymphadenitis.** Also called adenitis, this inflammation of the lymph node is caused by an infection of the tissue in the node. The infection can cause the skin overlying the lymph node to swell, redden, and feel warm and tender to the touch. It usually affects the lymph nodes in the neck and is often caused by a bacterial infection that can be easily treated with an antibiotic.
- **Lymphomas.** These cancers start in the lymph nodes when lymphocytes undergo changes and start to multiply out of control. The lymph nodes swell, and the cancer cells crowd out healthy cells and may cause tumors (solid growths) in other parts of the body.
- **Spleenomegaly** (enlarged spleen). In someone who is healthy, the spleen is usually small enough that it can't be felt when you press on the abdomen. But certain diseases can cause the spleen to swell to several times its normal size. Most commonly, this is due to a viral infection, such as mononucleosis. But in some cases, more serious diseases such as cancer can cause the spleen to expand.

If you have an enlarged spleen, your doctor will probably tell you to avoid contact sports like football for a while. If you're hit, the swollen spleen is vulnerable to rupturing (bursting). And if it ruptures, it can cause a huge amount of blood to be lost.

- **Tonsillitis.** Tonsillitis is caused by an infection of the tonsils, the lymphoid tissues in the back of the mouth at the top of the throat that normally help to filter out bacteria. When the tonsils are infected, they become swollen and inflamed, and can cause a sore throat, fever, and difficulty swallowing. The infection can also spread to the throat and surrounding areas, causing pain and inflammation. Someone with repeated tonsil infections may need to have them removed in a procedure called a tonsillectomy.

YOGA-VIDYA: THE SCIENCE OF YOGA

INTRODUCTION

Yoga is the **science of the SELF**. Yoga can also be termed the **science of man in depth**, the **science of conscious evolution** or the **science of human possibilities**. Yoga not only has the concepts but also the tools and technology needed to find OUR SELF. While the modern science looks outward the Yogi searches the depth of his own self. According to Yogamaharishi Dr Swami Gitananda Giri Guru Maharaj who was one of the foremost authorities on Rishiculture Ashtanga Yoga in the last century, **Yoga is a science and not only is it a science but is the mother of Science**. Dr. I K Taimni, another learned scholar known for his great analytical works on Yoga, even goes to the extent of calling Yoga the **"Science of Sciences".**

YOGA AS A SCIENCE

The characteristic of a science or Vidya is the approach and not merely content or quality of knowledge. Though Yoga has its foundations more than 5000 years ago and is principally an oral tradition, the verbal basis of **Yoga-Vidya** (Yogic Science) is found in the Upanishads (especially the Katha-Upanishad, Shvetashvatara-Upanishad and Maitrayaniya-Upanishad), the Yoga Sutras of Patanjali and the Bhagavad Gita. According to Prof. TR Anantharaman, President of the Indian Academy of Yoga, all of these Yoga scriptures are pre Buddhistic in nature and share a systematic and broad scientific basis. **Katha Upanishad,** one of the first written works on Yoga mentions the **Yoga-Vidya** (science of Yoga) and **Yoga-Vidhi** (the technological know how) of Yoga. The pure science of Yoga is **Adhyatma Vidya** (science of man in depth) while the technology or applied science (rules of Yoga practice) that is, the technology of unification or integration, is called **Yoga-Vidhi**. The scientific attitude of Yoga can be seen from the firm insistence on **Pariprasna** (enquiry or dialogue) as a pre requisite to higher knowledge as enunciated in the Bhagavad Gita (IV.34). Similarly the Yoga Sutras of Patanjali display a scientific attitude towards the acquisition of **Pramana** (true knowledge). Patanjali says that true knowledge can be acquired (Yoga Sutra: Chapter I, Verse7) by direct perception (**Pratyaksha**), rational inference (**Anumana**) and from reliable testimony (**Agama**). This use of the intellect (**Buddhi**) endowed with discrimination (**Viveka**) is typical of all Yoga traditions and their teachings. The Bhagavad Gita, which is sometimes referred to as the **Yoga Shastra,** shows the exchange between Arjuna and Yogeshwar Krishna to be of a genuine spirit of enquiry and a keen desire for truth, as one would expect from a modern scientist and his guide. The **Shiva-Samhita** (V.26-30) lists the characters of a fully qualified disciple (**shishya**) as follows. "**Endowed with great energy and enthusiasm, intelligent, heroic, learned in the scriptures, free from delusion...**" Aren't these very same qualities required by a true scientist (a seeker of true knowledge)?

TOOLS AND TECHNOLOGY OF YOGA (YOGA-VIDHI)

The process of Yoga is one of the understanding and achievement of Mind Control. The Yogis discovered that the mind has many levels such as **Mudha** (dull and inert mind), **Kshipta** (distracted mind), **Vikshipta** (partially distracted mind), **Ekagratha** (concentrated mind) and **Niruddha** (controlled mind). They also found that the thought waves (**Chitta-Vritti**) were five fold and are **Pramana** (conception), **Viparyaya** (misconception), **Vikalpa** (imagination), **Nidra** (sleep) and **Smrithi** (memory). They realized that without controlling these mental fluctuations there was no hope of spiritual evolution. This is why Maharishi Patanjali says, "Yoga is the stilling of the whirlpools of the mind (**Yogash chittavritti nirodhah**). Once this is achieved the Yogin rests in his essential self (**Tada drishtu swarupeva sthanam**). The method to achieve this state is through dedicated and determined practice and dispassion (**Abyasa vairagyabhyam tannirodhah**).

The Yogi views his being as a manifestation of the Divine and realizes that he is not only the physical body but also has four other bodies; the energy body, the mental body, the body of wisdom and the body of eternal bliss. This concept is known as the **Pancha Kosha**. He follows a systematic practice (**Abyasa**) of the eight fold path of Ashtanga (Raja) Yoga consisting of the moral restraints (**Yama**), ethical observances (**Niyama**), firm and comfortable postures (**Asana**), expansion of the vital life force (**Pranayama**), control of the senses (**Pratyahara**), concentration (**Dharana**) leading into meditation (**Dhyana**) and ultimately transcending the individual self in cosmic consciousness (**Samadhi**). This conscious evolution may take years and years (even lifetimes) of disciplined and dedicated practice (**Abyasa**), detachment or dispassion (**Vairagya**) and loads of discrimination (**Viveka**). Through such a systematic manner the Sadhak (seeker of Truth) attempts to unite (**Yuj**) his individual self (**Jivatma**) with the universal self (**Paramatma**).

VIEWS ON YOGA-VIDYA BY EMINENT YOGIS AND SCIENTISTS

Swami Vivekananda said, **"Yoga is really one of the grandest sciences…take up the study of this science as you would any other science of material nature and remember there is no mystery and no danger in it."**

Dr. I K Taimni, an eminent scholar known for his excellent work on the Yoga Sutras of Patanjali (The Science of Yoga) says, **"This science of sciences is too comprehensive in its nature and too profound in its doctrine to be fitted into the framework of any particular philosophy-either ancient or modern. It stands in its own right as a science based upon the eternal laws of the higher life and does not require the support of any science or philosophical system to uphold its claims. Its truths are based in the experiences and experiments of an unbroken line of mystics, occultists, saints and sages, who have realized and borne witness to them through the ages."**

Sri RR Diwakar, who was one of the founding fathers of the modern Indian political state, has the following to say. "While modern science (that is of an **experimental** nature) has brought us to the brink of a nuclear war, the Yoga-Vidya (that is **experiential** in nature) on the other hand brings about peace, harmony, love, friendliness and cooperation."

This experiential nature of Yoga is well brought out by **Vyasa's Yoga-Bhashya** wherein he says, "Yoga must be known through Yoga. Yoga grows through Yoga. He who is attentive towards Yoga long delights in yoga."(III.6). Similarly the **Yoga-Shikha-Upanishad** warns of the "**snare of textbooks**" (**Shastra-Jala**) referring to bookish learning without accompanying experience.

Dr. Georg Feuerstein Ph.D., Director of the Yoga Research Centre USA says in his excellent book 'The Shambala Guide to Yoga', "Long before physicists discovered that matter is energy vibrating at a certain rate, the Yogis of India had treated this body-mind as a playful manifestation of the ultimate power (Shakti), the dynamic aspect of Reality. They realized that to discover the true Self, one had to harness attention because the energy of the body-mind follows attention. A crude example of this process is the measurable increase of blood flow to our fingers and toes that occurs when we concentrate on them. The yogis are very careful about where they place their attention, for the mind creates patterns of energy, causing habits of thought and behavior that can be detrimental to the pursuit of genuine happiness".

Dr Dean Ornish, an eminent American medical doctor who has shown that Yogic lifestyle can reverse heart disease says, "Yoga is a system of perfect tools for achieving union as well as healing."

Dr VSSM Rao writes that, "The tradition of Yoga is so perfect that we have to seek ways of expounding it in modern scientific terminology instead of simply evaluating it in terms of current concepts of science, which is expanding so rapidly that a time may come when man would like to live by his intuition rather than by scientific planning, bristling with conflicts and balancing a number of variables not completely understood."

According to Dr B Ramamurthy, eminent neurosurgeon, Yoga practice re-orients the functional hierarchy of the entire nervous system. He has noted that Yoga not only benefits the nervous system but also the cardiovascular, respiratory, digestive, endocrine systems in addition to bringing about general biochemistry changes in the yoga practitioners.

Professor Dr SV Rao, an eminent medical doctor says, "**Yoga is a science because it is verifiable.** Yoga as a science of living is also an art. **Yoga, therefore, may be defined as the science and art of optimum living**. Yoga has the capacity to move, either side by side with medical science or independently. This is because Yoga has a sound system of etiology, diagnosis and pathogenesis of disease. Thus we have a complete system by itself in Yoga."

Yogamaharishi Dr Swami Gitananda Giri Guru Maharaj says, "Yoga is scientific and many of it practices can be measured by existing scientific methods. As a science of mind it offers a safe method of concentration and meditation educing a practical application of the power of the human mind. Its entire process is centered in awareness, that is why I call it the **science of awareness**."

PRESENT STATUS OF YOGA-VIDYA

Institutions such as AIIMS, BHU, NIMHANS, DIPAS, JIPMER, VK Yogas, Kaivalyadhama, Bihar School of Yoga and our own ICYER have done vast amounts of work in bringing forth the scientific methods of Yoga Vidya. Universities such as BHU, Sagar, Himachal, Venkateshwara and Andhra University have created Centers for Yoga education and Research and are doing great service. Scientists such as Dr BK Anand, Dr KK Datey, Dr KN Udupa, Dr B Ramamurthy, Dr W Selvamurthy, Dr T Desiraju, Dr Nagendra, Dr Nagaratna, Dr Shirley Telles, Dr MV Bhole, Dr Rajapurkar, Dr Mittimohan, Dr Lajpat Rai and Dr Madanmohan have contributed extensively towards the scientific understanding of Yoga Vidya and Yoga Vidhi. The Central Government has created the **Central Council for Research in Yoga and Naturopathy (CCRYN)** that is the governing body for Yoga research and education in our country under the Ministry of Health. Various private institutions are running in our country and doing their best to propagate Yoga-Vidya. Yoga therapy is being used both in conjunction with modern medicine or alternative systems of medicine as well as on its own in various centers. Various conditions such as diabetes, hypertension, arthritis, mental depression, bronchial asthma etc have been found to be relieved by Yoga Therapy and centers such as sVYASA, Kaivalyadhama, Manipal Institute and the Moraji Desai National institute are doing a great deal of work in this field.

WHY HAVEN'T WE MADE BETTER USE OF THIS MAGNIFICIENT SCIENCE ?

Because, even fifty years after independence we still suffer from a 'colonial hangover' believing that 'the west is best' and that all our ancient knowledge is hocus-pocus. We do not see and understand this great Yoga-Vidya until western scientists come and certify that it is OK!!.

Though the interest for Yoga-Vidya in the west is growing day by day and more and more people are turning towards Yoga, this is not the same in our country. Lack of proper infrastructure and absence of a proper systematized approach in the propagation of Yoga are still drawbacks in our nation. The youngsters are being drawn away from our culture and blindly ape the hedonistic western lifestyle.

Unless we change our mindset we cannot understand our wonderful culture and the great **science of Total Man** that has arisen from it. This is why it is imperative that the youth of our nation are awakened to the greatness inherent in our beloved nation and given the proper and systematic training in Yoga and our cultural heritage. Catch them young must be our aim if we are to educate them about the greatness of our cultural heritage.

INTEGRAL PSYCHOLOGY OF YOGA

INTRODUCTION

The art and science of Yoga, that is one of the greatest treasures of our unique Indian cultural heritage has a lot to offer in terms of an understanding of the human mind. Yoga treats man as a multi layered, conscious being, possessing three bodies (Sthula, Sukshma and Kaarana Sharira) and being enveloped in a five layered (Pancha Kosha) of existence. This ancient science of mind control as codified by Maharishi Patanjali more than 2500 years ago helps us to understand our mental processes as well as the cause - effect relations of a multitude of problems facing modern man. Modern man is the victim of stress and stress related disorders that threaten to disrupt his life totally. Yoga offers a way out of this 'whirlpool of stress' and is a wholistic solution to stress. Yogic life style, Yogic diet, Yogic attitudes and various Yogic practices help man to strengthen himself and develop positive health thus enabling him to withstand stress better. This Yogic "health insurance" is achieved by normalizing the perception of stress, optimizing the reaction to it and by releasing the pent up stress effectively through various Yogic practices. Yoga is a wholistic and integral science of life dealing with physical, mental, emotional and spiritual health of the individual and society.

WHAT IS YOGA?

Yoga may be defined as a process (journey) as well as a state (goal) in many ways. Yoga is the science and art of quieting the subconscious mind, a way of life, skill in action, union of thought, word and deed, integration of our personality at all levels, the science of conscious evolution and the method to attain as well as the state of emotional and mental equanimity.

