BIOLOGY POINTERS
BASIC CONCEPTS AND LAWS

Biology

- the area of science dealing with living things. It includes biological concepts and process skills, technology and attitudes and values for addressing the needs and problems of society. In recent years, the development of techniques in genetic engineering and increased understanding of the molecular basis of cellular processes have led to the emergence of a new and exciting field of scientific research called biotechnology.

Introduction

ORGANIC COMPOUNDS
- characterized by the presence of carbon.

a. ***Carbohydrates*** - are made up of carbon, hydrogen, and oxygen (e.g., sugar, starches, and cellulose) atoms. They have the general formula $C_nH_{2n}O_n$. Their sizes range from the small simple sugars like glucose and fructose to the large and complex forms like starch and glycogen. Only the simple sugars (monosaccharides) can easily pass across cell membranes. Most carbohydrates serve as energy molecules or energy reserves in living organisms.
Cellulose - gives strength and protection to plant cells.

b. ***Lipids*** – are macromolecules such as fats, oils and waxes. They are made up of carbon, hydrogen, and oxygen. The building blocks used to form fats are fatty acids and glycerol. Some excess food in the body is stored as fats. Lipids that are liquid at room temperature are known as oils. Waxes serves as protective body covering to organisms. They make plant and animal tissues water-resistant.

c. ***Proteins*** - are made up of repeating units of amino acids. They are a component of the muscles and all other tissues. In the form of enzymes, they control the rate of chemical reactions inside the cell. Without the enzymes, such chemical processes hardly occur.

d. ***Enzymes*** - are proteins that act as catalysts (substances that can increase or speed up chemical reaction). Enzymes are specific in their actions. They are not used up in the reaction.

e. ***Nucleic Acids*** - are carriers of hereditary information in living organisms. What an organism looks like, and what it can do, are controlled by nucleic acids.

f. ***Vitamins*** - are substances necessary in very small amount for body growth and activity. They are also needed to prevent certain diseases. Vitamins are organic substances essential to life but not required as energy sources. The sources of most Vitamins are plants and bacteria.

INORGANIC COMPOUNDS

- characterized by the absence of carbon.

a. ***Water*** - is the most abundant inorganic compound. About 65% to 95% of the substances of every living thing is water. It is the medium of transport for food, minerals and other substances in living system.
b. ***Carbon dioxide*** - supplies the carbon found in substances made by living things.
- are chemical elements or compounds occurring naturally. They may come from the soil maybe dissolved in water, or maybe found as salt in seawater. Minerals are absorbed by plant roots in the form of ions.

LIFE FUNCTIONS

- All living things carry out certain activities or functions in order to maintain life.

a. ***Nutrition*** is the process of ingesting and absorbing food to provide the energy for life, promote growth, and repair or replace damages tissues.
b. ***Transport*** involves movement of nutrients water, ions, and other materials into and out of the various cells and tissues of organisms. This process includes absorption of small molecules across cell membranes and secretion of biochemicals such as enzymes, mucous, and hormones. In many species, the circulatory system plays an important role in transport.
c. ***Metabolism*** includes the process by which nutrients and simple molecules are used to form more complex molecules for growth, repair, and reproduction (anabolism). Metabolism also includes the process of breaking down complex molecules to release energy from chemical bonds (catabolism) and to provide small molecules such as simple sugars and amino acids as budding blocks for more complex molecules (anabolism).
d. An internal balance in all aspects of metabolism and biological function is called ***homeostasis***.
e. ***Digestion*** is a special form of catabolism that breaks food down into smaller molecules and releases energy.
f. ***Absorption*** allows small molecules to pass through cell membranes throughout the body tissues. This allows for a gas exchange and in some species such as plants and fungi nutrients are obtained by absorption from soil and water.
g. ***The behavior of living things is a response to stimuli in the environment***. These stimuli may include things such as light, chemical signals, noise, or a change in the seasons.
h. ***Excretion*** is the elimination of waste products.
i. ***Reproduction*** is the process by which an organism produces offspring either sexually or asexually. Its main purpose is for the perpetuation of species. It is classified into two types, namely:

1. **Asexual** - is the reproduction without the use of gametes or sex cells. One parent organism ran reproduce by itself.

a. **Fission** - is the splitting of the body of an organism into two identical parts. (e.g., Paramecia and planaria)
b. **Budding** - is the growing of bud out of the parent cells of bodies which when detached can grow into another organism that resembles the appearance of parent (e.g., sponges, and yeast)
c. **Sporulation** - is the spore formation as in fern plant and mushrooms.

2. **Sexual** - requires the union of male and female gametes called "fertilization". Male gametes are called sperm cells and female gametes are called egg cells. Fertilization is classified into two types, namely:

a. **External Fertilization** - the union of sperm cells and egg cells happen outside the body of the female organisms. (e.g., seashells, starfishes, frogs, fishes)

b. **Internal Fertilization** - the union of sperm cells and egg cells happen inside the body of a female organism (e.g., higher forms of animals and human)

Cells

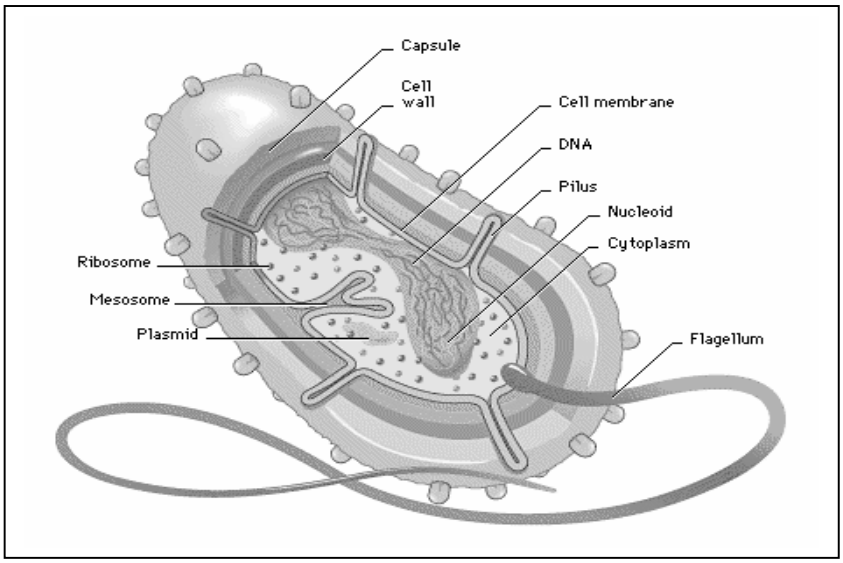
- are the smallest structures capable of basic life processes, such as taking in nutrients, expelling waste, and reproducing. All living things are composed of cells. Some microscopic organisms, such as bacteria and protozoa, are unicellular, meaning they consist of a single cell. Plants, animals, and fungi are multicellular; that is, they are composed of a great many cells working in concert.

Cell Structure

PROKARYOTIC CELL

- found only in bacteria and archaebacteria, all the components, including the DNA, mingle freely in the cell's interior, a single compartment.
- are among the tiniest of all cells, ranging in size from 0.0001 to 0.003 mm (0.000004 to 0.0001 in) in diameter.

- can be rod like, spherical, or spiral in shape, are surrounded by a protective cell wall.
- live in a watery environment, whether it is soil moisture, a pond, or the fluid surrounding cells in the human body. Tiny pores in the cell wall enable water and the substances dissolved in it, such as oxygen, to flow into the cell; these pores also allow wastes to flow out.



Anatomy of a Simple Bacterium

Bacteria cells typically are surrounded by a rigid, protective cell wall. The cell membrane, also called the plasma membrane, regulates passage of materials into and out of the cytoplasm, the semi-fluid that fills the cell. The DNA, located in the nucleoid region, contains the genetic information for the cell. Ribosomes carry out protein synthesis. Many baceteria contain a pilus (plural pili), a structure that extends out of the cell to transfer DNA to another bacterium. The flagellum, found in numerous species, is used for locomotion. Some bacteria contain a plasmid, a small chromososme with extra genes. Others have a capsule, a sticky substance external to the cell wall that protects bacteria from attack by white blood cells. Mesosomes were formerly thought to be structures with unknown functions, but now are know to be artifacts created when cells are prepared for viewing with electron microscopes.