The Yogarudda or one who has attained to the state of Yoga is described in the Bhagavad Gita as follows: - He is one who is unaffected by the senses, not attached to the fruits of action and has renounced all desires.

YOGIC VIEW OF THE MIND

Yoga views the mind as having four internal processes or Antahkarana. These processes are the Chitta (memory bank or the subconscious), the Manas (conscious mind), the Buddhi (discriminating intellect) and the Ahamkara or ego principle (consisting of the impure ego that feels all is ME and MINE as well as the pure ego which understands that all is mine as a manifestation of the Divine). The Buddhi is further said to possess three powers: the power of will (Iccha Shakti), the power of action, (Kriya Shakti) and the power of wisdom (Jnana Shakti). It is important that all these powers work together in synchrony for otherwise there will be disaster.

Yoga also describes Chitta Bhumi or states of the mind. These consist of the undeveloped, inert mind that is as dull as stone (Mudha), the totally distracted state of mind (Kshipta), the partially distracted state of mind (Vikshipta), the concentrated state of mind (Ekagratha) and the controlled mind of the true Yogi (Niruddha).

The modifications or fluctuations of the mindstuff as described by Maharishi Patanjali in the Yoga Sutras are of five types. These are Pramana (cognition), Viparyaya (misconception), Vikalpa (imagination), Nidra (sleep) and Smrithi (memory). He also states that when the mind is not controlled there is identification with these Vrittis (Vritti Sarupyam Itarata) and that the whole process of Yoga is aimed at "Chittavritti Nirodhah" in order that we are established in our true self (Swarupevastaanam). Patanjali elucidates that the key to success is dedicated and determined practice (Abhyasa) and a detached attitude towards everything (Vairagya).

MODERN MAN AND THE YOGI

There are some important differences in the way the worldly man and the realised Yogi view the world and life in general.

The worldly man always feels that his problem lies elsewhere and that he is the innocent victim of circumstances and fate. Yoga teaches us that most of our problems lie within us and that we have to undergo conscious change in order to solve them. Yogamaharishi Dr Swami Gitananda Giri used to often tell his students, "You don't have any problem---YOU are the problem!"

While the worldly man searches for happiness in the pursuit of external experiences, the Yogi realizes that supreme happiness (Paramanandam) lies within our inner being and that we only need to realise the folly of looking for happiness outside to be truly happy. True contentment (Santhosha) that is one of the Pancha Niyama (five ethical observances of Ashtanga Yoga) is the key to unexcelled happiness. Pujya Swamiji used to say, "Health and Happiness are your birthright—claim them! Don't barter them away for the plastics of the modern world".

Whereas the worldly man fears hell and aspires for a heaven to be attained after death, the Yogi realizes that heaven and hell are no more than planes of consciousness. Heaven and hell lie within us and it is for us to determine whether we want our life to be heaven or hell, for ourselves and for those around us.

YOGIC PATHO-PSYCHOLOGY OF DISEASE

Stress and stress related disorders are the bane of the modern age and Yoga offers us an interesting insight into their cause and effect. The Nirvana Prakarana of the Laghu Yoga Vashishta describes the origin and destruction of mental and bodily diseases. Sage Vashishta teaches Lord Rama that there are two major classifications of disease. Those that are caused by the mind are primary (Adhija, the psychosomatic, stress disorders) while those that afflict the body directly are secondary (Anadhija, infectious disease, accidents etc). The primary disease has two sub divisions. These are the Samanya (ordinary physical diseases) and the Sara (the essential disorder of rebirth). Samanya diseases are the ones that affect man physically and may be destroyed by the correction of the mind-body disharmony. However only Atma Jnana can destroy the Sara or essential disorder of rebirth.

Samanya Adhija Vyadhi are the modern psychosomatic disorders such as hypertension, diabetes, bronchial asthma, peptic ulcers, irritable bowel syndrome etc. These psychosomatic disorders (Adhi-Vyadhi) are caused in the following manner. Disturbances at the level higher (Adhi) than the plane of mind (Manomaya Kosha) cause agitation in the mental body leading to haphazard flow of Prana and instability of the Nadis in the energy body (Pranamaya Kosha). This ultimately causes disease (Vyadhi) in the physical body (Annamaya Kosha) through hypo, hyper and disturbed metabolic activities such as secretion, digestion, assimilation and utilization.

Thousands of years ago, Yogeshwar Krishna in the Bhagavad Gita (often referred to as the bible of Yoga) taught us about the Yogic patho–psychology of stress and how through our attraction to the worldly sensory objects we cause our own destruction. These potent ancient teachings hold true even in today's world.

In chapter Two (Samkhya Yoga), in verse 62 and 63, the pattern of behaviour (stress response) is given that ultimately leads to the destruction of man.

Verse 62: "Brooding on the objects of the senses, man develops attachment to them; from attachment (Sangha or Chanuraaga) comes desire (Kama) and from unfulfilled desire, anger (Krodha) sprouts forth."

Verse 63: "From anger proceeds delusion (Moha); from delusion, confused memory (Smriti Vibramah); from confused memory the ruin of reason and due to the ruin of reason (Buddhi Naaso) he perishes."

In Verse 64 of the second chapter, Lord Krishna also gives us a clue to equanimity of mind (Samatvam) and how to become a person settled in that equanimity (Stitha Prajna) who is not affected by the opposites (Dwandhwa). He says, "But the disciplined yogi, moving amongst the sensory objects with all senses under control and free from attraction (Raaga) and aversion (Dwesha), gains in tranquility."

According to Maharishi Patanjali, most of our problems stem from the five psycho-physiological afflictions (Pancha Klesha) that are inborn in each and every human being. These Pancha Klesha are ignorance (Avidya), egoism (Asmita) and our sense of needing to survive at any cost (Abinivesha) as well as the attraction (Raaga) to external objects and the repulsion (Dwesha) to them. Ignorance (Avidya) is usually the start of most problems along with the ego (Asmita). Then, our sense of needing to survive at any cost (Abinivesha) compounds it further. Both attraction (Raaga) to external objects and the repulsion (Dwesha) to them need to be destroyed in order to attain tranquility as well as equanimity of emotions and the mind. Maharishi Patanjali further states that the practice of Kriya Yoga (Yoga of mental purification) consisting of Tapas (disciplined effort), Swadhyaya (self analysis) and Ishwara Pranidhana (surrender to the Divine will) is the means to destroy these five mental afflictions and attain to the state of Samadhi or oneness with the Supreme Self or the Divine.

HOW DOES YOGA HELP US?

The Yogic concepts of Samatvam (mental and emotional equanimity) and Stitha Prajna (the even minded, balanced human being) give us role models that we may strive to emulate. An understanding of the Pancha Kleshas (five psycho-physiological afflictions) and their role in the creation of stress and the stress response help us to know ourself better and understand the how's and why's of what we do. The concept of the Pancha Koshas (the five layered existence of man as elucidated in the Taittiriya Upanishad) helps us to understand that we have more than only the physical existence and also gives us an insight into the role of the mind in causation of our physical problems as well as psychosomatic disorders. All of these concepts help us to look at life with a different perspective (Yoga Drishti) and strive to evolve consciously towards becoming Humane Beings.

The concept of Vairagya (dispassion or detachment) when understood and cultivated enables us to be dispassionate to the Dwandwas (the pairs of opposites) such as praise-blame, hot-cold and the pleasant-unpleasant situations that are part and parcel of our existence in this life.

The regular practice of Yoga as a 'Way of Life' (as taught by Yogamaharishi Dr Swami Gitananda Giri Guru Maharaj) helps us reduce the levels of physical, mental and emotional stress. This Yogic 'way of life' lays emphasis on right thought, right action, right reaction and right attitude. In short Pujya Swamiji defined Yogic living as "right-use-ness of body, emotions and mind".

The regular practice of Yogasanas, Kriyas, Mudras, Bandhas and Pranayamas helps to recondition the physical (Annamaya Kosha) and energy (Pranamaya Kosha) bodies. The practice of Pratyahara, Dharana and Dhyana techniques helps to recondition the mind body (Manomaya Kosha) apparatus. All of these Yogic practices help to foster a greater mind-emotions-body understanding and bring about the union and harmony of body, emotions and mind. This righteous (right-use-ness) union is Yoga in its truest sense.

Patanjali advises us to cultivate the following attitudes for right living. These attitudes are friendliness towards those who are happy (Maitri - Sukha), compassion towards those who are miserable (Karuna - Dukha), cheerfulness towards the virtuous (Mudhita - Punya) and indifference towards the wicked (Upeksha - Apunya).

Yoga helps us to take the right attitude towards our problems and thus tackle them in an effective manner. "To have the will (Iccha Shakti) to change (Kriya Shakti) that which can be changed, the strength to accept that which can not he changed, and the wisdom (Jnana Shakti) to know the difference" is the attitude that needs to the cultivated. An attitude of letting go of the worries, the problems and a greater understanding of our mental process helps to create a harmony in our body, and mind whose disharmony is the main cause of 'Aadi – Vyadhi' or psychosomatic disorders.

CONCLUSION

Through the dedicated practice of Yoga as a way of life, we can become a truly balanced humane being (Sthitha Prajna) with the following qualities as described in the Bhagavad Gita:

- Beyond passion, fear and anger. (II.56)
- Devoid of possessiveness and egoism. (II.71)
- Firm in understanding and unbewildered. (V.20)
- Engaged in doing good to all beings. (V.25)
- Friendly and compassionate to all. (XII.13)
- Having no expectation, pure and skillful in action. (XII.16)

The Yogi wishes peace and happiness not only for himself, but also for all beings on all the different planes of existence. He is not an "individualist" seeking salvation for only himself but on the contrary is an "universalist" seeking to live life in the proper evolutionary manner to the best of his ability and with care and concern for his human brethren as well as all beings on all planes of existence.

"Om, Loka Samasta Sukhino Bhavanthu Sarve Janaha Sukhino Bhavanthu"

"Om Shanti, Shanti, Shanti Om"

YOGIC ASPECTS OF DIET

One should eat to live and not live to eat. Food should not be the main purpose of life for a human being. However it is an important part of the human life. Bhagavad Gita advises ***Mitahara*** or moderation in diet as well as all aspects of life.

Food may be divided to different types according to the Gunas.

- Sattva - Fresh / uncooked Food
- Rajas - Spicy / stimulating items
- Tamas - old /processed food.

Satvik Diet:

- Plenty of Water
- Freshly cooked food
- Uncooked – Salads, sprouts, fruits
- High fiber
- Nutritive – greens
- Soups and juices – mineral balance

Yogic Method of eating:

- A Yogic should fill his stomach as
    - ½ stomach of food
    - ¼ stomach of water and
    - ¼ stomach for the divine (or) (empty)
- Everybody should take 2- 2½ liter of water per day for efficient functioning of all cells and tissues as well as the organs and systems of the body.
- Food consumed at the time of anger or when the mind is disturbed is a potent Poison.
- Balanced diet with equal importance to the constituents of food is also important.
- One has to take food in a proper and clean place.
- Eat according to hunger only and not for taste.
- Eating should be in a slow movement action and it should be eaten properly by chewing properly.
- Eating at the right time is also important and in the good company with sharing.

According to the Doshas

- Anti Vata diet – warm , heavy, fruits ,avoid beans
- Anti Pitta – cool, raw, fruits– avoids oils and spices
- Anti Kapha diet– dry food, avoid fruits, can take more of spices

Swami Kuvalayananda on diet

- Lacto Veg. diet with cereals but not much pulses.
- Egg – high protein – not good for Yoga.
- Low protein diet – as there is increased sympathetic drive initially
- Low salt / salt free diet
- No stimulant / irritating items.
- Unwise to dogmatize: Eskimo: on veg. diet ?

Dr Swami Gitananda Giri on diet

- Lacto vegetarian diet
- 40% raw, fresh foods, natural seasonal foods
- 60% cooked food -whole grain products
- Don’t overcook
- Save the water for sambar, soups and sources
- Skin of the Veg /fruits – alkaline
- Poly unsaturated oils
- Avoid refined food items
- Avoid unnatural / produced items
- EAT to satisfy hunger and not psychological disturbance.
- Beware of bad habits – appetite
- Don’t misuse salt or spices
- Balanced diet in Calorie needs with adequate vitamins and minerals

DIET POWER

Yogis have long realised the importance of a controlled special diet in Sadhana, but only recently has diet become a subject of study in Sports Medicine as a source of power, energy and endurance with the capacity for speeding up the recovery along with rebuilding and remodeling of organic tissue. Controlled diet in sports should not be looked at from the standpoint of “instant results”, but rather as a factor which builds the body slowly towards speed, endurance and power, and above all, gives the body the ability to recuperate, heal and rejuvenate. The vegetarian diet, as understood in Yoga, is the most natural one for biological man. It offers him an abundant source of food, carrying life sustaining nutrients, power and energy, and above all, offers a diet low in toxins.

Activities such as strenuous, acrobatic Yoga practices and sports produce excess metabolic waste matter, which then has to be cleansed through the body’s various eliminative systems. Improper diet inhibits this cleansing process, making it difficult to eliminate waste through the lungs, skin, urinary bladder, kidneys and the bowel and causes an unwelcome toxic load on the body. This in time has disastrous consequences in the form of diseases through infection, premature aging, and stiffness, leading to muscular and skeletal disorders. Muscular cramps and spasms are a common indication of a shortage of vital minerals in the diet and of toxic waste matter accumulating in the system. Irregular and difficult breathing are a direct consequence of a heavy animal protein diet and indicate a neglect of proper breathing techniques.

The fastest, the fleetest, the most sure-footed animals in nature and those species having the greatest endurance and strength are the vegetarian members of the animal kingdom. Good examples are the deer for speed and the elephant for strength. Biologically, man is also a vegetarian, but one who turned to an animal flesh and animal by-product diet at some time in his evolution. Still millions of humans today are natural vegetarians and possess great endurance strength, and longevity. It is a modern myth that a high animal protein diet produces the best athletes. Perhaps it does produce the most violent and vicious animal instincts in some of the aggressive, competitive and combative sports.