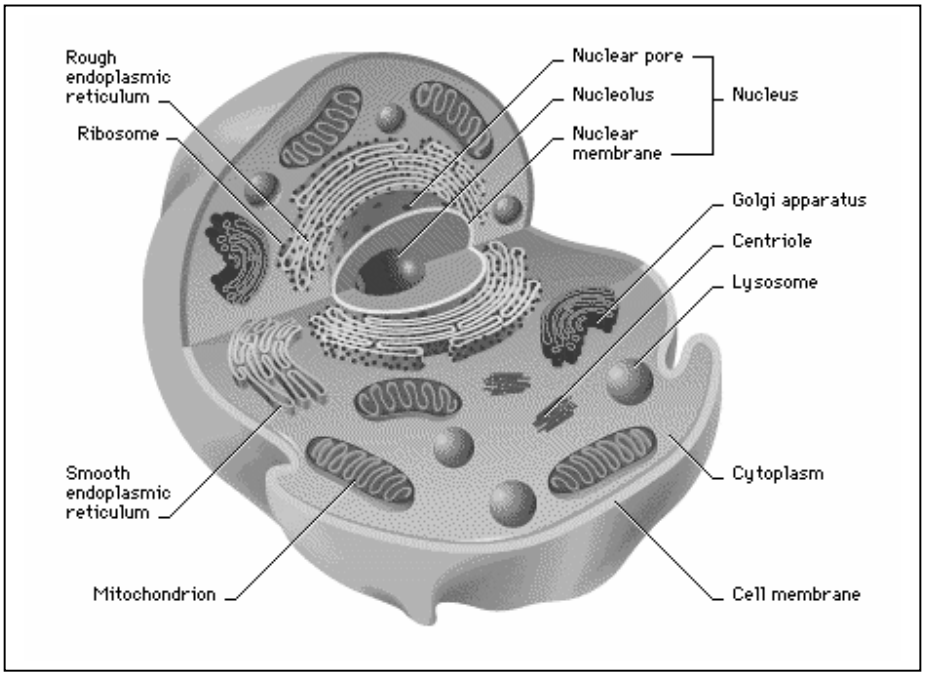
Plasma Membrane is a thin membrane pushed up against the inner surface of the prokaryotic cell wall. The plasma membrane, composed of two layers of flexible lipid molecules and interspersed with durable proteins, is both supple and strong. Unlike the cell wall, whose open pores allow the unregulated traffic of materials in and out of the cell, the plasma membrane is selectively permeable, meaning it allows only certain substances to pass through. Thus, the plasma membrane actively separates the cell's contents from its surrounding fluids.

Cytoplasm is the semifluid that fills the cell enclosed in the plasma membrane. Composed of about 65 percent water, the cytoplasm is packed with up to a billion molecules per cell, a rich storehouse that includes enzymes and dissolved nutrients, such as sugars and amino acids. The water provides a favorable environment for the thousands of biochemical reactions that take place in the cell. Within the cytoplasm of all prokaryotes is deoxyribonucleic acid (DNA), a complex molecule in the form of a double helix, a shape similar to a spiral staircase.

Ribosomes, also immersed in the cytoplasm are the only organelles in prokaryotic cells—tiny bead-like structures. These are the cell's protein factories. Following the instructions encoded in the DNA, ribosomes churn out proteins by the hundreds every minute, providing needed enzymes, the replacements for worn-out transport proteins, or other proteins required by the cell.

EUKARYOTIC ANIMAL CELLS

- are typically about ten times larger than prokaryotic cells. In animal cells, the plasma membrane, rather than a cell wall, forms the cell's outer boundary. With a design similar to the plasma membrane of prokaryotic cells, it separates the cell from its surroundings and regulates the traffic across the membrane.

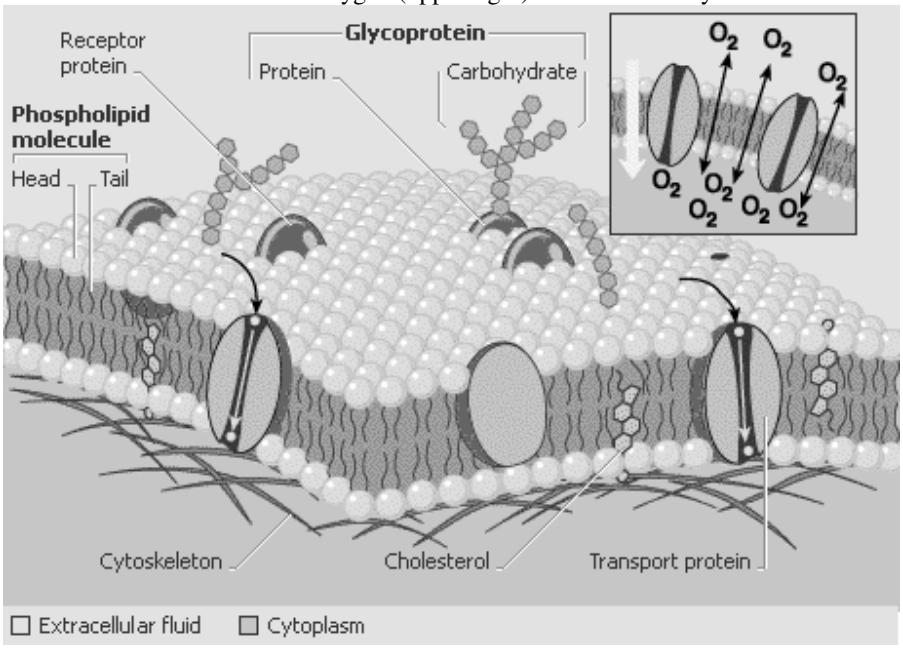


Animal Cell
An animal cell typically contains several types of membrane-bound organs, or *organelles*. The nucleus directs activities of the cell and carries genetic information from generation to generation. The mitochondria generate energy for the cell. Proteins are manufactured by ribosomes, which are bound to the rough endoplasmic reticulum or float free in the cytoplasm. The Golgi apparatus modifies, packages, and distributes proteins while lysosomes store enzymes for digesting food. The entire cell is wrapped in a lipid membrane that selectively permits materials to pass in and out of the cytoplasm.

Eukaryotic cell cytoplasm is similar to that of the prokaryote cell except for one major difference: Eukaryotic cells house a nucleus and numerous other membrane-enclosed organelles. Like separate rooms of a house, these

organelles enable specialized functions to be carried out efficiently. The building of proteins and lipids, for example, takes place in separate organelles where specialized enzymes geared for each job are located.

Plasma Membrane
The plasma membrane that surrounds eukaryotic cells is a dynamic structure composed of two layers of phospholipid molecules interspersed with cholesterol and proteins. Phospholipids are composed of a hydrophilic, or water-loving, head and two tails, which are hydrophobic, or water-hating. Tiny gaps in the membrane enable small molecules such as oxygen (upper right) to diffuse readily into and out of the cell.



Nucleus of a Cell
is the largest organelle in an animal cell. It contains numerous strands of DNA, the length of each strand being many times the diameter of the cell. The nucleus, present in eukaryotic cells, is a discrete structure containing chromosomes, which hold the genetic information for the cell. Separated from the cytoplasm of the cell by a double-layered membrane called the nuclear envelope, the nucleus contains a cellular material called nucleoplasm. Nuclear pores, present around the circumference of the nuclear membrane, allow the exchange of cellular materials between the nucleoplasm and the cytoplasm.

***Endoplasmic* Reticulum** is an elongated membranous sac attached to the nuclear membrane. Endoplasmic reticulum takes two forms: rough and smooth. Rough endoplasmic reticulum (RER) is so called because it appears bumpy under a microscope. It functions on synthesis of membrane proteins, secretory proteins and hydrolytic enzymes and also formation of transport vesicles. Smooth endoplasmic reticulum functions on lipid synthesis, carbohydrate metabolism in liver cells, detoxification in liver cells and calcium ion storage.

Ribosomes in eukaryotic cells have the same function as those in prokaryotic cells—protein synthesis—but they differ slightly in structure. Eukaryote ribosomes bound to the endoplasmic reticulum help assemble proteins that typically are exported from the cell. The ribosomes work with other molecules to link amino acids to partially completed proteins. These incomplete proteins then travel to the inner chamber of the endoplasmic reticulum, where chemical modifications, such as the addition of a sugar, are carried out. Chemical modifications of lipids are also carried out in the endoplasmic reticulum.

Smooth Endoplasmic Reticulum (SER), lacks ribosomes and has an even surface. Within the winding channels of the smooth endoplasmic reticulum are the enzymes needed for the construction of molecules such as carbohydrates and lipids. The smooth endoplasmic reticulum is prominent in liver cells, where it also serves to detoxify substances such as alcohol, drugs, and other poisons.

Golgi apparatus, an organelle that resembles a stack of deflated balloons. It is packed with enzymes that complete the processing of proteins. These enzymes add sulfur or phosphorous atoms to certain regions of the protein, for example, or chop off tiny pieces from the ends of the proteins. The completed protein then leaves the Golgi apparatus for its final destination inside or outside the cell. During its assembly on the ribosome, each protein has acquired a group of from 4 to 100 amino acids called a signal. The signal works as a molecular shipping label to direct the protein to its proper location.

Lysosomes are small, often spherical organelles that function as the cell's recycling center and garbage disposal. Powerful digestive enzymes concentrated in the lysosome break down worn-out organelles and ship their building blocks to the cytoplasm where they are used to construct new organelles. Lysosomes also dismantle and recycle proteins, lipids, and other molecules.

Mitochondria are the powerhouses of the cell. Within these long, slender organelles, which can appear oval or bean shaped under the electron microscope, enzymes convert the sugar glucose and other nutrients into adenosine triphosphate (ATP). This molecule, in turn, serves as an energy battery for countless cellular processes, including the shuttling of substances across the plasma membrane, the building and transport of proteins and lipids, the recycling of molecules and organelles, and the dividing of cells. Muscle and liver cells are particularly active and require dozens and sometimes up to a hundred mitochondria per cell to meet their energy needs. Mitochondria are unusual in that they contain their own DNA in the form of a prokaryote-like circular chromosome; have their own ribosomes, which resemble prokaryotic ribosomes; and divide independently of the cell.

Cytoskeleton, a dynamic network of protein tubes, filaments, and fibers, crisscrosses the cytoplasm, anchoring the organelles in place and providing shape and structure to the cell. Many components of the cytoskeleton are assembled and disassembled by the cell as needed. During cell division, for example, a special structure called a spindle is built to move chromosomes around. After cell division, the spindle, no longer needed, is dismantled. Some components of the cytoskeleton serve as microscopic tracks along which proteins and other molecules travel like miniature trains. Recent research suggests that the cytoskeleton also may be a mechanical communication structure that converses with the nucleus to help organize events in the cell.

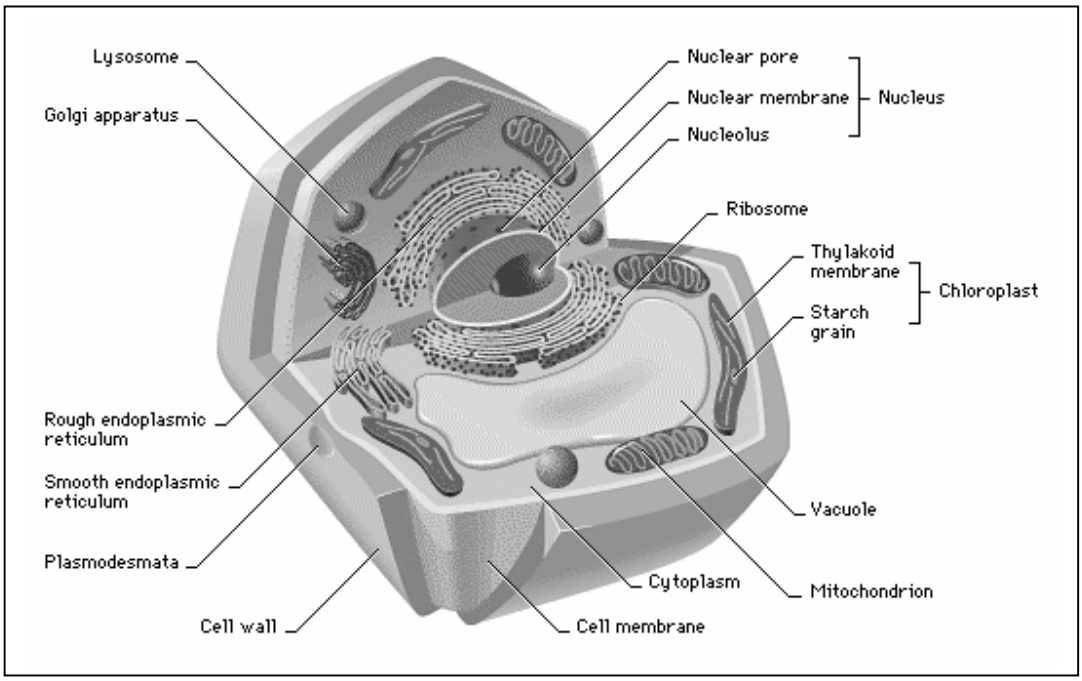
EUKARYOTIC PLANT CELLS

- Plant cells have all the components of animal cells and boast several added features, including chloroplasts, a central vacuole, and a cell wall. Chloroplasts convert light energy—typically from the Sun—into the sugar glucose, a form of chemical energy, in a process known as photosynthesis.
- contain a variety of membrane-bound structures called organelles. These include a nucleus that carries genetic material; mitochondria that generate energy; ribosomes that manufacture proteins; smooth endoplasmic reticulum that manufactures lipids used for making membranes and storing energy; and a thin lipid membrane that surrounds the cell. Plant cells also contain chloroplasts that capture energy from sunlight and a single fluid-filled vacuole that stores compounds and helps in plant growth. Plant cells are surrounded by a rigid cell wall that protects the cell and maintains its shape.

Chloroplasts, like mitochondria, possess a circular chromosome and prokaryote-like ribosomes, which manufacture the proteins that the chloroplasts typically need.

Central vacuole of a mature plant cell typically takes up most of the room in the cell. The vacuole, a membranous bag, crowds the cytoplasm and organelles to the edges of the cell. The central vacuole stores water, salts, sugars, proteins, and other nutrients. In addition, it stores the blue, red, and purple pigments that give certain flowers their colors. The central vacuole also contains plant wastes that taste bitter to certain insects, thus discouraging the insects from feasting on the plant.

Cell wall surrounds and protects the plasma membrane. Its pores enable materials to pass freely into and out of the cell. The strength of the wall also enables a cell to absorb water into the central vacuole and swell without bursting. The resulting pressure in the cells provides plants with rigidity and support for stems, leaves, and flowers. Without sufficient water pressure, the cells collapse and the plant wilts.



SUMMARY OF COMAPRISONS BETWEEN PROKARYOTIC AND EUKARYTIC CELLS

Cell Structure	Prokaryotic Cell	Eukaryotic
Nuclear MEmbrane	absent	Present
Membrane-bound organelles	absent	Present
Ribosomes	Small	Large
Chloroplasts	absent	Present
Mitochondria	absent	Present
Chromosomes	Single circular	Multiple double helix

ANIMAL CELLS VS PLANT CELLS

Plant cells contain cell walls, vacoules, and chloroplasts that animal cells don't. On the other hand, animal cells ahave centiroles and lysosomes that plant cells don't.

Life Classification of Organisms

Biologists use a standard way of naming organisms. A systematic ay of giving scientific names is by using the *genus* and *species* names of an organism. This is known as binomial nomenclature.

Levels of Classification

Kingdom → Phylum → Class → Order → Family → Genus → Species

Family - group of genera with related characteristics. The family is below the order and above the genus in biological groupings. The names of families in modern classification are usually derived from a genus of the family, called the type genus. The family names of animals always end in idae, as in Equidae, the horse family; those of plants almost always end in aceae, as in Dipsacaceae, the teasel family.

Genus - category of classification of living things; specifically, a group of species closely related in structure and evolutionary origin. The position of a genus, in classification of the kingdoms of living forms, is below family or subfamily, and above species.

Species - is a group of closely related organisms that are able to interbreed and produce fertile offspring

THE FIVE KINGDOMS

The Kingdom *Prokarya* or Bacteria are distinguished from the life forms in all other kingdoms in that they do not have a membrane bound nucleus containing the genetic material of the cell. They are called "prokaryotes". The genetic material is simply found in strands ("plasmids") within the cell's cytoplasm. Note that what was previously called blue green algae are now classified as cyanobacteria because they are prokaryotes. Since they are so different from all other life, under the five kingdom system, Bacteria also comprise the Superkingdom *Prokarya*.

The cells of life forms in the other four kingdoms are classified as "eukaryotes" and have a nucleus in which the genetic material is organized on "chromosomes" within a cellular nucleus. These four kingdoms comprise the Superkingdom *Eukarya*. Besides the presence or absence of a nucleus, there are other major differences between prokaryotes and eukaryotes. For example, Bacteria are all over the map in whether they utilize oxygen or another gas such as nitrogen or methane. Some cannot even tolerate oxygen—for these "anaerobic" Bacteria, oxygen is a poison. Almost all eukaryotes are aerobes—they need oxygen to live. That some Bacteria require an oxygen-free environment harkens back to the earth's earliest times and suggest their ancient origin.

The Kingdom *Animalia* is comprised of multi-celled organisms which develop from an embryo resulting from the fertilization of an egg by a much smaller sperm. However, even among the vertebrate animals, there is an exception to sexual reproduction that makes the definition slightly less than a 100% accurate. A species of lizard of the genus *Cnemidophorus* reproduces by parthenogenesis—no males or sperm required. Yet I think everyone would accept that this lizard is an animal (this lizard being one exception that proves the rule—there are other a few other parthenogenetic animals). Animals also share the characteristic that most must ingest or

eat other living or decayed organic matter as food to live (or live as parasites or symbionts off of the nutrients provided by other living things) (although this trait is also shared with some of the members of the Kingdom *Protoctista*).

The Kingdom *Plantae* is composed of multi-celled organisms that grow from embryos that are usually the result of sexual fusion of a male and female cell. Again there are exceptions although somewhere in every plant's past, there were sexual forbears. Most plants (but again not all) plants engage in photosynthesis—that complicated and almost miraculous process whereby the energy of sunlight is used by the plant to produce carbohydrates and gaseous $O_2$from H_2O and CO_2. As a result, plants are the great producers of life. Plants generally have a rigid cell wall composed of cellulose. They are non-motile (the entire organism does not move about under its own energy) but some produce motile cells.

The Kingdom *Fungi* is comprised of non-motile cells that have cell walls made of chitin (the same hard stuff that the outer bodies of insects are made of) and not cellulose. Therefore, some argue that fungi are more closely related to animals than plants. Fungi develop from spores without any embryonic stage. They digest other living things outside their bodies by releasing enzymes and then absorbing the product.

Kingdom *Protista* is the catch-all kingdom for everything that does not fit into the other four. It is comprised of many microscope organisms that are of great interest to this group (as well as some macroscopic organisms). These include protozoa (or protista under the more modern name) and algae but also such diverse organisms as slime molds and slime nets. Although we often think of this group from its microscopic members, it is also comprised of some large organisms such as giant kelps that can grow as much as 10 meters (over 30 feet).