Anyone questioning the ability of the vegetarian diet to build up a super sportsman need only to look at the astounding records of Edmond Moses (USA), Paavo Nurmi (Finland), and Murray rose (New Zealand) amidst a galaxy of other Olympic vegetarian super athletes.

While vegetarianism as a way of life is catching on in all Western countries and a great amount of information is now available to support the vegetarian concepts of non-violent super energy, the public knowledge is as yet limited. It is the purpose of this chapter to encourage a deeper study of the vegetarian diet and the spectacular role it can play in the development of a well-rounded-out human personality, as well as producing a strong and healthy physique.

One of the first and most necessary pieces of information is that, "the universe and all its power are contained in a tiny seed". The end product of the growth of this seed contains only an extension of nutrients, roughage, and energy producing material. The power is in the seed. Indeed, a seed is a very good model to explain the wondrous powers of universal energy in minute form. A seed is a microcosm of universal forces inherent in food.

The power in a seed or for that matter in any food can be described in four terms:

- **Biogenic,**
- **Bioactive,**
- **Biocidic and**
- **Biostatic.**

When water is applied to a seed, the bioactive stage is that where the seed sprouts and grows, releasing tremendous energy in the form of enzymes. In this phase protein changes to essential amino acids and when the starch changes into simple sugars the Vitamin content of a seed can increase as much as 300 percent in the case of vitamin E and up to 600 percent in the case of Vitamin C. The biocidic stage occurs in the aging and self destruction of a dying seed, and the biostatic stage is when the seed dies, not having fulfilled its purpose.

These categories provide a conceptual model for the function of food in the diet and in the very modern sense allow us to understand the role that various kinds of food play in producing health and energy or in reducing energy, leading to infection, sickness and disease. The **biogenic** stage can be incorporated into one's regular diet by the sprouting of seeds grains, pulses, peas, beans and lentils and many other fruit-pit items such as fruit-pits, nuts and fruit stones. All biogenic foods are able to synthesize entirely new compounds and substances in our body system affording natural immunity to infection, destroying microbes and other ingested poisons. They also aid in correcting faulty digestive processes and add to the bulk of the diet producing good elimination. The life sustaining bioactive group of foods includes all fruits and vegetables as long as they are unprocessed foods.

This **bioactive** group of foods should be in a natural, raw, uncooked or semi-processed state whenever possible. The fiber in a bioactive diet stimulates the digestive and eliminative processes, keeping the intestinal tract young and active and avoiding the onset of aging disorders. There are two types of fibers in the bioactive group which are to be seen in the residue and bulk of whole grains, seed cases and shells as well as the peels and rinds of fruits and vegetables and in the long fibers in all green leafy foods. The gel in fruit is the second category and helps to keep an active digestive system and promote the absorption of nutrients, vitamins and minerals from the intestinal tract, keeping the body light and youthful.

The **biocidic** group includes life-destroying and health destroying foods that are in the process of rot and decay. This includes all animal flesh, fish and fowl and animal by-products. In modern times this biocidic group has become a menace to mankind through the addition of preservatives, chemical additives, extenders, adulterants, coloring and flavors. The 'fast-food phenomena' has added to this health-destroying group. All processed foods with chemical additives, grown on land needing chemical fertilizers and sprayed with pesticides and ripened chemically should be completely avoided as they will destroy the healthiest of bodies and minds.

The **biostatic** group is made up of dead foods containing toxins, poisonous matter, and decaying noxious cellular ingredients. All over cooked and long stored food must be termed biostatic. This would include all types of frozen and tinned foods and much so-called dried or dehydrated food.

A good, power-packed, healthy diet should be made up of 40 to 60 percent of raw and unprocessed food and the balance being made up of lightly cooked, steamed, or baked dishes.

Most modern youngsters are "always hungry" and on the look out for a "handful of munchies". These modern taste satisfiers do nothing but titillate the tongue and can lead to a break down in health, destroying a hoped-for-career, accelerating the aging process and unfortunately, also inhibiting the development of a dynamic mind.

Dried nuts, sunflower seeds, roasted pulses and grams, sprouted seeds and grains, pieces of fresh fruit and raw vegetables can replace in a healthy sense the "munchies". These youngsters should be taught to germinate and sprout seeds, grains and grams while in school and college. Even in northern countries sprouts and germinated seeds can be raised without the sun and in cold climates. In sprouting beans, peas and grams, the starch is reduced but there is an increase in vitamins. Protein in wheat is increased in wheat sprouts by ten per cent and the essential amino acids like lysine, needed in the body for balance increases as much as 25 per cent. Vitamin C, the healing vitamin is increased in sprouting and the germination processes. Vitamin E content of sprouted wheat is tripled in four-day-old wheat grass.

Believe it on not, pro-Vitamin A or carotene is found in greater abundance in sprouted legumes, lentils, peas and beans than in the carrot. A study of vegetarian nutrition in Yoga and the role that it can play in a healthy diet is not only exciting but tremendously rewarding in the knowledge that can be acquired.

While a proper, balanced diet is essential to people of all ages, one must also recognize the role that water plays in the metabolism of the body. No matter how good the diet the body cannot transport nutrients, unless it possesses good blood circulation. Healthy circulation depends much upon fluids, most particularly water, in the diet. Vigorous Yogic and sports activities dehydrate the body quickly. Rapid breathing associated with exertion throws off moist-laden carbon dioxide from the body. Sweat increases and fluids are actually used up in dynamic activity by the cells. A sports enthusiast must learn to 'sip water". Gulping down water after rigorous Yogic or sports activity can be dangerous, but "sipping" water actually becomes beneficial. At least one liter per hour of fresh water must be replaced in the body. Shorter periods of time can be adjusted to 250 mls. Every 15 to 20 minutes.

Mineral replacement fluids are now available for this purpose but fresh fruit juices still represent the body's best way of absorbing the needed fluids along with vitamins and minerals most acceptable to the body in the shortest period of time. Adding lime or lemon juice to other fruit juices enhances the Vitamin C content. Excess body activity in hot climates or in the tropics requires a greater intake of salt which is sweated out through the pores of the skin and passed through urine. Fresh fruits and vegetables as well as salads made up of fresh greens put back natural salts into the tissues and cells. Table salt should be used with caution and with all attention to the body's real needs.

Soups made up of fresh vegetables, especially greens, have high potassium content and replace needed cellular constituents quickly, avoiding strain on the bowels, kidneys and bladder. A light broth or soup made from grains along with vegetables like tomato, beans and potato replaces necessary minerals which may be lost in a strenuous workout.

One should never over eat when the body is tired or strained. Instead, it is better to take plenty of fluids, fruit or vegetable juices or light soups, and then have a lengthy relaxation or sleep. Over loading the body when tired interrupts proper digestion and may lead to damage in the circulatory system as well as accumulation of mucous in the respiratory tract.

It is also important that some mono-unsaturated fats be included in the diet. Poly-unsaturated fats have long been extolled for their virtue in a natural diet for strength and endurance, but in these modern times many of these valuable fruit, vegetable and nut-fats go rancid when stored for a lengthy period of time, and therefore are highly treated with chemical stabilizers and preservatives. Mono-unsaturated fats are stored longer and more safely and should be used in dressings for salads and in soups and other dishes.

A small amount of mono-unsaturated oil or fresh poly-unsaturated oil can be added to cooked dishes and soups just before serving. It is important to be cautious as they are turned into dangerous saturated fats by frying or cooking. Saturated fats found in all animal flesh, fish, fowl and animal by-products clog up the circulatory system leading to premature aging, heart disease and untimely early death.

Remember that sugars and starches are only fuel for the body and the unrefined sugars and unrefined starches break down more slowly in the system. Starch, a granular carbohydrate, is found in most plants, vegetable foods, grains and pulses. Reacting with certain digestive enzymes, maltose and dextrin are produced as fuel for endurance. Refined sweets and sugars indeed are super octane fuels but have their drawbacks. The main source of sugar, as sweet crystalline carbohydrate, is from sugarcane, the sugar beet and the sap of trees like the maple and fruits. Neither type of carbohydrate rebuilds the system.

The protein building blocks for this purpose must come through a balance of amino acids from nitrogenous sources. All animal protein is originally derived from grains, grasses, leaves of trees, legumes and vegetarian sources. A judicious combination of grains and vegetables, nuts, legumes and grain seeds produce all known amino acids to build a strong, healthy, long lasting physical body.

It is thus quite clear that a mixed diet of grains, seeds, nuts and vegetables is more than adequate for health, a strong muscular system, good skeleton structure, and the harmonious working of all body organs. The pacifying effect of the vegetarian diet producing a calm, clear concern for the world also recommends itself to all people irrespective or any man made barrier.

The best diet in the world can be completely negated by smoking of tobacco, the use of alcohol, and by many popular drugs, especially the so-called "consciousness enhancing" drugs. A clean life style goes a long way to winning out in life's real contests, no matter what the game. A young sportsman today must remember that he may have a future as a sporting coach or as a good, healthy citizen and that health is built in the "spring time" of one's life. It is sad to note that many sportsmen "sell off" any chance for a healthy future and a happy, contented, vigorous old age for ego-aggrandizement and fleeting monetary pleasures.

Strength, endurance, and positive wholesome enjoyment are not the prerogative of youth alone. Food is the source of energy. Sustenance, change and growth in our lives. At all times "Diet Power" is the fuel for contented emotions, peace of mind, and success in its most real sense. The greatest champion is he who has vanquished his own lower nature, and "Diet Power" gives a "rocket thrust" to that eternal human struggle.

From the book, "Yoga and Sports" by Yogamaharishi Dr Swami Gitananda Giri Guru Maharaj and Yogamani Yogacharini Kalaimamani Smt Meenakshi Devi Bhavanani, Satya Press, Ananda Ashram, Puducherry, South India

HOW TO WIN AN ARGUMENT WITH A MEAT-EATER

While their numbers are rapidly growing, vegetarians are still a minority, and it is not unusual to be confronted with a meat-eater who not only protects his own right to eat flesh, but argues aggressively that vegetarians should join him in his carnivorous diet. Carnivores may regard non meat-eaters as a strange lot who munch on "rabbit food," and whose diet doesn't have the substance to make them strong, productive human beings. The following presentation is designed to turn the tables on such discussions by showing the devastating effects of meat-eating both on individuals and on our planet. It is based on a richly informative poster entitled, "How to win an argument with a meat-eater," published by Earthsave, an organization based in Felton, California, giving facts from Pulitzer Prize nominee John Robbins' book Diet for a New America. Below are eight separate arguments against meat-eating and in favor of a vegetarian diet.

1. The Hunger Argument against meat-eating

Much of the world's massive hunger problems could be solved by the reduction or elimination of meat-eating. The reasons:

- livestock pasture needs cut drastically into land which could otherwise be used to grow food;
- Vast quantities of food which could feed humans is fed to livestock raised to produce meat.

This year alone, twenty million people worldwide will die as a result of malnutrition. One child dies of malnutrition every 2.3 seconds. One hundred million people could be adequately fed using the land freed if Americans reduced their intake of meat by a mere 10%.

Twenty percent of the corn grown in the U.S. is eaten by people. Eighty percent of the corn and 95% of the oats grown in the U.S. is eaten by livestock. The percentage of protein wasted by cycling grain through livestock is calculated by experts as 90%.

One acre of land can produce 40,000 pounds of potatoes, or 250 pounds of beef. Fifty-six percent of all U.S. farmland is devoted to beef production, and to produce each pound of beef requires 16 pounds of edible grain and soybeans, which could be used to feed the hungry.

2. The Environmental Argument against meat-eating

Many of the world's massive environmental problems could be solved by the reduction or elimination of meat-eating, including global warming, loss of topsoil, loss of rain forests and species extinction.

The temperature of the earth is rising. This global warming, known as "the greenhouse effect," results primarily from carbon dioxide emissions from burning fossil fuels, such as oil and natural gas. Three times more fossil fuels must be burned to produce a meat-centered diet than for a meat-free diet. If people stopped eating meat, the threat of higher world temperatures would be vastly diminished.

Trees, and especially the old-growth forests, are essential to the survival of the planet. Their destruction is a major cause of global warming and top soil loss. Both of these effects lead to diminished food production. Meat-eating is the number one driving force for the destruction of these forests. Two-hundred and sixty million acres of U.S. forest land has been cleared for cropland to produce the meat-centered diet. Fifty-five square feet of tropical rain forest is consumed to produce every quarter-pound of rain forest beef. An alarming 75% of all U.S. topsoil has been lost to date. Eighty-five percent of this loss is directly related to livestock raising.

Another devastating result of deforestation is the loss of plant and animal species. Each year 1,000 species are eliminated due to destruction of tropical rain forests for meat grazing and other uses. The rate is growing yearly.

To keep up with U.S. consumption, 300 million pounds of meat are imported annually from Central and South America. This economic incentive impels these nations to cut down their forests to make more pasture land. The short-term gain ignores the long-term, irreparable harm to the earth's ecosystem. In effect these countries are being drained of their resources to put meat on the table of Americans while 75% of all Central American children under the age of five are undernourished.

3. The Cancer Argument against meat-eating

Those who eat flesh are far more likely to contract cancer than those following a vegetarian diet.

The risk of contracting breast cancer is 3.8 times greater for women who eat meat daily compared to less than once a week; 2.8 times greater for women who eat eggs daily compared to once a week; and 3.25 greater for women who eat butter and cheese 2 to 4 times a week as compared to once a week.

The risk of fatal ovarian cancer is three times greater for women who eat eggs 3 or more times a week as compared with less than once a week.

The risk of fatal prostate cancer is 3.6 times greater for men who consume meat, cheese, eggs and milk daily as compared with sparingly or not at all.

4. The Cholesterol Argument against meat-eating

Here are facts showing that:

- U.S. physicians are not sufficiently trained in the importance of the relation of diet to health;
- Meat-eaters ingest excessive amounts of cholesterol, making them dangerously susceptible to heart attacks.