MOST COMMON VERTEBRATES

Vertebrate Type	Characteristics	Examples
Jawless fishes	Cold-blooded animals that live in water. These fishes have no bone structure and their sole support is from a simple cartilaginous rod known as the notochord.	Hagfish, lamprey
Cartilaginous fishes	Cold-blooded animals that live in water. Their notochord is surrounded by rings of cartilage known as vertebrae.	Sharks, skates, rays, chimaeras
Bony fishes	Cold-blooded animals that live in water. Their skeleton is made of bone, and most bony fishes also have an internal bladder that aids in buoyancy.	Sturgeon, herring, salmon, perch, cod, coelacanth
Amphibians	Cold-blooded animals that live some part of their life on land but usually must breed and develop from egg to larvae to adult in water. Most amphibian larvae use gills to breathe underwater. These gills	Frogs and toads, salamanders, newts, caecilians

	are then replaced in adults by lungs for breathing air.	
Reptiles	Cold-blooded animals with an outer covering of scales or bony plates that prevents their bodies from drying out when not near water. Reptiles reproduce by laying eggs protected by shells or by giving birth to live young. They do not have a larval stage. Mostly land-dwellers, they breathe air using lungs.	Snakes, crocodiles, alligators, lizards, turtles, tortoises
Birds	Warm-blooded animals whose body is covered with feathers. Birds have wings that in most cases help them fly.	Penguin, flamingo, eagle, turkey, thrush, parrot
Mammals	Warm-blooded animals, the females of which have milk-secreting organs that they use to feed their young. Mammals have highly developed brains, giving them an intelligence unmatched by any other group of animals. Most mammals reproduce by giving birth to live young. They are the only animals with hair, and they have specialized teeth that make it possible to eat a wide variety of plants and animals for food.	Platypus, kangaroo, bat, lion, wolf, mouse, seal, antelope, cow, dolphin, whale, lemur, monkey, ape, human

MOST COMMON INVERTEBRATES

Type	Characteristics	Examples
Porifera	Simple, multicellular animals with tissues but no distinct organs. Commonly known as sponges, they typically attach to rocks, shells, or coral.	Sponges
Cnidaria	Aquatic radially symmetrical animals with tentacles encircling the mouth at one end of the body. Cnidarians appear in two forms during their life cycle, the sessile, cylindrical polyp and the free-swimming medusa that looks like a jellyfish.	Coral, hydra, jellyfish, Portuguese man-of-war, sea anemone
Ctenophora	Jellyfish-like marine animals distinguished by eight rows of cilia that propel the body in swimming. They feed on other invertebrates using two retractable sticky tentacles to capture prey. All ctenophores are hermaphroditic and reproduce sexually. Many are luminescent.	Sea walnuts, comb jellies
Platyhelminthes	Structurally simple worms with no anus or circulatory system. Known as flatworms, their flattened bodies enable internal tissues to be near the skin surface, permitting gas and nutrient exchange with the environment..	Flatworms, flukes, tapeworms
Kinorhyncha or Echinodera	Tiny worms with spiny bodies. An outer protective cuticle is segmented and articulated. Found in the muddy bottoms of coastal waters, they feed on microorganisms and organic particles by means of a sucking pharynx. Reproduction is sexual.	*Echinoderes*, *Condyloderes*

Nematoda	Commonly known as roundworms, these animals are one of the most diverse and geographically widespread invertebrate phyla.	Ascarids, vinegar eels, cyst nematodes, heartworms, hookworms
Mollusca	Diverse animals found in water and on land. Most mollusks have a hard shell that protects a soft body, although in some mollusks the hard shell is missing or hardly visible. A feeding organ called a radula contains rows of teeth used to scrape food into the mouth. Enzymes in salivary glands partially digest food before it reaches the intestines. Reproduction is sexual and some mollusks have a larval form.	Chitons, oysters, snails, clams, squid
Annelida	Segmented worms with a muscular body wall used for burrowing. External hairs called setae aid in traction during burrowing. An internal coelom is divided into compartments by walls known as septum. The digestive system stretches from the mouth to the anus, differentiated into regions, each with a different function. Reproduction is sexual.	Lugworms, earthworms, leeches
Arthropoda	Largest and most diverse invertebrate phylum characterized by animals with jointed limbs, a segmented body, and an exoskeleton made of chitin. Arthropods are abundant and successful in almost all habitats	Ants, beetles, butterflies, lobsters, shrimp, crabs, scorpions, spiders, ticks
Echinodermata	Marine animals distinguished by their radial symmetry in which the body can be divided into five parts arranged around a central axis.	Sea stars, brittle stars, sea urchins, sand dollars, sea cucumbers

Life in Organisms: Plants

Plants are multicellular eukaryotes—that is, their cells contain membrane-bound structures called organelles. Plants differ from other eukaryotes because their cells are enclosed by more or less rigid cell walls composed primarily of cellulose. The most important characteristic of plants is their ability to photosynthesize. During photosynthesis, plants make their own food by converting light energy into chemical energy—a process carried out in the green cellular organelles called chloroplasts A few plants have lost their chlorophyll and have become saprophytes or parasites—that is, they absorb their food from dead organic matter or living organic matter, respectively—but details of their structure show that they are evolved plant forms.

Classification

***Non- flowering or non seed forming plants* –** produces pores for propagation

Flowering or seed plants

a. **Gymgiosperms –** seeds are expose or naked, meaning they are not enclosed within fruits. They do not produce fruits, instead they form cones.
b. **Angiosperms –** sees are found within fruits.
    i. monocotyledons
    ii. dicotyledons

Tissue Systems

There are many variants of the generalized plant cell and its parts. Similar kinds of cells are organized into structural and functional units, or tissues, which make up the plant as a whole, and new cells (and tissues) are formed at growing points of actively dividing cells. These growing points, called meristems, are located either at the stem and root tips (apical meristems), where they are responsible for the primary growth of plants, or laterally in stems and roots (lateral meristems), where they are responsible for secondary plants growth. Three tissue systems are recognized in vascular plants: dermal, vascular, and ground (or fundamental).

DERMAL SYSTEM

The dermal system consists of the epidermis, or outermost layer, of the plants body. It forms the skin of the plants, covering the leaves, flowers, roots, fruits, and seeds. Epidermal cells vary greatly in function and structure.

VASCULAR SYSTEM

The vascular tissue system consists of two kinds of conducting tissues: the xylem, responsible for conduction of water and dissolved mineral nutrients, and the phloem, responsible for conduction of food. The xylem also stores food and helps support the plants.

Xylem

The xylem consists of two types of conducting cells: tracheids and vessels. Elongated cells, with tapered ends and secondary walls, both types lack cytoplasm and are dead at maturity. The walls have pits—areas in which secondary thickening does not occur—through which water moves from cell to cell. Vessels usually are shorter and broader than tracheids, and in addition to pits they have perforation—areas of the

cell wall that lack both primary and secondary thickenings and through which water and dissolved nutrients may freely pass.

Phloem

The phloem, or food-conducting tissue, consists of cells that are living at maturity. The principal cells of phloem, the sieve elements, are so called because of the clusters of pores in their walls through which the protoplasts of adjoining cells are connected. Two types of sieve elements occur: sieve cells, with narrow pores in rather uniform clusters on the cell walls, and sieve-tube members, with larger pores on some walls of the cell than on others. Although the sieve elements contain cytoplasm at maturity, the nucleus and other organelles are lacking. Associated with the sieve elements are companion cells that do contain nuclei and that are responsible for manufacturing and secreting substances into the sieve elements and removing waste products from them.

GROUND SYSTEM

The ground, or fundamental, tissue systems of plants consist of three types of tissue. The first, called parenchyma, is found throughout the plants and is living and capable of cell division at maturity. Usually only primary walls are present, and these are uniformly thickened. The cells of parenchyma tissue carry out many specialized physiological functions—for example, photosynthesis, storage, secretion, and wound healing. They also occur in the xylem and phloem tissues.

Collenchyma, the second type of ground tissue, is also living at maturity and is made up of cells with unevenly thickened primary cell walls. Collenchyma tissue is pliable and functions as support tissue in young, growing portions of plants.

Sclerenchyma tissue, the third type, consists of cells that lack protoplasts at maturity and that have thick secondary walls usually containing lignin. Sclerenchyma tissue is important in supporting and strengthening those portions of plants that have finished growing.

Plant Organs

The body of a vascular plants is organized into three general kinds of organs, stems, and leaves. These organs all contain the three kinds of tissue systems mentioned above, but they differ in the way the cells are specialized to carry out different functions.

ROOTS

The function of roots is to anchor the plants substrate and to absorb water and minerals. The epidermis is just behind the growing tip of roots and is covered with root hairs, which are outgrowths of the epidermal cells. The root hairs increase the surface area of the roots and serve as the surface through which water and nutrients are absorbed.

Internally, roots consist largely of xylem and phloem, although many are highly modified to carry out specialized functions. Thus, some roots are important food and storage rgansxample, beets, carrots, and radishes. Such roots have an abundance of parenchyma tissue.

STEMS

Are usually above ground, grow upward, and bear leaves, which are attached in a regular pattern at nodes along the stem. The portions of the stem between nodes are called internodes. Stems increase in length through the activity of an apical meristem at the stem tip. This growing point also gives rise to new leaves, which surround and protect the stem tip, or apical bud, before they expand. Apical buds of deciduous trees, which lose their leaves during part of the year, are usually protected by modified leaves called bud scales.