It is strange, but true that U.S. physicians are as a rule ill-educated in the single most important factor of health, namely diet and nutrition. Of the 125 medical schools in the U.S., only 30 require their students to take a course in nutrition. The average nutrition training received by the average U.S. physician during four years in school is only 2.5 hours. Thus doctors in the U.S. are ill-equipped to advise their patients in minimizing foods, such as meat, that contain excessive amounts of cholesterol and are known causes of heart attack.

Heart attack is the most common cause of death in the U.S., killing one person every 45 seconds. The male meat-eater's risk of death from heart attack is 50%. The risk to men who eats no meat is 15%. Reducing one's consumption of meat, dairy and eggs by 10% reduces the risk of heart attack by 10%. Completely eliminating these products from one's diet reduces the risk of heart attack by 90%.

The average cholesterol consumption of a meat-centered diet is 210 milligrams per day. The chance of dying from heart disease if you are male and your blood cholesterol is 210 milligrams daily is greater than 50%.

5. The Natural Resources Argument against meat-eating

The world's natural resources are being rapidly depleted as a result of meat-eating.
Raising livestock for their meat is a very inefficient way of generating food. Pound for pound, far more resources must be expended to produce meat than to produce grains, fruits and vegetables. For example, more than half of all water used for all purposes in the U.S. is consumed in livestock production. The amount of water used in production of the average cow is sufficient to float a destroyer (a large naval ship). While 25 gallons of water are needed to produce a pound of wheat, 5,000 gallons are needed to produce a pound of California beef. That same 5,000 gallons of water can produce 200 pounds of wheat. If this water cost were not subsidized by the government, the cheapest hamburger meat would cost more than $35 per pound.

Meat-eating is devouring oil reserves at an alarming rate. It takes nearly 78 calories of fossil fuel (oil, natural gas, etc.) energy to produce one calorie of beef protein and only 2 calories of fossil fuel energy to produce one calorie of soybean. If every human ate a meat-centered diet, the world's known oil reserves would last a mere 13 years. They would last 260 years if humans stopped eating meat altogether. That is 20 times longer, giving humanity ample time to develop alternative energy sources.

Thirty-three percent of all raw materials (base products of farming, forestry and mining, including fossil fuels) consumed by the U.S. are devoted to the production of livestock, as compared with 2% to produce a complete vegetarian diet.

6. The Antibiotic Argument against meat-eating

Here are facts showing the dangers of eating meat because of the large amounts of antibiotics fed to livestock to control staphylococci (commonly called staph infections), which are becoming immune to these drugs at an alarming rate.

The animals that are being raised for meat in the United States are diseased. The livestock industry attempts to control this disease by feeding the animals antibiotics. Huge quantities of drugs go for this purpose. Of all antibiotics used in the U.S., 55% are fed to livestock.

But this is only partially effective because the bacteria that cause disease are becoming immune to the antibiotics. The percentage of staphylococci infections resistant to penicillin, for example, has grown from 13% in 1960 to 91% in 1988. These antibiotics and-or the bacteria they are intended to destroy reside in the meat that goes to market.

It is not healthy for humans to consume this meat. The response of the European Economic Community to the routine feeding of antibiotics to U.S. livestock was to ban the importation of U.S. meat. European buyers do not want to expose consumers to this serious health hazard. By comparison, U.S. meat and pharmaceutical industries gave their full and complete support to the routine feeding of antibiotics to livestock, turning a blind eye to the threat of disease to the consumer.

7. The Pesticide Argument against meat-eating

Unknown to most meat-eaters, U.S.-produced meat contains dangerously high quantities of deadly pesticides.

The common belief is that the U.S. Department of Agriculture protects consumers' health through regular and thorough meat inspection. In reality, fewer than one out of every 250,000 slaughtered animals is tested for toxic chemical residues.

That these chemicals are indeed ingested by the meat-eater is proven by the following facts:

1. Ninety-nine percent of U.S. mother's milk contains significant levels of DDT. In stark contrast, only 8% of U.S. vegetarian mother's milk containing significant levels of DDT. This shows that the primary source of DDT is the meat ingested by the mothers.
2. Contamination of breast milk due to chlorinated hydrocarbon pesticides in animal products found in meat-eating mothers versus non meat-eating mothers is 35 times higher.
3. The amount of the pesticide Dieldrin ingested by the average breast-fed American infant is 9 times the permissible level.

8. The Ethical Argument against meat-eating

Many of those who have adopted a vegetarian diet have done so because of the ethical argument, either from reading about or personally experiencing what goes on daily at any one of the thousands of slaughterhouses in the U.S. and other countries, where animals suffer the cruel process of forced confinement, manipulation and violent death. Their pain and terror is beyond calculation.

The slaughterhouse is the final stop for animals raised for their flesh. These ghastly places, while little known to most meat-eaters, process enormous numbers of animals each years. In the U.S. alone, 660,000 animals are killed for meat every hour. A surprising quantity of meat is consumed by the meat-eater. The average per capita consumption of meat in the U.S., Canada and Australia is 200 pounds per year! The average American consumes in a 72-year lifetime approximately 11 cattle, 3 lambs and sheep, 23 hogs, 45 turkeys, 1,100 chickens and 862 pounds of fish! Bon appetite!

People who come in contact with slaughterhouses cannot help but be affected by what they see and hear. Those living nearby must daily experience the screams of terror and anger of the animals led to slaughter. Those working inside must also see and participate in the crimes of mayhem and murder. Most who choose this line of work are not on the job for long. Of all occupations in the U.S., slaughterhouse worker has the highest turnover rate. It also has the highest rate of on-the-job injury.

9. Humans Have neither Fangs nor Claws

A ninth and most compelling argument against meat-eating is that humans are physiologically not suited for a carnivorous diet. The book Food for the Spirit, Vegetarianism in the World Religions, summarizes this point of view as follows. "Many nutritionists, biologists and physiologists offer convincing evidence that humans are in fact not meant to eat flesh._" Here are seven facts in support of this view:

"Physiologically, people are more akin to plant-eaters, foragers and grazers, such as monkeys, elephants and cows, than to carnivora such as dogs, tigers and leopards.

"For example, carnivora do not sweat through their skin; body heat is controlled by rapid breathing and extrusion of the tongue. Vegetarian animals, on the other hand, have sweat pores for heat control and the elimination of impurities.

"Carnivora have long teeth and claws for holding and killing prey; vegetarian animals have short teeth and no claws.

"The saliva of carnivora contains no ptyalin and cannot predigest starches; that of vegetarian animals contains ptyalin for the predigestion of starches.

"Flesh-eating animals secrete large quantities of hydrochloric acid to help dissolve bones; vegetarian animals secrete little hydrochloric acid.

"The jaws of carnivora only open in an up and down motion; those of vegetarian animals also move sideways for additional kinds of chewing.

"Carnivora must lap liquids (like a cat); vegetarian animals take liquids in by suction through the teeth.

"There are many such comparisons, and in each case humans fit the vegetarian physiognomy. From a strictly physiological perspective, then, there are strong arguments that humans are not suited to a fleshy diet."

10. The Health Benefits of Vegetarianism

It was only recently that smoking only recently became recognized as a health and environmental hazard. As a result of research and education on a habit once believed to be not only harmless but stylish, most major U.S. cities have banned smoking of cigarettes, cigars or pipes in all public places. Smoking has also been outlawed in government offices and completely eliminated from all domestic U.S. air flights. Now, another, even more devastating problem is under scrutiny. Its threat to health and the environment is being realized based on overwhelming evidence amassed by recognized authorities over the past fifty years. Recently a group of eminent doctors called the Physicians Committee for Responsible Medicine (PCRM), themselves members of the American Medical Association (AMA), have gathered to change the U.S. consciousness on human nutrition, particularly among the medical community. The PCRM is a nonprofit organization based in Washington, D.C., consisting of doctors and lay persons working together for compassionate and effective medical practice, research and health promotion. Founded in 1985, the PCRM is supported by over 3,000 physicians and 50,000 lay persons PCRM president Newal D. Barnard, M.D., is a popular speaker and the author of The Power of Your Plate.

As stated by the PCRM in their 1991 literature, "A vegetarian diet has been advocated by everyone from philosophers, such as Plato and Nietzsche, to political leaders, such as Benjamin Franklin and Gandhi, to modern pop icons such as Paul McCartney and Bob Marley. Science is also on the side of vegetarian foods. A multitude of studies have proven the health benefits of a vegetarian diet to be remarkable.

"Vegetarian is defined as avoiding all animal flesh, including fish and poultry. Vegetarians who avoid flesh, but do eat animal products such as cheese, milk and eggs are ovo-lacto-vegetarians (ovo = egg; lacto = milk, cheese, etc.). The ranks of those who eschew all animal products are rapidly growing; these people are referred to as pure vegetarians or vegans (vee'guns). Scientific research shows that ovo-lacto-vegetarians are healthier than meat-eaters, and vegans are healthier than ovo-lacto-vegetarians." It should be noted that the Indian Hindu tradition has always been lacto-vegetarian, permitting the consumption of milk products.

The PCRM literature lists a host of health benefits of a vegetarian diet, including the following:

- Preventing cancer: "Numerous epidemiological and clinical studies have shown that vegetarians are nearly 50% less likely to die from cancer than non vegetarians."
- Preventing heart disease and lowering blood pressure.
- Preventing and reversing diabetes.
- Preventing and alleviating gallstones, kidney stones and osteoporosis.
- Preventing and alleviating asthma.

11. The New Four Food Groups

In 1991 the Physicians Committee for Responsible Medicine submitted a proposal to change the official "four food groups" which have been promoted by U.S. nutritionists in the U.S. for the past 35 years. Their proposal reflects the fact that the long-held belief in meat as an essential dietary element is being displaced with new findings on the harmful effects of a meat-centered diet. The PCRM Update, May-June 1991, explains, "On April 8, 1991, PCRM unveiled a proposal to replace the Four Basic Food Groups. The Four Food Groups have been part of U.S. government recommendations since 1956, but promote dietary habits which are largely responsible for the epidemics of heart disease, cancer, stroke and other serious illnesses in this country. The old four groups were meat, dairy, grains and fruits/vegetables. The 'New Four Food Groups' are grains, legumes, vegetables and fruits. Meat and dairy will lose their food group status [by this proposal]. The 'New Four Food Groups' represents a nutrition plan that is based on healthy, fiber-rich plant foods rather than the former emphasis on cholesterol-and-fat-laden foods. 'The meat and dairy groups were the principal sources of cholesterol and saturated fat, which is the biggest culprit in raising blood cholesterol,' says PCRM Nutritionist Virginia Messina, M.P.H., R.D. 'These foods are simply not necessary in the human diet.' " PCRM poster offers the following description of the four new food groups.

1. Whole grains include breads, pastas, rice, corn and all other grains. Note the emphasis on whole grains rather than refined grains. Build each of your meals around a hearty grain dish-grains are rich in fiber and other complex carbohydrates, as well as protein, B vitamins and zinc.
2. Vegetables are packed with nutrients; they provide vitamin C, beta-carotene, riboflavin and other vitamins, iron, calcium and fiber. Dark green, leafy vegetables such as broccoli, collards, kale, mustard and turnip greens, chicory or bok choy are especially good sources of these important nutrients. Dark yellow and orange vegetables such as carrots, winter

squash, sweet potatoes and pumpkin provide extra beta-carotene. Include generous portions of a variety of vegetables in your diet.

3. Legumes, which is another name for beans, peas and lentils, are all good sources of fiber, protein, iron, calcium, zinc and B vitamins. This group also includes chickpeas, baked and refried beans, soy milk, tofu, tempeh and texturized vegetable protein.
4. Fruits are rich in fiber, vitamin C and beta-carotene. Be sure to include at least one serving each day of fruits that are high in vitamin C-citrus fruits, melons and strawberries are all good choices. Choose whole fruit over fruit juices, which don't contain as much healthy fiber.

12. Common Dietary Concerns

Those considering a vegetarian diet generally worry about getting enough nutrients, since the belief that meat is a necessary part of keeping strong and healthy is still extremely widespread. Armed with decades of nutritional research data, the PCRM addresses this issue head-on:

"The fact is, it is very easy to have a well-balanced diet with vegetarian foods. Vegetarian foods provide plenty of protein. Careful combining of foods is not necessary. Any normal variety of plant foods provides more than enough protein for the body's needs. Although there is somewhat less protein in a vegetarian diet than a meat-eater's diet, this actually an advantage. Excess protein has been linked to kidney stones, osteoporosis, and possibly heart disease and some cancers. A diet focused on beans, whole grains and vegetables contains adequate amounts of protein without the 'overdose' most meat-eaters get."

Other concerns are allayed as follows:

"Calcium is easy to find in a vegetarian diet. Many dark, green leafy vegetables and beans are loaded with calcium, and some orange juices and cereals are calcium-fortified. Iron is plentiful in whole grains, beans and fruits."

Vitamin B12: There is a misconception that without eating meat one cannot obtain sufficient v. B12, which is an essential nutrient. This simply not true. The PCRM advises: "Although cases of B12 deficiency are very uncommon, it is important to make sure that one has a reliable source of the vitamin. Good sources include all common multiple vitamins (including vegetarian vitamins), fortified cereals and fortified soy milk."

"During pregnancy one's nutritional needs increase. The American Dietetic Association has found vegan diets adequate for fulfilling nutritional needs during pregnancy, but pregnant women and nursing mothers should supplement their diets with vitamins B12 and D.

"vegetarian children also have high nutritional needs, but these, too, are met within a vegetarian diet. A vegetarian menu is 'life-extending.' As young children, vegetarians may grow more gradually, reach puberty somewhat later, and live substantially longer than do meat-eaters. Do be sure to include a reliable source of vitamin B12."

Besides the fortified cereals and soy milk mentioned above vitamin B12 sources that are widely available are multiple vitamins, brewers yeast and other potent dietary supplements.

Those interested in supporting or learning more about the work of the PCRM should write to PCRM, P.O. Box 6322, Washington, D.C., 20015.