LEAF

The primary photosynthetic organ of most plants. Leaves are usually flattened blades that consist, internally, mostly of parenchyma tissue called the mesophyll, which is made up of loosely arranged cells with spaces between them. The spaces are filled with air, from which the cells absorb carbon dioxide and into which they expel oxygen. The mesophyll is bounded by the upper and lower surface of the leaf blade, which is covered by epidermal tissue. A vascular network runs through the mesophyll, providing the cell walls with water and removing the food products of photosynthesis to other parts of the plants.

The leaf blade is connected to the stem through a narrowed portion called the petiole, or stalk, which consists mostly of vascular tissue. Appendages called stipules are often present at the base of the petiole.

Many specialized forms of leaves occur. Some are modified as spines, which help protect plants from predators. Insectivorous plants possess highly modified leaves that trap and digest insects to obtain needed nutrients. The individual parts of flowers—carpels, stamens, petals, and sepals—are all modified leaves that have taken on reproductive functions.

Life in Organisms: Animals

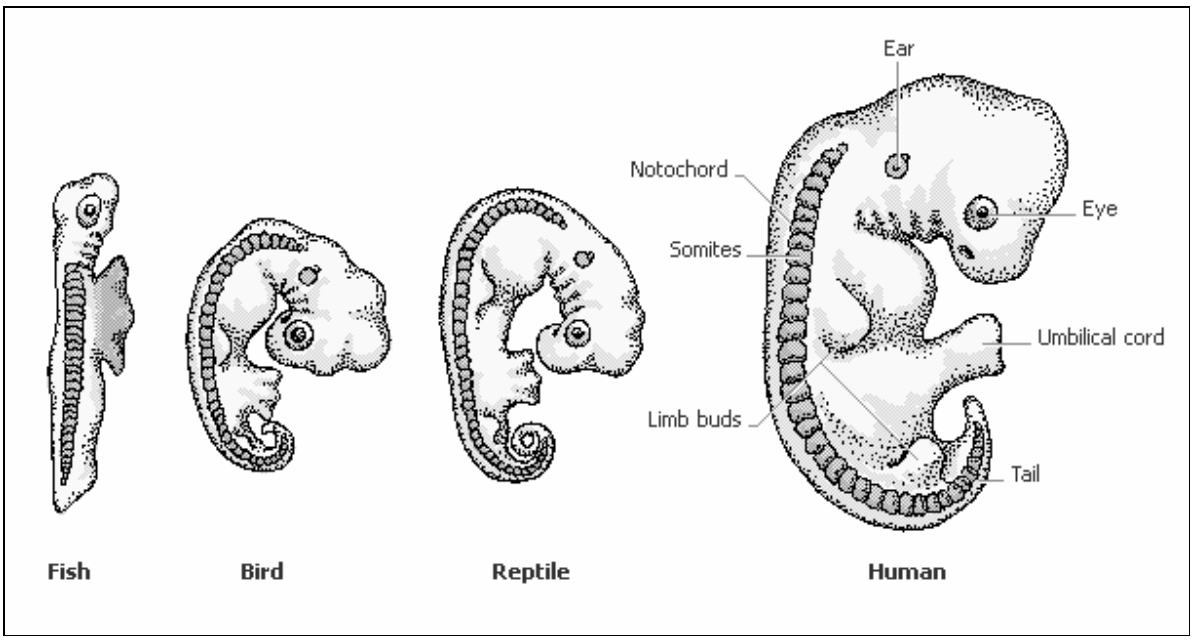
Types of Animals

Presently, animals are classified according to a broader range of characteristics, including their internal anatomy, patterns of development, and genetic makeup. These features provide a much more reliable guide to an animal's place in the living world. They also help to show how different species are linked through evolution. Scientists divide the animal kingdom into approximately 30 groups, each called a phylum (plural phyla).

VERTEBRATES AND INVERTEBRATE

Vertebrates

One phylum of animals, the chordates, has been more intensively studied than has any other, because it comprises nearly all the world's largest and most familiar animals as well as humans. This phylum includes mammals, birds, reptiles, amphibians, and fish together with a collection of lesser-known organisms, such as sea squirts and their relatives. The feature uniting these animals is that at some stage in their lives, all have a flexible supporting rod, called a notochord, running the length of their bodies. In the great majority of chordates, the notochord is replaced by a series of interlocking bones called vertebrae during early development. These bones form the backbone, and they give these animals their name—the vertebrates.



Vertebrate Embryos
Vertebrates that evolved from fish pass through similar embryonic stages. As a flexible notochord develops in the back, blocks of tissue called somites form along each side of it. These somites will become major structures, such as muscle, vertebrae, connective tissue, and,

later, the larger glands of the body. Just above the notochord lies a hollow nerve cord. Such similarities formed the basis for German biologist Ernst Haeckel's biogenetic law, which states that an animal's embryonic development recapitulates its evolution. Although scientists now know that this law does not hold absolutely, Haeckel's idea has remained influential.

Invertebrates

- are far more numerous and diverse and include an immense variety of animals from sponges, worms, and jellyfish to mollusks and insects. Compose the 98 percent of the animal kingdom. The only feature these diverse creatures share in common is the lack of a backbone.

COLD-BLOODED AND WARM-BLOODED ANIMALS

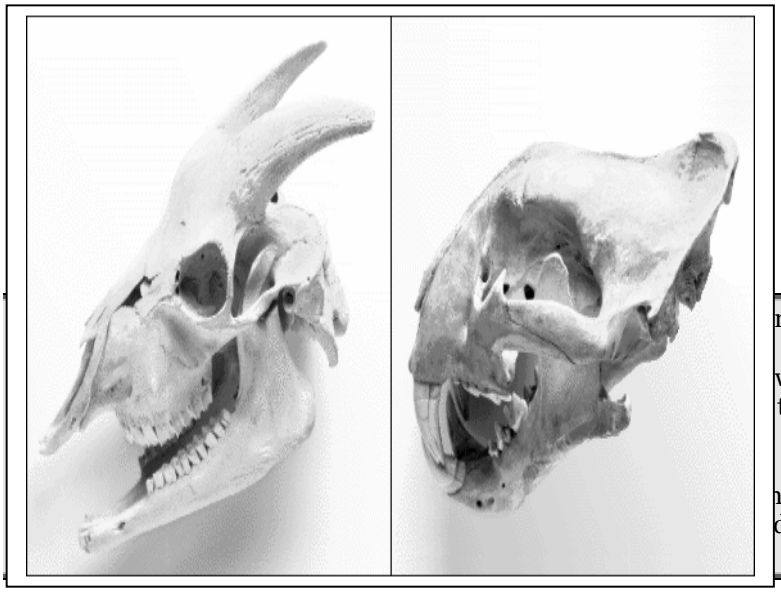
Cold blooded or ectoderm

- an animal whose temperature is dictated by its surroundings. Reptiles, amphibians, and fish.
- Although they do not maintain a constant warm temperature, some of these animals do manage to raise their body temperature far above that of their surroundings. They do this by behavioral means, such as basking in direct sunshine when the surrounding air is cool.

Warm blooded or endoderm

- an animal that keeps its body at a constant warm temperature by generating internal heat.
- these animals generate heat through their metabolic processes, and they retain it by having insulating layers of fat, fur, or feathers. Because their bodies are always warm, they can remain active in some of the coldest conditions on earth.

CARNIVORES AND HERBIVORES



Meat Eaters and Plant Eaters
In carnivores (*right*), the front of the skull has a pair of enlarged canine teeth and the lower jaw moves only in an up and down direction, which assists with the capture and holding of prey. In herbivores (*left*), the canine teeth are absent and the premolars

and molars are well developed. The jaw construction also allows for the lateral movement of the lower jaw in relation to the upper jaw, which helps to provide a grinding motion necessary for rendering plant materials into a state suitable for swallowing and digestion.

Plant-eaters, or herbivores, often do not have to search far to find things to eat, and in some cases—for example wood-boring insects—they are entirely surrounded by their food. The disadvantage of a plant-based diet is that it can be difficult to digest and is often low in nutrients.

Carnivores live on flesh from other animals that is often nutrient-rich and easy to digest but difficult to obtain. Finding and capturing this kind of food calls for keen senses. But even though a hunter has acute vision or a highly developed sense of smell, a large proportion of a hunter's victims manage to escape. If this happens too often, a predator quickly starves.

Omnivore, an animal that eats both animal flesh and vegetable matter. The term omnivore indicates similarities in the behavior and physiology of many unrelated animals; for example, many small birds and mammals are omnivorous.

ANIMAL REPRODUCTION

Asexual reproduction, animals produce offspring without needing a partner. Asexual reproduction is most common in simple animals such as flatworms and cnidarians.

Sexual reproduction, involves two parents. The parents produce sperm and egg cells (gametes), which are brought together to form a fertilized cell (zygote) with a new and unique combination of genes. In this genetic lottery, offspring inherit unique combinations of characteristics that increase the likelihood that at least some individuals in the population can survive changes in the environment. In most cases, each partner is either male or female, but in some animals—such as earthworms, slugs, and snails–each one is a hermaphrodite, an animal that has both male and female organs. Hermaphrodites usually fertilize each other, with both partners producing young.