13. Vegetarianism in Hinduism

Food for the Spirit, Vegetarianism and the World Religions, observes, "Despite popular knowledge of meat-eating's adverse effects, the non vegetarian diet became increasingly widespread among Hindus after the two major invasions by foreign powers, first the Muslims and later the British. With them came the desire to be 'civilized,' to eat as did the sahib. Those actually trained in Vedic knowledge, however, never adopted a meat-oriented diet, and the pious Hindu still observes vegetarian principles as a matter of religious duty.

"That vegetarianism has always been widespread in India is clear from the earliest Vedic texts. This was observed by the ancient traveler Megasthenes and also by Fa-hsien, a Chinese Buddhist monk who, in the fifth century, traveled to India in order to obtain authentic copies of the scriptures.

"These scriptures unambiguously support the meatless way of life. In the Mahabharata, for instance, the great warrior Bhishma explains to Yudhishtira, eldest of the Pandava princes, that the meat of animals is like the flesh of one's own son, and that the foolish person who eats meat must be considered the vilest of human beings [Anu. 114.11]. The eating of 'dirty' food, it warns, is not as terrible as the eating of flesh [Shanti. 141.88] (it must be remembered that the brahmanas of ancient India exalted cleanliness to a divine principle).

"Similarly, the Manusmriti declares that one should 'refrain from eating all kinds of meat,' for such eating involves killing and leads to karmic bondage (Bandha) [5.49]. Elsewhere in the Vedic literature, the last of the great Vedic kings, Maharajah Parikshit, is quoted as saying that 'only the animal-killer cannot relish the message of the Absolute Truth [Shrimad Bhagavatam 10.1.4].' "

WHAT IS RESEARCH?

The term research has been used in so many contexts and with such a variety of meanings that it is difficult for the student to sort it all out. Much of what we have been taught about research is based on misconceptions.

Let's list first what research is not.

Here are a few examples:

- Research is not just information gathering. A student going to the library and reading information on African Elephants is not research.
- Research is not rearranging facts. A student writing a report on behavior of pendulums is not research.
- Research is not a sales pitch. A new improved toothpaste developed after years of research is rarely if ever real research.

Now lets turn to the question, "what is research?"

True research is a quest driven by a specific question which needs an answer. Paul Leedy, in his book "Practical Research: Planning and Design" lists eight characteristics of research which serve us well in defining research for the student. Here are those eight characteristics.

1. Research originates with a question or a problem.
2. Research requires a clear articulation of a goal.
3. Research follows a specific plan of procedure.
4. Research usually divides the principal problem into more manageable sub-problems.
5. Research is guided by the specific research problem, question, or hypothesis.
6. Research accepts certain critical assumptions. These assumptions are underlying theories or ideas about how the world works.
7. Research requires the collection and interpretation of data in attempting to resolve the problem that initiated the research.
8. Research is, by its nature, cyclical; or more exactly, spiral or helical.

These steps include,

1. establishing a research question,
2. finding background information
3. planning and conducting a specific research method
4. collecting and studying data
5. analyzing the data
6. formulating and establishing a conclusion,
7. looking for areas of further research
8. stating the values associated with the research knowledge, and
9. publishing the research work for others to view.

Actually research is continual and expanding. As one question is answered many more are generated. Researchers depend upon previous work to expand the knowledge base on any research frontier. A better representation of research might be a series of interconnected Vee's forming an upward spiral. Questions spurring research leading to conclusions which in turn lead to new questions or modifications of the original questions. These in turn lead to new conclusions and so on.

RESEARCH

Research is often described as an active, diligent, and systematic process of inquiry aimed at discovering, interpreting, and revising facts. This intellectual investigation produces a greater understanding of events, behaviors, or theories, and makes practical applications through laws and theories. The term research is also used to describe a collection of information about a particular subject, and is usually associated with science and the scientific method.

The word research derives from Middle French (see French language); its literal meaning is 'to investigate thoroughly'.

Thomas Kuhn, in his book The Structure of Scientific Revolutions, traces an interesting history and analysis of the enterprise of research.

BASIC RESEARCH

Basic research (also called fundamental or pure research) has as its primary objective the advancement of knowledge and the theoretical understanding of the relations among variables (see statistics). It is exploratory and often driven by the researcher's curiosity, interest, or hunch. It is conducted without any practical end in mind, although it may have unexpected results pointing to practical applications. The terms "basic" or "fundamental" indicate that, through theory generation, basic research provides the foundation for further, sometimes applied research. As there is no guarantee of short-term practical gain, researchers often find it difficult to obtain funding for basic research. Research is a subset of invention

APPLIED RESEARCH

Applied research is done to solve specific, practical questions; its primary aim is not to gain knowledge for its own sake. It can be exploratory, but is usually descriptive. It is almost always done on the basis of basic research. Applied research can be carried out by academic or industrial institutions. Often, an academic institution such as a university will have a specific applied research program funded by an industrial partner interested in that program. Common areas of applied research include electronics, informatics, computer science, material science, process engineering, drug design...

There are many instances when the distinction between basic and applied research is not clear. It is not unusual for researchers to present their project in such a light as to 'slot' it into either applied or basic research, depending on the requirements of the funding sources. The question of genetic codes is a good example. Unraveling it for the sake of knowledge alone would be basic research – but what, for example, if knowledge of it also has the benefit of making it possible to alter the code so as to make a plant commercially viable? Some say that the difference between basic and applied research lies in the time span between research and reasonably foreseeable practical applications.

RESEARCH METHODS

The scope of the research process is to produce some new knowledge. This, in principle, can take three main forms:

1. Exploratory research: a new problem can be structured and identified
2. Constructive research: a (new) solution to a problem can be developed
3. Empirical research: empirical evidence on the feasibility of an existing solution to a problem can be provided

Research methods used by scholars:

- Action research
- Case study

- Classification
- Experience and intuition
- Experiments
- Eye tracking
- Interviews
- Map making
- Mathematical models and simulations
- Participant observation
- Physical traces analysis
- Semiotics
- Statistical data analysis
- Statistical surveys
- Content or Textual Analysis

Research is often conducted using the hourglass model. The hourglass model starts with a broad spectrum for research, focusing in on the required information through the methodology of the project (like the neck of the hourglass), then expands the research in the form of discussion and results.

RESEARCH PROCESS

Generally, research is understood to follow a certain structural process. Though step order may vary depending on the subject matter and researcher, the following steps are usually part of most formal research, both basic and applied:

1. Formation of the topic
2. Hypothesis
3. Conceptual definitions
4. Operational definitions
5. Gathering of data
6. Analysis of data
7. Conclusion, revising of hypothesis

A common misunderstanding is that by this method a hypothesis can be proven. Instead, by these methods no hypothesis can be proven, rather a hypothesis may only be disproven. A hypothesis can survive several rounds of scientific testing and be widely thought of as true (or better, predictive), but this is not the same as it having been proven. It would be better to say that the hypothesis has yet to be disproven.

A useful hypothesis allows prediction and within the accuracy of observation of the time, the prediction will be verified. As the accuracy of observation improves with time, the hypothesis may no longer provide an accurate prediction. In this case a new hypothesis will arise to challenge the old, and to the extent that the new hypothesis makes more accurate predictions than the old, will supplant it.

DEFINITIONS OF COMMONLY USED RESEARCH TERMS

Blinded studies: Blinded studies are done so that neither the researchers' nor the participants' expectations about the experimental treatment can influence the study results. Ordinarily, in a "single-blinded" study, the participants do not know whether they are in an experimental group or a control group. In a "double-blinded" study, neither the participants nor the researchers know which participants are in which group.

Clinical trial: A clinical trial is a research study designed to test the safety and/or effectiveness of drugs, devices, treatments, or preventive measures in humans. Clinical trials can usually be divided into four categories or "phases".

Control group: Participants in a control group are used as a standard for comparison. For example, a particular study may divide participants into two groups - an "experimental group" and a "control group." The experimental group is given the experimental treatment under study, while the control group may be given either the standard treatment for the illness or a placebo. At the end of the study, the results of the two groups are compared.

Experimental group: Study participants in the experimental group receive the drug, device, treatment, or intervention under study. In some studies, all participants are in the experimental group. In "controlled studies," participants will be assigned either to an experimental group or to a control group.

Informed consent: Informed consent is the participant's agreement to be in a study after being fully informed about what participating will involve. Informed consent begins with a discussion between the researchers and the prospective participants. The discussion includes important information about the research study such as:

- The purpose of the study
- The procedures involved
- The risks of participating in the study
- The benefits of participating in the study
- How long the study will last
- How the participant's confidentiality will be protected
- What will happen if the study causes harm to the participants
- That participation is voluntary
- That participants are free to withdraw from the study at any time.

Based on this discussion with the researcher, participants are asked to sign a consent form that includes this same important information in writing. Prospective study participants can take the consent form home to discuss it with family and friends before signing it. Once the form is signed, participants are given a copy of the signed consent form so that they can review it at any time. Participants should feel free to ask the researchers questions before, during, and after the study. Informed consent is an ongoing process.

Institutional Review Board (IRB): An IRB is the group or committee that is given the responsibility by an institution to review that institution's research projects involving human subjects. The primary purpose of the IRB review is to assure the protection of the safety, rights and welfare of the human subjects. At the University of Washington, the IRB is called the "Human Subjects Review Committee."

Investigational or experimental device: An investigational or experimental device is a medical device (such as an artificial heart valve or a screw used to hold bones together) that has not yet received approval from the U.S. Food and Drug Administration (FDA) for marketing.

Investigational or experimental drug: An investigational or experimental drug is a drug that is not yet approved for marketing - it is not commercially available.

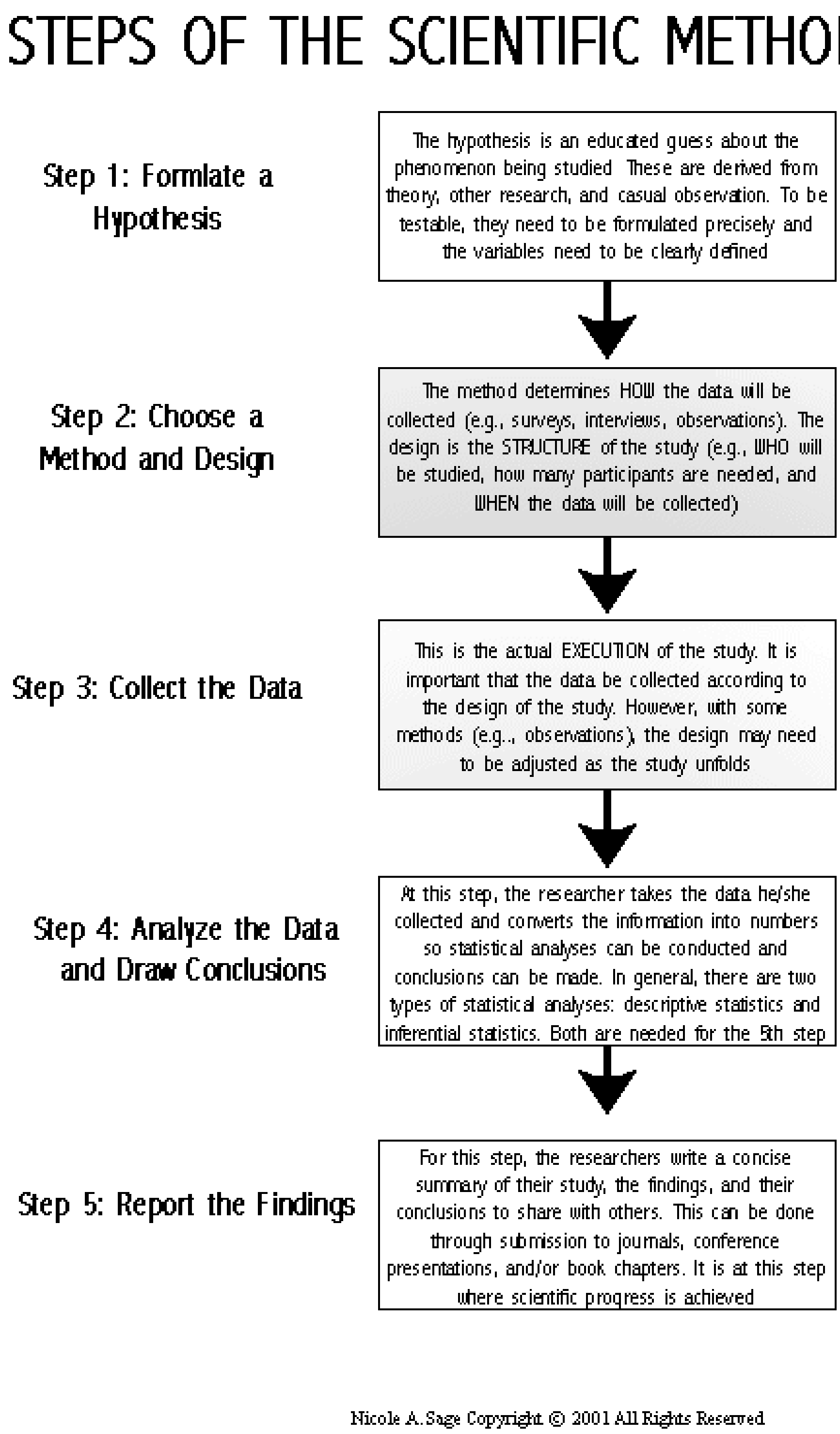
Placebo: A placebo is an inactive substance which may look like medicine but contains no medicine - a "sugar pill" with no treatment value. In some studies, the participants in a control group may be given a placebo.

Principal investigator: The principal investigator is the chief researcher - the person in charge of carrying out a study.

Protocol: The protocol is the formal design or action plan of a research study. The protocol explains what will be done, when, how, and why. A particular study may be done by several researchers around the nation or around the world. Each researcher follows the same protocol so that at the end of the study information from all of the researchers can be combined and compared.