Internal fertilization takes place inside the female's body. The male typically has a penis or other structure that delivers sperm into the female's reproductive tract. All mammals, reptiles, and birds as well as some invertebrates, including snails, worms, and insects, use internal fertilization.

Internal fertilization does not necessarily require that the developing embryo remains inside the female's body. In honey bees, for example, the queen bee deposits the fertilized eggs into special compartments

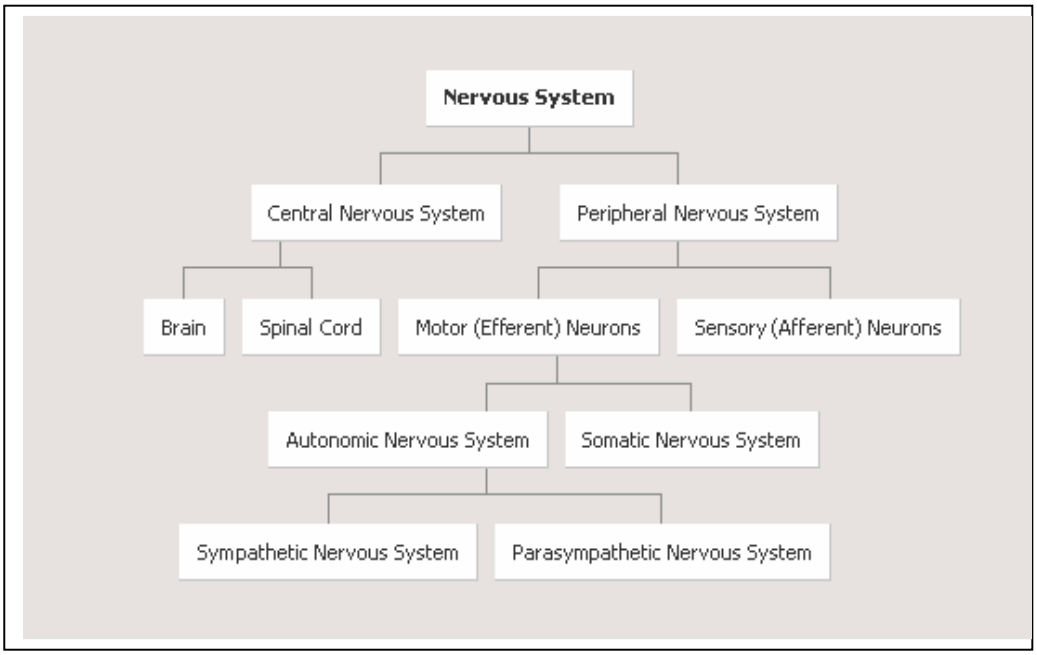
in the honeycomb. These compartments are supplied with food resources for the young bees to use as they develop.

Organ Systems of the Body

MUSCULOSKELETAL SYSTEM

The human skeleton consists of more than 200 bones bound together by tough and relatively inelastic connective tissues called ligaments. The different parts of the body vary greatly in their degree of movement. Thus, the arm at the shoulder is freely movable, whereas the knee joint is definitely limited to a hingelike action. The movements of individual vertebrae are extremely limited; the bones composing the skull are immovable. Movements of the bones of the skeleton are effected by contractions of the skeletal muscles, to which the bones are attached by tendons. These muscular contractions are controlled by the nervous system.

NERVOUS SYSTEM



Nervous System Organization

The nervous system is composed of the central nervous system and the peripheral nervous system. The central nervous system, which includes the brain and spinal cord, processes and coordinates all incoming sensory information and outgoing motor commands, and it is also the seat of complex brain functions such as memory, intelligence, learning, and emotion. The peripheral nervous system includes all neural tissue outside of the central nervous system. It is responsible for providing sensory, or *afferent,* information to the central nervous system and carrying motor, or *efferent,* commands out to the body's tissues. Voluntary motor commands, such as moving muscles to walk or talk, are controlled by the *somatic* nervous system, while involuntary motor commands, such as digestion and heart beat, are controlled by the *autonomic* nervous system. The autonomic nervous system is further divided into two systems. The sympathetic nervous system, sometimes called the "fight or flight" system, increases alertness, stimulates tissue, and prepares the body for quick responses to unusual situations. In contrast, the parasympathetic nervous system, sometimes called the "rest and repose" system, conserves energy and controls sedentary activities, such as digestion.

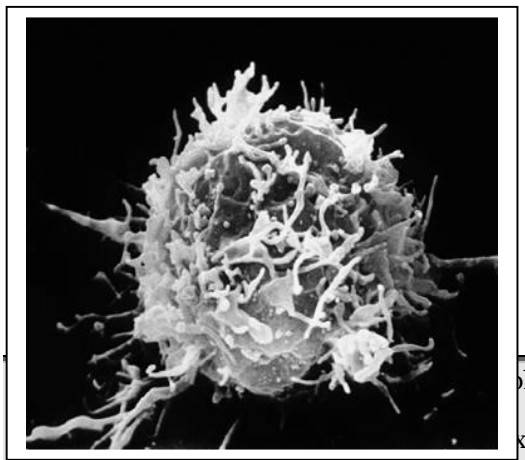
The nervous system has two divisions: the somatic, which allows voluntary control over skeletal muscle, and the autonomic, which is involuntary and controls cardiac and smooth muscle and glands. The autonomic nervous system has two divisions: the sympathetic and the parasympathetic. Many, but not all, of the muscles and glands that distribute nerve impulses to the larger interior organs possess a double nerve supply; in such cases the two divisions may exert opposing effects. Thus, the sympathetic system increases heartbeat, and the parasympathetic system decreases heartbeat. The two nervous systems are not always antagonistic, however.

Human Brain
The human brain has three major structural components: the large dome-shaped cerebrum (top), the smaller somewhat spherical cerebellum (lower right), and the brainstem (center). Prominent in the brainstem are the medulla oblongata (the egg-shaped enlargement at center) and the thalamus (between the medulla and the cerebrum). The cerebrum is responsible for intelligence and reasoning. The cerebellum helps to maintain balance and posture. The medulla is involved in maintaining involuntary functions such as respiration, and the thalamus acts as a relay center for electrical impulses traveling to and from the cerebral cortex. Lack of blood flow to any part of the brain results in a stroke, permanent damage that interferes with the functions of the affected part of the brain.

CIRCULATORY SYSTEM

Human Circulatory System The human circulatory system is composed of the muscular heart and an intricate network of elastic blood vessels known as arteries, veins, and capillaries. These structures work together to circulate blood throughout the body, in the process delivering life-preserving oxygen and nutrients to tissue cells while also removing waste products.

IMMUNE SYSTEM



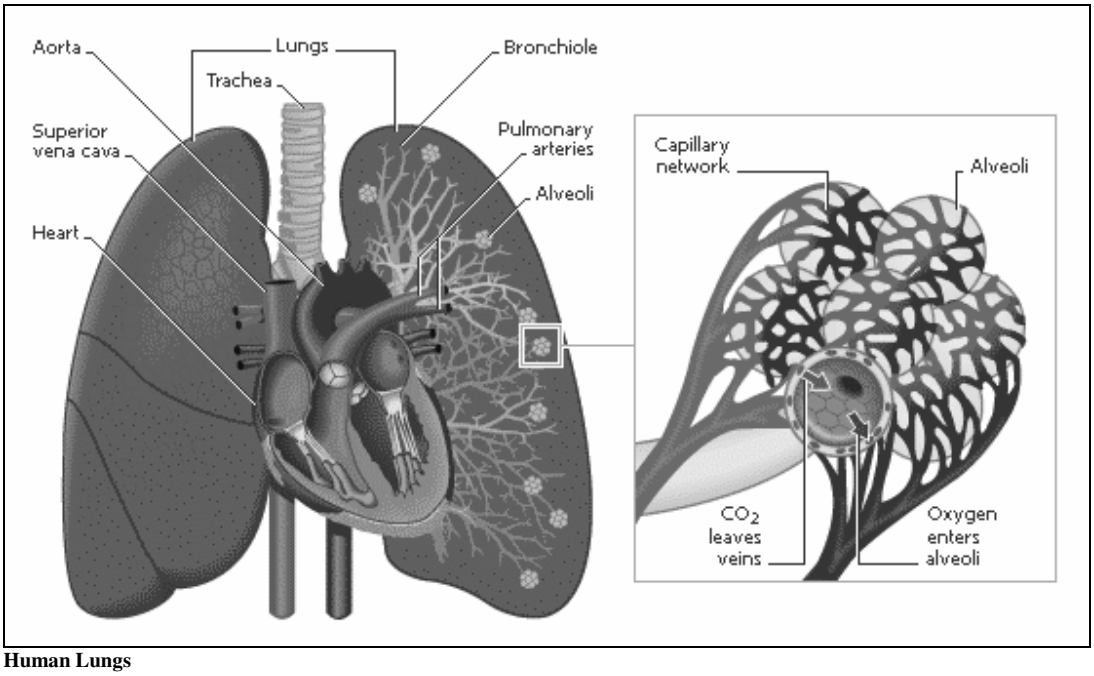
Lymphocyte
Scanning electron micrograph of a normal T lymphocyte. T lymphocytes are specialized white blood cells that identify and destroy invading organisms such as bacteria and viruses. Some T lymphocytes directly destroy invading organisms, whereas other T lymphocytes regulate the immune system by directing immune responses.