Random assignment: Random assignment is assignment by chance, like flipping a coin or pulling numbers out of a hat. This method is sometimes used to determine who is in the experimental group and who is in the control group. For example, in a study with random assignment to one of two groups, participants have a 50% chance of being assigned to either group.

Sponsor: The sponsor is the company, research institution, group, foundation, or government agency that funds a research study.



RESEARCH ETHICS

Ethical system to prevent people from being used as scientific guinea pigs

What is meant by Ethics?

It is a body of principles governing right and wrong

What is Medical Ethics?

" the values and guidelines that should govern decisions in medicine"

Universal Principles of Ethics

- Beneficience & Non-maleficience
- Justice & equality
- Autonomy

Some historical facts…

- Nazi experiments on Jews
- Tuskegee experiments on syphilis
- Experiments on 400 prisoners in Chicago – infected with malaria
- Nuremberg Code (1947) – first international statement on the ethics of medical research on humans
- Helsinki Declaration (1964) – World Medical Association formulated general principles on use of human subjects for research
- International covenant on civil and political rights (1966) "…no one shall be subjected without his/her consent to medical or scientific treatment"
- WHO and the CIOMS (1982) – Proposed international guidelines for biomedical research involving human subjects

Ethical issues involved in research

- Voluntary participation
- Informed consent
- Risk of harm
- Anonymity
- Confidentiality
- Right to services

Informed Consent – important considerations

- Mandatory for all studies in humans
- Written consent in vernacular
- Fully informed consent
- Special categories – children, mentally ill patients, pregnant women, those with diminished autonomy

Components of Informed Consent

- Explain in lay terms
- Option to withdraw at any time
- Treatment will not be withheld
- Explain all untoward reactions
- Direct benefits (if any)
- Signature of subject & witness
- Informed consent forms must be passed by the Ethics Committee

Some ethical problems….

- A scientist was doing work on perinatal transmission of HIV. He wanted blood samples from the infant and the mother. Since all the women admitted for labour had to give a sample of blood for various tests, the patients were not informed of the tests being done for HIV but additional blood was drawn from them.
- A study on gastric carcinoma was being conducted. All patients coming to the surgery OPD with complaints of dyspepsia were subjected to endoscopy and gastric biopsy after taking informed consent that the test **may** reveal a malignancy. From each patient 12 biopsy samples were collected (normally 3-4 are taken).
- The Head of the Department of Pharmacology wanted to conduct a bioavailability study on a well known antibiotic. He asked the undergraduate (3rd and 4th semester) students and PGs to participate in the study as healthy volunteers. Written informed consent was taken from all volunteers.
- A clinical trial on antiretroviral drugs was conducted in AIDS patients from a small slum in Mumbai. The trial was funded by an Organization from a developed country. The drugs were very effective and the interim analysis showed a significant improvement in those treated with the drugs. The study was abandoned immediately and the drugs were used for the treatment of AIDS in the country which funded the research.
- A study required estimation of neurotransmitters from foetal brain. The investigator collected brains of aborted foetuses. No permission was sought from the parents of the aborted foetuses.
- A study comparing the antidepressant effect of a drug and electroconvulsive therapy was done on major depressives. Informed consent on behalf of the patients was taken from whoever brought the patient to the hospital.
- A trace element was to be tried for its effect on pregnancy induced nausea and vomiting. Animal studies showed no teratogenic or toxic effects. Educated women in their first trimester were enrolled for the study. All gave written informed consent.

Ethical self -test

When in doubt apply the ethical self-test

Would I like my near and dear to be treated thus?

Compiled from a presentation by Prof Dr B. Gitanjali, MD PhD

Professor of Pharmacology, JIPMER, Pondicherry

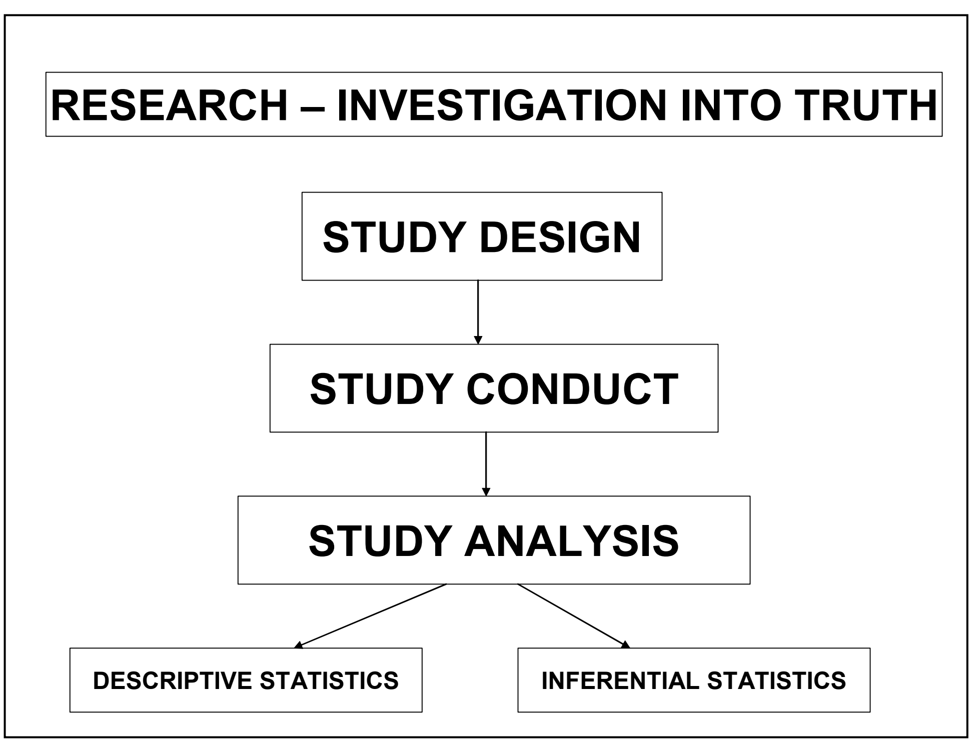
BENEFITS AND DRAWBACKS OF YOGA RESEARCH.

BENEFITS

1. To relieve or clarify the misconceptions among people about Yoga.
2. To clean their mysterious attitude – to open out every aspect of Yoga and to solve the mystery for them.
3. Any science can improve only if research is done on it. Otherwise it will become stagnant and not grow any more.
4. Yoga can be proved to be effective in all faculties – namely physical, psychological, mental spiritual and psychic levels of human beings.
5. Research helps people who are ignorant to know the benefits and good things that we can achieve through Yoga.
6. therapeutical efforts can be enhanced
7. Standardization of practices may be possible with regard to benefits
8. Promotion and propagation of Yoga is achieved

DRAWBACKS

1. Difficulty in human controlled/ blind trials
2. There is no standardization in this field.
3. There is no common syllabus or agreement on it found anywhere
4. Getting trained subjects for research is difficult.
5. Trained observer is also difficult to find.
6. Finance is another problem. Sanction is very limited for research.
7. Yoga is an experiential science and it cannot be measured physically.
8. There are not any developed equipments found to measure the benefits of Yoga physically.



SCIENTIFIC STUDIES OF YOGA

The Physiological Concept

Yogic procedures maintain normal body functions. They affect higher functions of the central nervous system (C.N.S) like perception, planning, execution of tasks, learning and memory. Yoga with breath control techniques increases the cerebral blood flow (Reader 1993). Meditation or Dhyana trains the mind to concentrate on an inner or outer object, channelises the thoughts in an attempt to get beyond mental distractions. It improves coherence between the two cerebral hemispheres signifying synchronization of logical and intuitive function. It increases alertness, along with relaxation. Alertness decreases the reaction time of the brain. Twelve weeks of Yoga is known to decrease the visual and auditory reaction times (Telles et al 1995; Uma et al 1989). Pranayama alone and Mukh bhastrika have shown similar effects (Borkar and Pednekar 2003; Ananda Balayogi Bhavanani et al 2003). Similarly, planning and execution of any task, thought to be a frontal lobe function is enhanced. Yoga accompanied with meditation for a month has shown decreases in time required to perform certain tasks (Manjunath and Telles 2001). Spatial tasks are enhanced during left nostril breathing and verbal tasks during right nostril breathing. Breathing through a particular nostril also improves spatial memory scores (Naveen et al 1997). Perception of any geometrical illusion is influenced by retinal, cortical and cognitive judgmental factors. A decrease was observed following practice of focusing and defocusing (Telles et al 1997; Vani et al 1997). Similarly, the process of learning involves selection, choosing, decision-making and other higher brain functions. However, maze learning may improve due to repeated performance rather than Yoga alone (Telles et al 2000a). The ability to perform rapid fractionated movements depends upon monosynaptic connections between the cortex and the ventral horn cells of the spinal cord. Dexterous or skilled actions depend upon speed of gross movement of the hand and arms steadiness, rhythm, coordination of eyes and motor control. This was seen to improve after Yoga. Presumably, a reduction in anxiety can account for these benefits (Telles et al 1994; Manjunath and Telles 1999). Nevertheless, higher functions of the CNS are augmented by a yogic lifestyle.

The body is ultimately controlled by the CNS through its relationship with the autonomic nervous system (ANS) and the neuroendocrine processes. Yogic processes have a tremendous influence on the central nervous system. It helps an individual to gain control over the ANS resulting in homeostatic functioning of the body. However, there is no definite model of sympathetic activation or relaxation during practice of meditation and there can be individual variations (Telles and Desiraju 1993a). Selvamurthy et al found that six months of Yoga resulted in an autonomic shift towards the parasympathetic nervous system. Sirsasana is associated with increased sympathetic activity while Shavasana brings about a reduction in the sympathetic response (Manjunath and Telles 2003; Madanmohan et al 2002). Yogic breathing exercises include right and left nostril breathing. These breathing techniques stimulate different divisions of the ANS, thus having useful implications in treating psycho physiological disorders associated with hemispheric and autonomic imbalance (Jella 1993; Shannahoff 1991). Right nostril breathing correlates with the activity phase of the basic rest activity cycle, it activates the sympathetic nervous system as shown by an increase in the oxygen consumption and left nostril breathing decreased the sympathetic activity as manifested by an increase in the level of volar galvanic skin resistance (Werntz et al 1983; Telles et al 1996).

Studies of EEG and evoked potential have indicated that there is increase in cortical activity along with synchronization. Marked uniformity of frequency, amplitude and electrical activity was observed in all areas of the brain (Khare and Nigam 2000). Nostril rhythm increases the theta rhythm, the mean alpha (a) and beta (b) power followed by reduction in the asymmetry in b band in the EEG (Stancak and Kuna 1994; Stancak et al 1996; Wallace et al 1971). Practice of Santhi kriya has shown to increase the a activity in both the occipital and prefrontal area (Satyanarayana et al 1992), while an increase in b activity is reported in those practicing Sudarshan Kriya for a long time (Bhatia et al 2003). Six months of Sahaj Yoga decreases the seizure frequency in patients of epilepsy.

Stress reduction is suggested as a probable cause of benefit (Panjwani et al 1995, 1996).

Meditation with the thought focused on the syllable "OM" showed an increase in amplitude with a reduction in latency of middle latency auditory evoked potentials (AEP) (Telles and Desiraju 1993b, Telles et al 1994). Pranayama exercise of Ujjayi and Bhastrika also increased the amplitude and decreased the latency of Na wave of middle latency AEP, indicating facilitation of processes of sensory signal transmission. These practices involve the use of various cortical mechanisms and corticofugal control processes that may alter the process of information processing at the level of the brain stem (Telles et al 1992). Similarly in epileptics, improvement in AEP, visual contrast sensitivity has also been observed (Panjwani et al 2000). Yoga thus increases CNS activity, synchronization, improves sensory processing and balances the ANS.

Yoga and Physical Fitness

Yoga is not restricted to any particular age group. It is therapeutic for patients but it is also practiced in normal individuals to keep physically fit. A study reporting increased physical fitness in school children practicing Yoga has been reported (Gharote 2000). It is thus advisable to start early. Yoga also slows down ageing as shown by a decrease in the reduction of baroreflex sensitivity with age in subjects who were practicing Yoga for five years (Bharshankar et al 2003). Yogic asanas are isometric exercises that involve a coordinated action of synergic and antagonist muscles in bringing about steadiness, flexibility and accuracy of movement. Improvement is seen in static motor performance, hand-eye coordination, grip strength, cardiovascular endurance, anaerobic power, thermoregulatory efficiency, and orthostatic tolerance. The practice of Yoga for six months to one year improves performance by increasing stretch duration, endurance and decreasing the onset of fatigue (Telles et al 1993a,1994; Dash and Telles 2001; Raghuraj et al 1997).

The mechanisms of yogic breathing may involve improvement in oxygen consumption with better oxygen delivery, utilization and minimal energy expenditure as seen in subjects who practiced pranayama. A higher work rate with reduced oxygen consumption per unit of work without increase in blood lactate levels is reported (Raju et al 1994). There is an accompanied increase in peripheral blood flow, along with a decrease in body weight (Selvamurthy et al 1983; Satyanarayana et al 1992; Telles and Desiraju 1992a; Bera and Rajapurkar 1993; Ray et al 1986). Regular and continuous use of any muscle prevents fat deposition, increases flexibility and heightens performance. Ujjayi with long and short kumbhak (breath holding) may exert their effects by alterations in the skeletal muscle activity, ANS discharge, and cerebral blood flow. Breath holding with a short kumbhak increases oxygen consumption, while a long kumbhak during Ujjayi decreases oxygen consumption, and metabolic rate (Telles and Desiraju 1991). Siddhasana is also known to increase oxygen consumption, and metabolic rate compared to shavasana (Rai et al 1994). Virasana likewise induces a hyper metabolic state temporarily characterized by increased ventilation, and enhanced sympathetic activity. This gets neutralized on assuming a shavasana posture (Rai and Ram 1993a). Yoga can improve exercise performance by increasing flexibility, psychological motivation and decreasing heart rate, minute ventilation, oxygen consumption/unit work and respiratory quotient (Ray et al 2001; Raju et al 1997). Above all, Yoga increases the subjective well-being in subjects (Malathi et al 2000).

Yoga and Biochemical Changes

The benefits of Yoga are accompanied by biochemical changes. After three months of Yoga, a significant increase in the level of creatinine phosphokinase and decrease in pyruvate to lactate ratio indicating increased muscular activity with anaerobic metabolism was noted (Sahay et al 1982). A decrease in lactate, catecholamine, dopamine beta hydroxylase, cholinesterase, monoamine oxidase, and cholesterol has been reported. A similar reduction in blood glucose, cholesterol, dopamine beta hydroxylase, monoamine oxidase, and increase in urinary ketoteriods has been reported in sports teachers after three months of training (Telles et al 1993b; Delmonte1985; Udupa et al 1975). Three months of Kriyas, Yoga and a vegetarian diet decreases urinary excretion of adrenaline, nor adrenaline, dopamine, aldosterone, and serum testosterone and leutenising hormone. Cortisol levels decrease in blood along with increased excretion (Kamei et al 2000; Schmidt et al 1997). The biochemical changes indicate a hypo metabolic state (Selvamurthy et al 1983; Wallace et al 1971; Rai and Ram 1993b). Regional glucose metabolism in the CNS is altered during meditative relaxation (Herzog et al 1990). Improvement in glucose homeostasis, with reduction in fasting blood sugar, hyperglycemia, glycosylated hemoglobin, and dose of oral hypoglycemic drugs required after 6, and 12 weeks of Yoga in Non Insulin Dependant Diabetes patients (NIDDM) has been observed (Monro et al 1992; Jain et al 1993). The changes are suggestive of decrease in stress, sympathetic activity, better glucose utilization and exercise tolerance.

Yoga and Hormonal Balance

The glandular activity is increased and hormonal profile is balanced. There is a decrease in cortisol, growth hormone, and thyroxin. On the other hand, prolactin levels increased with no change/ decrease in catecholamine. There may be notable difference in the effect of different types of asanas and exercises. Suryanamaskar influences the skeletal muscle with less influence on the vital organs. Yogic practices increase the protein bound iodine (PBI); improve the thyroid and adrenocorticoid functions. Sarvangasana rehabitates the thyroid gland (Delmonte 1985; Udupa et al 1975). Ujjayi with long and short kumbhak effects adrenomedullary secretions (Telles and Desiraju 1991). Melatonin production believed to be psycho-sensitive, may bring about the psychological benefits of Yoga therapy in stress management (Massion et al 1995).

Yoga and Psychiatric Disorders

The ability of Yoga to bring about a reduction in sympathetic activity is the basis of its use in stress management. Sahaj Yoga practiced for six months was able to increase galvanic skin resistance (GSR), indicating a reduction in sympathetic activity. There was a reduction in blood lactate and VMA activity (Panjwani et al 1995). A range of conditions where Yoga is beneficial in psychiatric problems has been identified (Vahia et al 1996). Subjects of obsessive compulsive disorder have shown improvement in Yale/Brown obsessive-compulsive scale and perceived stress scale (Shannahoff 1996). Sudarshan Kriya Yoga has been used in depression and melancholia (Janakiramaiah et al 2000). A thirty minute session of yogic stretching and breathing exercises produced marked augmentation in perception of physical and mental energy. It increases the feeling of alertness and enthusiasm. It is more invigorating than relaxation or visualization techniques especially when practiced in a group setting (Wood 1993). Reduction in symptoms of perceived stress in psychosomatic disorders like peptic ulcer and hypertension is noted with immediate improvement, while patients with anxiety had a delayed response. The response improved with the duration of treatment (Sethi et al 1982). Similarly, in normal male volunteers a decreased neurotism index, lowered mental fatigability, lowered incidence of subjective complains, and increased performance quotient was observed by scientists. Practice of Yoga makes a person psychologically stable and mentally more composed. A decreased neuro humoral responsiveness and decreased neuroticism may be responsible for curtailing the incidence of complaints (Udupa et al 1973). Yoga relaxation techniques involving disengement enhances coping skills (Khasky and Smith 1999). However, coping with specific health problems may require specialized training (Kroner-Herwig et al 1995).

In addition to psychological and psychiatric disorders, Yoga has shown beneficial effects as a therapeutic tool for mentally retarded children with an improvement in intelligent quotient (IQ) and social adaptation parameters after one year of integrated therapy (Uma et al 1989). An optimal level of stress is beneficial because it can improve performance. Yogic practices reduce anxiety and may help the individual to cope with different types of stressors. A sense of well-being, a relaxed mind, improved concentration, attention, memory, and mental efficiency is seen following the practice of Yoga. The results indicate a tranquil state of mind during routine activities, accompanied by increased attention during stressful situations (Malathi and Damodaran 1999). It also improves the general well-being of an individual and strengthens mental resolve. This forms the rationale of its use in prisoners and children of broken homes (Telles and Naveen 1997). However, it has not proven to be of more value than psychotherapy in drug addicts (Shaffer et al 1997).

Yoga and Cardiovascular Response

The cardiovascular system is controlled by the ANS. Yogic procedures differentially affect the ANS. Those that decrease the sympathetic activity are useful in controlling the diastolic blood pressure in mild to moderate hypertensives. Improvement in risk factors may benefit patients of coronary artery disease. Some of the asanas routinely recommended for improvement in cardiovascular function include Halasana, Paschimottanasana, Virasana, Siddhasana, Shavasana and nadi shodana pranayama (without breath holding). Yoga accompanied by breath control increases cardiac output, decreases the hepatic, renal blood flow and increases cerebral blood flow in the peripheral vessels (Reader 1993). Yoga is also associated with a decrease in the heart rate and diastolic blood pressure (BP) (Baride et al 1994). Heart rate alterations in various types of pranayama and in single thought and thoughtless states have been described (Telles and Desiraju 1992 a,b). Heart rate increases in Siddhasana and Virasana are likely due to increased metabolism (Rai et al 1994; Rai and Ram 1993b). The effects of inspiratory and expiratory phases of normal quiet breathing, deep breathing and savitri pranayama breathing on heart rate and mean ventricular QRS axis was investigated in young healthy untrained subjects. Pranayama breathing produced significant cardio acceleration and an increase in the QRS axis during the inspiratory phase compared to eupnoea. These changes were similar to the changes observed during the corresponding phase of deep breathing or savitri pranayama breathing (Madanmohan et al 1986). Marked heart rate variability (HRV), increased amplitude of oscillations as seen during meditation indicate that it is not a quiescent state as generally believed (Peng et al 1999).

Yoga with other regimes like muscle relaxation produces lowering of BP that has favored its use as a non-drug therapy (Andrews et al 1982). A study has shown that Yoga may be more useful than drugs, but this has been observed in mild and moderate hypertension only (Murugesan et al 2000). Transcendental meditation likewise resulted in lowering of BP in borderline hypertensives. The change is attributed either to an integrated hypothalamic response associated with a decreased sympathetic activity or a placebo effect (Benson et al 1974). In a study after 6 months of Yoga training, exercise was found to increase the systolic but not the diastolic BP (Gopal et al 1973).

Yoga is not only an exercise, it is a lifestyle. In a classical paper, Dean Ornish showed that by following a lifestyle of low vegetarian diet, cessation of smoking, stress management training and moderate exercise, a significant number of patients had regression of coronary artery stenosis as analyzed by quantitative coronary angiography. It was suggested that coronary arteriosclerosis was reversed after 1 year with comprehensive lifestyle changes without the use of lipid lowering drugs. (Ornish et al 1990; Manchanda et al 2000). The effect of yogic lifestyle on some modifiable risk factors has been studied in angina patients and normal subjects with risk factors. The subjects practicing Yoga showed a regular decrease in cholesterol, triglyceride, low density lipoprotein (LDL), while the high density lipoprotein (HDL) increased. The effect began four weeks after treatment and continued till 14 weeks thereafter (Mahajan et al 1999).Hypertension autonomic function tests indicate attenuation of the sympatho-adrenal and rennin-angiotensin activity. Yogic asanas can modulate cardiovascular responses. The different types of breathing procedures affect the ANS. Right nostril breathing activates the sympathetic nervous system and increases the heart rate. Alternate nostril breathing brings about a balance in the ANS (Shannahoff 1993). Kapalabhati practice showed an increase in the low frequency band and decrease in the high frequency band of the heart rate variability spectrum indicating increased sympathetic activity (Raghuraj et al 1998). Nadi Shoddhana pranayama increased both components of HRV. Yogic asanas were found to be effective as tilt procedures in correcting the baroreflex sensitivity in patients, represented by the a index at high frequency, and was seen to increase after 6 weeks of Yoga indicating enhancement of parasympathetic activity (Selvamurthy et al 1998; Bowman et al 1997). Sarvangasana is a posture with the body inverted. It is comparable to a negative "g" position. Echocardiographic recordings showed a reduction in heart rate and left ventricular end diastolic volume. The sympathetic inhibition is due to stimulation of high pressure baroreceptors and low pressure cardiopulmonary receptors. In this position there is sympathetic stimulation also due to isometric contraction of upper limb and neck muscles to support the body (Konar et al 2000). The net effect of the two will determine the autonomic response. Orthostatic responses were altered such that the cardiac output improved more than peripheral resistance to maintain the BP. Shavasana also brings about a faster recovery after treadmill exercise compared to sitting in a chair or lying supine (Bera et al 1998).

Yoga and the Respiratory System

The various practices use breathing exercises (pranayama), suryanamaskar, dhyana, devotional sessions, asanas, kriyas, and yogic chair breathing (Nagarathna and Nagendra 1985; Singh 1987a; Nagarathna et al 1991). Yogic Kriyas like Kunjal and Vastra dhauti use warm water and cloth for cleansing of nasopharynx, oropharynx oesophaus and stomach. The osmolality of fluid may decrease inflammation and thus reduce the sensitivity of receptors in the bronchi thereby increasing the threshold of provocation. Sutra Neti desensitizes nerve endings of the nasal passage making it resistant to allergens. Kapalabhati removes the residual secretions by moving the neck in all directions and forcing out secretions forcefully through the nose. Hence, by this mechanism Yoga and naturopathy may be both useful in treating asthma (Satyaprabha et al 2001).

Pranayama techniques form an important component of Yoga. The types of pranayama generally used are surya bhedana, bhastrika, and nadi shodana. The idea is to maintain a slow rhythmic pattern of breathing using both nostrils alternately. This produces a balancing effect on the ANS. Short kumbhak or breath holding increases O_2 consumption while long kumbhak decreases O_2 consumption (Telles and Desiraju 1991). Prolongation of breath holding time with increase in Forced Vital Capacity (FVC), Forced vital capacity in first second (FEV1), maximum voluntary ventilation (MVV), peak expiratory flow rate (PEFR) and lowered respiratory rate has been reported after six weeks of training in pranayama (Joshi et al 1992). Techniques involving focusing on a single thought resulted in regularity of respiration while in the no thought state there was reduction in the rate and regularity of respiration (Telles and Desiraju 1992a). Savitri type breathing had a similar effect as deep breathing on cardiovascular parameters (Madanmohan et al 1986). In a study of patients practicing hatha Yoga, long term manipulation of breathing by practicing slow deep breathing likely results in overstretching of pulmonary stretch receptors, chronic manipulation results in vagus blockage, thereby vagal manipulation is decreased. This also leads to a conditioning or learning of a pattern of breathing with ample tidal volume and a slow rate (Stanescu et al 2001).

Various respiratory parameters improve after Yoga. A significant increase in FVC, FEV, FEV1, PEFR, increase in the vital capacity, tidal volume increase in expiratory and inspiratory pressures, breath holding time and decease in the respiratory rate is documented to help symptoms of weekly attacks, and scores for drug treatment. Improved exercise tolerance, faster recovery after exercise, decrease in inhaler use, and improvements in bronchial provocation response has also been documented (Gopal et al 1973; Nagarathna and Nagendra 1985; Yadav and Das 2001; Tandon 1978; Singh et al 1990). This effect is not merely due to exercise as the sports teachers with training in physical activity for 8-9 years have also shown improvement (Telles et al 1993b).

Some asanas used for respiratory disease are Yogic chair breathing, Vajrasana, Tadasana, Sasankasana, Shavasana, Naukasana, Bhujangasana, Ustrasana, Urdh hastottanasana, Gomukasana, Ardha Matsyendrasana, Matsyasana, and Makarasana. In specific yogic postures like Siddhasana there is a larger tidal volume, O_2 consumption, CO_2 elimination and minute ventilation compared to shavasana and a relaxed posture of sitting in a chair (Rai et al 1994). Virasana also increased minute ventilation, respiratory rate, tidal volume, O2 consumption and CO2 elimination, O2 pulse with a lesser ventillatory equivalent. The response gets eliminated when the subject retrieves back to shavasana (Rai and Ram 1993). Shavasana is a calming procedure while cyclic meditation involves yogic postures along with periods of supine relaxation. It was found that the results in decease in oxygen consumption, respiratory rate and increase in tidal volume compared favorably to Shavasana alone (Telles et al 2000b). During transcendental meditation there is an increase in respiratory rate, minute ventilation, oxygen consumption, and co2 elimination, with no change in the respiratory quotient. There was reduction in arterial blood pH, lactate levels, and arterial PO2, while PCO2 remained unchanged indicating a wakeful metabolic state (Wallace et al 1971).

An eight-stepped Yoga chair breathing procedure consists of neck muscle relaxation, and asanas with breathing exercises. This may reduce the panic anxiety element contributing to aggravation of bronchial obstruction. The effect seems to be acute, but patients have been followed for 54 months with beneficial effects. Similar results to Yoga asanas and breathing exercises may be observed by techniques like progressive muscle relaxation, postural drainage, and pink city exerciser (Nagendra and Nagarathna 1986; Singh 1987b; Freedberg et al 1987; Lorin et l 1971). Resistive breathing training requires the person to breathe against a resistive load. These respiratory maneuvers may lead to better tolerance of hyperemia, improve the strength and endurance of respiratory muscles and decrease the onset of fatigue. Exercise using a bicycle ergometer and breathing exercises may cause subjective improvement, increase exercise tolerance without lung volume and ventilation in severe obstructive disease by improving neuromuscular coordination (Brundin 1974). Yogic exercises and asanas may benefit individuals by similar mechanisms.