The body defends itself against foreign proteins and infectious microorganisms by means of a complex dual

system that depends on recognizing a portion of the surface pattern of the invader. The two parts of the system are termed cellular immunity, in which lymphocytes are the effective agent, and humoral immunity, based on the action of antibody molecules.

RESPIRATORY SYSTEM

Respiration is carried on by the expansion and contraction of the lungs; the process and the rate at which it proceeds are controlled by a nervous center in the brain.

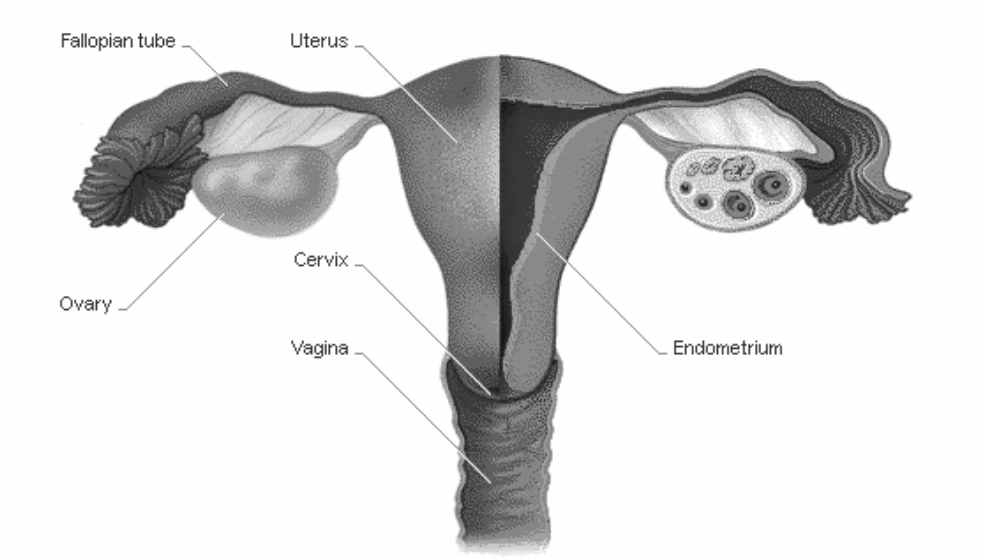


Human Lungs

Air travels to the lungs though a series of tubes and airways. The two branches of the trachea, called bronchi, subdivide within the lobes into smaller and smaller air vessels. They terminate in alveoli, tiny air sacs surrounded by capillaries. When the alveoli inflate with inhaled air, oxygen diffuses into the blood in the capillaries to be pumped by the heart to the tissues of the body, and carbon dioxide diffuses out of the blood into the lungs, where it is exhaled.

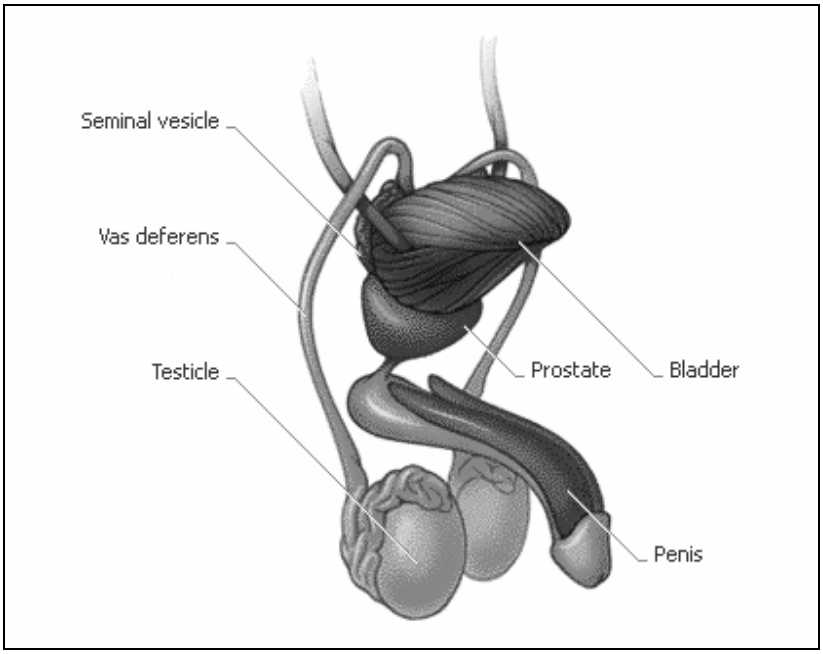
THE REPRODUCTIVE SYSTEM

Reproduction is accomplished by the union of male sperm and the female ovum. In coitus, the male organ ejaculates more than 250 million sperm into the vagina, from which some make their way to the uterus. Ovulation, the release of an egg into the uterus, occurs approximately every 28 days; during the same period the uterus is prepared for the implantation of a fertilized ovum by the action of estrogens. If a male cell fails to unite with a female cell, other hormones cause the uterine wall to slough off during menstruation. From puberty to menopause, the process of ovulation, and preparation, and menstruation is repeated monthly except for periods of pregnancy. The duration of pregnancy is about 280 days. After childbirth, prolactin, a hormone secreted by the pituitary, activates the production of milk.



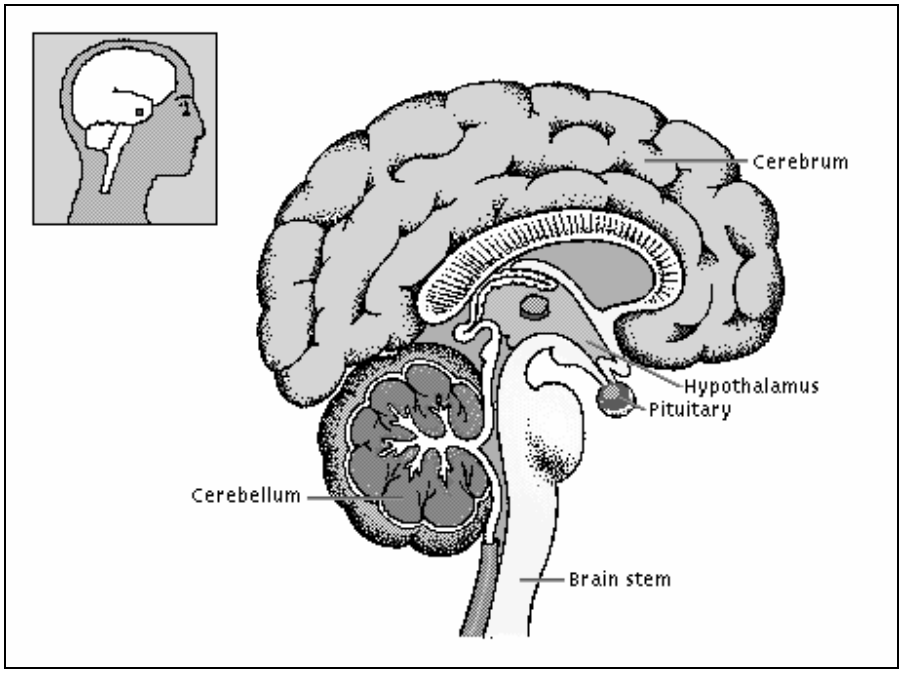
Female Reproductive System

The bones of the human female pelvis form a bowl-shaped cavity that supports the weight of a developing fetus and encloses the organs of the female reproductive tract. Two ovaries, the female gonads, produce mature eggs. Leading away from the ovaries are the fallopian tubes, or oviducts, the site of fertilization. The uterus, a muscular organ with an expandable neck called the cervix, houses the developing fetus, which leaves the woman's body through the vagina, or birth canal.



Male Reproductive System The organs of the male reproductive system enable a man to have sexual intercourse and to fertilize female sex cells (eggs) with sperm. The gonads, called testicles, produce sperm. Sperm pass through a long duct called the vas deferens to the seminal vesicles, a pair of sacs that lies behind the bladder. These sacs produce seminal fluid, which mixes with sperm to produce semen. Semen leaves the seminal vesicles and travels through the prostate gland, which produces additional secretions that are added to semen. During male orgasm the penis ejaculates semen.