The various mechanisms responsible for the improvement include reduction of psychological over activity, emotional instability, vagal efferent discharge and evacuation of sputum. Slow breathing with and without humidified air had a bronchoprotective and bronchorelaxing effect, increased autonomic control, and a positive endogenous corticosteroid release (Nagarathna and Nagendra 1985; Singh 1987a; Tandon 1978; Singh 1987 b; Jain et al 1991). Yogic breathing is also known to decrease the chemoreflex sensitivity to hypoxia and hypercapnia (Spicuzza et al 2000). Pranayama is believed to decrease the anxiety element as well. Since asthma is a psychosomatic and chronic disease, a psychosomatic imbalance with an increased vagal tone is one of its various etiopathogenesis. Yoga therapy may first bring internal awareness, correct autonomic imbalance, control the breathing, improve the immune status and alter physiological variables. Even one week after Yoga therapy, improvements in ventillatory functions in asthmatics have been observed. This could be due to reductions in sympathetic reactivity and relaxation of voluntary inspiratory and expiratory muscles. Both transcendental meditation and Yoga have proven to be effective alternative medicines for controlling symptoms of asthma (Lane 1991; Wilson 1975). Yoga is also valuable in the treatment of COPD (Behera 1998).

Conclusion

The practice of Yoga is a tremendous gift from our Indian culture. Only recently have we begun to understand the vast potentials and health benefits. However, it has also become fashionable to talk about Yoga rather indiscriminately and Yoga is assuming a significant commercial potential. It can be argued that the benefits of Yoga may be due to the dynamics of group activity and the mere fact that the person is engaged in any exercise. This psychological aspect can influence the physiological state. In this context, it is important to find scientific explanations for the perceived benefits of Yoga. This can also help us to select specific items and individualize therapies. However, much more needs to be done and it is only a matter of time when scientific objectivity will be well established. Presently, it is well known that Yoga has become internationally accepted.

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YOGA RESEARCH –WHAT ARE WE DOING?

This is a very vital question that has been asked by one of our students (TJ) who has been disillusioned with his medical studies

I give below his mail as well as responses from Dr R Nagarathna (Dean, Division of Yoga and Life Sciences, SVYASA, Bangalore and Chief Medical Officer, SVYASA), Dr MV Bhole, (retired director of research at Kaivalyadhama, one of India's oldest Yoga institutions at Lonavla, Maharasthra), Dr Kaviraja Udupa, Senior Resident Physiology, JIPMER, Pondicherry and myself. I also add on a mail from Prof R Narasimhan the retired Director Professor and Head, Dept of Pathology at JIPMER who is presently with the Ramachandra Medical Institute at Chennai.

I welcome all of you to take part in this discussion and would be interested to hear from the medical doctors and yoga scientists on this group as well as other Sadhakas on this path

Dr Ananda Balayogi Bhavanani

Chairman ICYER, Puducherry, South India

From TJ

I have been blessed to be part of an academic establishment that keeps its doors open to its students. It's funny, I made the decision to "leave" medicine (or this version of it) some time ago, but actually overcome the inertia of my present 3 or so weeks ago. For the past 2 weeks, I've been getting everything in order to complete my second year of medical school and take my leave.

Now that I've closed these doors (in a way that I can re-open them when and should I chose to), I am at my greatest period of uncertainty as to which option to pursue. My fear is that by taking leave to discover my most realized path (simplifying my goals and intentions) I am creating a greater uncertainty as I try to assess what (or which) that path is.

How do you view your role as a researcher?

Do you feel like you are trying to "prove" phenomena that are already known to be "true"; do you feel like you're reducing yoga to fit current paradigms?

Please do not see these questions as an attack on your research. As someone who's felt both the synergy and conflict between so-called eastern and western medicine, as someone who sees the advantages and disadvantages to "good" scientific research methods - randomization, blinding, setting controls for creating specific targeted therapies, I am just always left with the feeling that scientific research forces yoga to be too small in order to fit into its own conception of what knowledge is, its own scope that seeks greater reduction, not greater harmony or totality. How do you see "good, useable" data? I am so curious on this subject.

I do believe that I can walk the path of a scientific healer and a yogi simultaneously. Again, it's this question of how.

From Dr Ananda Balayogi Bhavanani, Chairman ICYER, Puducherry

It was interesting to read your mail and I am putting your question on the groups for answers from the other Yoga scientists that are out there in the cyber space with us

I am happy that you count your blessings for such an attitude (not so common in this day and age) will help you throughout your whole life

Crossroads are always a place to be careful and there will be undoubtedly lots of uncertainly.

It is however important to keep moving and not stay at the cross road forever!

To think is good but to act is better!

Yoga research is still in its infancy and has to face a lot of problems

It is true that modern science tries to make yoga smaller in order to make it fit the demands of science. Most scientists are looking for one asana to cure one disease just as there is a pill for every ill!

We still don't have the facilities to research the higher aspects of yoga and most research has been on the Asana, Pranayama and to some extent on the meditative and so called meditation techniques such as TM

I believe that we have to first start within the system and follow its rules and guidelines- one must learn to play by the rules of the game. Once we have mastered the game then we can go beyond the rules and make our own ones!

Later on, I feel we can expand the process to include other aspects of yoga

Yoga views man as a multilayered being while science looks upon him as a single layered entity

We have to start someplace and the present is the place to start

It is important to determine the physiological and psychological benefits of various yogic practices on their own as well as in combination in order to come upon a wholistic view in later years

Indian researchers are limited by finance, time and facilities and so most of the research in India (and there has been a lot) has been in the very basic aspects of yoga

CCRYN does a great job in funding yoga research but is still much disorganized as seen in most governmental bodies. They need to take more initiative in coordinating the research in different centers rather than just handing out money to different people.

Yoga is a method of going inwards, within this and us is very difficult if not impossible to study using the tools of traditional scientific research

The necessity of the hour is to legitimize yoga practices in the eyes of the scientific community who tend to dismiss the benefits otherwise is a disdainful manner

It is also important that more scientific minded persons take up yoga and more yogis go into the study of science so that we can build a bridge between these two great aspects of our civilization.

Swamiji always stimulated his students to take up a study of science in order to present the yogic teachings in a modern scientific manner and not as some mumbo jumbo techniques. I find many yoga teachers treating patients of various diseases about which they themselves have not a clue! I feel that is simple quackery and a crime against humanity.

I feel that Swamiji's vision of Scientific Yoga is the goal towards which we must work with renewed vigor and determination.

I hope that more of the yoga scientists out there in the group will respond with their views on this topic that is also very close to my heart

Yours in Yoga,

Dr Ananda

From Dr R Nagarathna, Dean, Division of Yoga and Life Sciences, SVYASA, Bangalore and Chief Medical Officer, SVYASA

Dear Dr. Ananda,

Thanks for this fundamental query.

I believe the same way as you say. One VC of Bangalore University once said that we are trying to validate the 5000 years old science by a 500 years old modern science. Well we need to do research in this framework to win the confidence of the world at large so that they can listen to what you want to say.

It is fascinating to know how the modern science has been able to unravel the mysteries of the universe by such strict way of probing and not accepting anything without subjecting to very rigorous scrutiny. Otherwise we would still have been in the age of spirits, leeches, and the so-called Kakataliya nyaya would have flourished. But as we have come this far we have to go further ahead by dropping out the excess of this rigor and go to something, which is beyond science and logic. Here was the advantage of the oriental seers who had best of both and also could see what should be the direction in which research should go to see a healthy and happy society. They also seems to have known where they should not do too much of probing and move on to go beyond logic.

Our aim should be to go the way that the modern science has gone, gain their acceptance and then blow our trumpet about all that we are talking about

-- Namely

1. validity and reproducibility of internal experiences to be accepted
2. not only look for objective gadget oriented evidence,
3. the so-called placebo effect now being considered discardable effect to be researched into etc.

As you can see we in our center have at least been able to retain some part of the holistic approach of yoga by calling it IAYT right from day one instead of doing the same mistake that ayurveda physicians did when they started going into extract active ingredients and doing animal experiments. Now that this tract has been tried by this Indian scientists it becomes difficult and almost impossible to change the trend amongst researchers to go back to the holistic concept of ayurveda.

Dr. Ananda we all have a bigger duty to do apart from only validating the ancient techniques by the modern techniques of research.

We should go into many many researchers doing internal research and relive those states of consciousness. Scientists should experience those states and then start giving a holistic look for everything that is happening.

We should also be able to give a direction for the whole research that is going on in any field of science today. -- The slogan --'publish or perish' is becoming a wrong habit. Cutthroat competition amongst researchers is another malady, which is not the right thing to happen with Saraswathi.

Please join hands to first publish in the way the modern scientists want. Get 20 publications of yours in renowned journals of high regard in the field of science and then people will start listening to you.

I hope your student will peruse his medicine studies, go through the tough phase for 6 years, which is not a waste in one's life span, and then start involving in this type of activities.

Nagarathna

From Dr MV Bhole, retired director of research at Kaivalyadhama, one of India's oldest Yoga institutions at Lonavla, Maharastra

There are only two sciences, which are working with human beings directly. One is Yoga and the other is Medicine. Other sciences do keep the human beings in their purview, but not in the centre. The three modalities: Jiva - Jagat and Iswara. One of these three remains in the center and other two remain in the periphery.

Medicine can work with the unconscious human beings and also the animals, but Yoga requires only the conscious human beings having the capacity and the ability to make Resolves (Samkalpa - Vikalpa and Nischaya) and to be able to execute them. Other kinds of human beings have to solely depend on "Guru Krupa".

Our ancient traditional knowledge is not easily and uniformly available to one and all. It follows "Guru - Shishya" or "Father - Child" Parampara and/or very closely guarded "Family Traditions". What you (Dr Ananda) got from Rev. Swami Gitananda Ji as his son and his disciple, I could not get. That is the fundamental difference in the eastern and western approach. Our traditions are still based on the "Principles of Business Management or strong Survival Needs". They are yet to become "Open Education Systems".

If one is not fortunate enough to have been born as a Brahmin having access to the living tradition and/or if you are not fortunate enough to have your training under the direct guidance of a "Guru" with "His Grace" (Gurukrupa) in Indian "Guru-Shishya Parampara"; then you have no other alternative than to follow the existing western approach.

If one has no knowledge of Sanskrit and does not know how to decipher complex sanskrit terms into simple Sanskrit, then one has to depend on the translations of old yoga literature in other language either Indian and/or western. The translators may not be "Realized" or "Emancipated Souls".

If one has been educated and brought up in western way of thinking and analysis, then how one can easily switch over to the Indian way of thinking and analyzing yoga texts, terms, techniques, states of consciousness etc.?

All people do not come to yoga in the olden classical motivation to know "Who am I?". They have other demands, which require different approaches to find suitable answers. Preset day Yoga Experts, many a times, are not willing to deviate from their path for reasons best known to them. In that situation, one has no other go than to resort to other types of approaches and explanations.

There is no attack on my research. I know what I have done and I am doing. In what direction I am traveling and I want to guide people coming to me. Everything begins and starts in a "Very Small" way. Slowly it grows. Every big work and/or task has to be divided into suitable pieces e.g. Ashtanga of Patanjali, Shadangas of Gheranda etc. Where is the Conflict?? I cannot understand.

In regard to your last question on how to walk the path of a scientific healer and a yogi simultaneously my answer is "**Oh yes, you can surely do it. Go to Ananda Ashram where there is the living tradition of Rishi Culture blended with modern medicine without any conflict and/or contradiction.**

From Prof R Narasimhan the retired Director Professor and Head, Dept of Pathology at JIPMER who is presently with the mahatma Gandhi Medical Institute at Puducherry.

Dear Dr. Ananda,

I appreciate the concerns Of Dr. Nagarathna. I am so glad to see your well-balanced picture of the scenario today and you have practically addressed every question raised. I fully endorse what you had quoted about Swamiji's views on this. Thank you for the mails, which I find interesting, thought provoking and stimulating at times to find the answer within.

Narasimhan

From Dr Kaviraja Udupa, Former Senior Resident Physiology, JIPMER, Pondicherry and Doctoral Research Fellow at NIMHANS, Bangalore

The question raised by your student is absolutely correct. Even after 3-4 years of research in yoga under Dr. Madanmohan Ji & yourself, I feel we need lots of retrospection of our works based on these questions

Yoga, the cultural heritage of our country definitely has more stuff in it than to be proved its authenticity by using modern science. The major difference I find between modern medicine & yoga is the humanitarian approach in yoga. Modern medicine completely lacks it, it sees a person as a machine with different systems, organs, tissues...Human values, ethics, social support...are lacking not only in medicine but present day world which is resulting in stressful modern world, terrorism & whole lot of evils...this is a vicious cycle in turn resulting in all other pervading problems.

Then where is the solution? I feel it's the combination of true modern scientific knowledge & yoga as way of life. All limbs of Ashtanga yoga should be given their due importance & should be implemented in all walks of life. Yoga teachers, researchers, different schools of yoga should work together & show the common man the yogic way of life than fighting against each other. In addition to giving yoga training to normal persons (to whom Yama & Niyama practice to be given properly), patient population should be taken care of (give them the specific Asanas & Pranayamas which are complement to allopathic treatment and provide them the psychological support to take care of psychosomatic involvement). I feel just talking to the patient for half an hour each will solve most of his/her problem rather than treating them as spoiled machinery.

I strongly feel your student should continue his studies, get proper knowledge of one system of medicine, which is highly advanced, in treating emergencies & also give fairly good amount of knowledge about human life. He can study more about yoga simultaneously, adopting its lifestyle himself now & propagate it for the betterment of whole mankind in days to come. I wish him all the best