THE ENDOCRINE SYSTEM



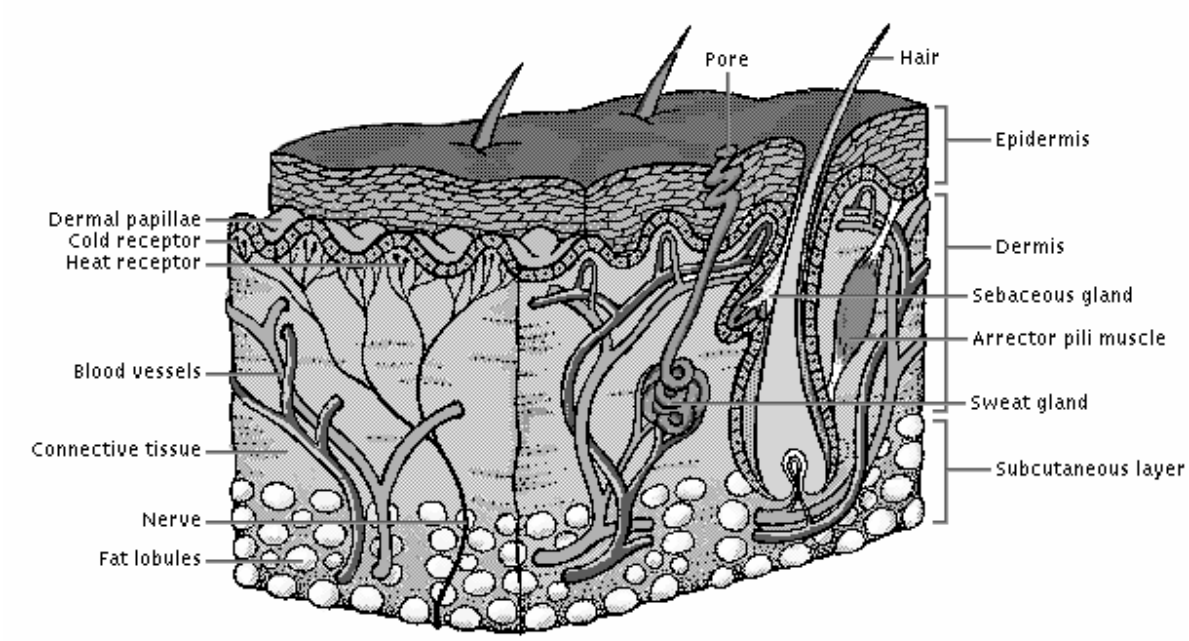
Pituitary Gland
Called the master gland, the pituitary secretes hormones that control the activity of other endocrine glands and regulate various biological processes. Its secretions include growth hormone (which stimulates cellular activity in bone, cartilage, and other structural tissue); thyroid stimulating hormone (which causes the thyroid to release metabolism-regulating hormones); antidiuretic hormone (which causes the kidney to excrete less water in the urine); and prolactin (which stimulates milk production and breast development in females). The pituitary gland is influenced both neurally and hormonally by the hypothalamus.

In addition to the integrative action of the nervous system, control of various body functions is exerted by the endocrine glands. An important part of this system, the pituitary, lies at the base of the brain. This master gland secretes a variety of hormones, including the following: (1) a hormone that stimulates the thyroid gland and controls its secretion of thyroxine, which dictates the rate at which all cells utilize oxygen; (2) a hormone that controls the secretion in the adrenal gland of hormones that influence the metabolism of carbohydrates, sodium, and potassium and control the rate at which substances are exchanged between blood and tissue fluid; (3) substances that control the secretion in the ovaries of estrogen and progesterone and the creation in the testicles of testosterone; (4) the somatotropic, or growth, hormone, which controls the rate of development of the skeleton and large interior organs through its effect on the metabolism of proteins and carbohydrates; and (5) an insulin inhibitor—a lack of insulin causes diabetes mellitus.

DIGESTIVE AND EXCRETORY SYSTEMS

Human Digestive System The human digestive system consists of a series of organs and structures that help break down food and absorb nutrients for use throughout the body. Food enters the digestive system through the mouth and passes through the esophagus, stomach, small intestine, large intestine, and rectum. Other organs, such as the liver, further aid in the breakdown of food, absorption of nutrients, and elimination of undigestible materials from the body.

INTEGUMENTARY SYSTEM



Structure of the Skin
The skin consists of an outer, protective layer (epidermis) and an inner, living layer (dermis). The top layer of the epidermis is composed of dead cells containing keratin, the horny scleroprotein that also makes up hair and nails.

The skin is an organ of double-layered tissue stretched over the surface of the body and protecting it from drying or losing fluid, from harmful external substances, and from extremes of temperature. The inner layer, called the dermis, contains sweat glands, blood vessels, nerve endings (sense receptors), and the bases of hair and nails. The outer layer, the epidermis, is only a few cells thick; it contains pigments, pores, and ducts, and its surface is made of dead cells that it sheds from the body. (Hair and nails are adaptations arising from the

dead cells.) The sweat glands excrete waste and cool the body through evaporation of fluid droplets; the blood vessels of the dermis supplement temperature regulation by contracting to preserve body heat and expanding to dissipate it. Separate kinds of receptors convey pressure, temperature, and pain. Fat cells in the dermis insulate the body, and oil glands lubricate the epidermis.

Cell Division and Reproduction

Mitosis

Cell division produces two daughter cells in each succession that are roughly identical copies of the parental cell before it starts to enlarge or grow. This kind of cell division constitutes what is exactly called mitosis. Mitosis is made up of four main stages:

1. **Prophase**- each chromosome gradually condenses and thickens, and becomes more visible even under an ordinary light microscope; the nuclear membrane and nucleolus gradually dissociate and spindle fibers radiating from two opposite poles are formed.
2. **Metaphase-** each chromosome moves toward an imaginary line, called the equatorial plate, that divides the cell into two; the chromosomes are perpendicular to the long axes of the spindle fibers.
3. **Anaphase-** the kinetochore that joins two sister chromatids together splits and each chromatid or single stranded chromosome moves toward opposite poles.
4. **Telophase-** the single stranded chromosomes relax into the extended state upon reaching the poles; the nuclear membrane and nucleolus re-form in each pole. Cytokinesis, which divides the cytoplasm, usually occurs at the latter part of this stage.

Meiosis

Meiosis takes place in special cells that produce what we call the sex cells. During meiosis, two cell divisions occur to produce four daughter cells from the original parent cell. Each resulting cell has half the chromosomal DNA of the parent cell. A half set of chromosomes in an organism is known as the haploid number. In the first cell division of meiosis the chromosomes of a gamete cell duplicate and join in pairs. The paired chromosomes align at the equator of the cell, and then separate and move to opposite poles in the cell. The cell then splits to form two daughter cells. As meiosis proceeds, the two daughter cells undergo another cell division to form four cells, each of which bears half of the number of chromosomes found in the other cells of the organism. It also ensures that reproduction will produce a zygote that has received one set of chromosomes from the male parent and one set of chromosomes from the female parent to form a full set of chromosomes. The entire set of chromosomes in an organism is known as the diploid number. Once formed, the zygote continues to divide and grow through the process of mitosis.

Prophase 1	❖ The nuclear membrane breaks down ❖ The nucleolus disappear ❖ Spindle fibers begin to form ❖ Single chromosome strands appear and double up
Metaphase 1	❖ Two sister chromatids pair with its homologous sister chromatids ❖crossing over between the homologue pair ❖spindle fibers completely forms
Anaphase 1	❖ homologoues of each pair split and move to the opposite sides, the chromosomes number on each side is half the original number ❖ the cell membrane begins to pinch
Telophase 1	❖ the nucleolus appear ❖ the nuclear membranes fro ❖ pinching of the cell membrane is completed so there are two new cells

Meiosis II

Prophase 2	❖ spindle fiibers begin to form ❖ the nuclear membrane breaks
Metaphase 2	❖ the chromosomes align at the center ❖ spindle fibers form completely
Anaphase 2	❖ the chromatids of each chromosome are pulled apart and move toward opposite sides
Telophase 2	❖ the nuclear membrane appears ❖ the membrane pinches completely to form cells

Heredity

- process of transmitting biological traits from parent to offspring through genes, the basic units of heredity. Heredity also refers to the inherited characteristics of an individual, including traits such as height, eye color, and blood type.

Some of Mendel's Basic Concepts

GENETICS is the study of how heredity works and, in particular, of genes.

GENE is a section of a long deoxyribonucleic acid (DNA) molecule, and it carries information for the construction of a protein or part of a protein. Through the diversity of proteins they code for, genes influence or determine such traits as eye color, the ability of a bacterium to eat a certain sugar, or the number of peas in a pod. A virus has as few as a dozen genes. A simple roundworm has 5000 to 8000 genes, while a corn plant has 60,000. The construction of a human requires an estimated 50,000 genes.

ALLELES are members of a gene pair.

GENOTYPE – The genetic composition of a cell or individual. Genotypes can be any of the following examples

AA – homozygous dominant (made of two dominant alleles)
Aa – a hetrozygous dominant (made of one dominant an one recessive allele
Aa – homozygous recessive (made up of two recessive alleles)

PHENOTYPE – the expression or manifestation of the genotype (can be morphological, physiological or biochemical, sexualo, behavioral)
AA- will exhibit a dominant trait
Aa- will also exhibit a dominant trait
Aa – will exhibit the ercessive trait

LAW OF INDEPENDENT SEGREGATION states that members of a gene 9pair) separate independently of the separation of the other gene pairsduring meiosis or gamete formation

LAW OF INDEPENDENT ASSORTMENT states that diferent gene pairs assort to recombine with each other independently of the assortment of the other gene pairs during meiosis or gamete formation.

Females have two X chromosomes, and males have one X and one Y chromosome. The Y chromosome is about one-third the size of the X chromosome. A sperm, the reproductive cell produced by the male, can carry either

one X or one Y chromosome. An egg, the reproductive cell produced by the female, can carry only the X chromosome. When a sperm with an X chromosome unites with an egg, the result is a child with two X chromosomes—a female. When a sperm with a Y chromosome unites with an egg, however, the result is a child with one X and one Y chromosome—a male. Thus, the father determines the gender of the child.

CODOMINANCE- when the two alleles in a gene pair appear together in the individual that is heterozygous for the trait

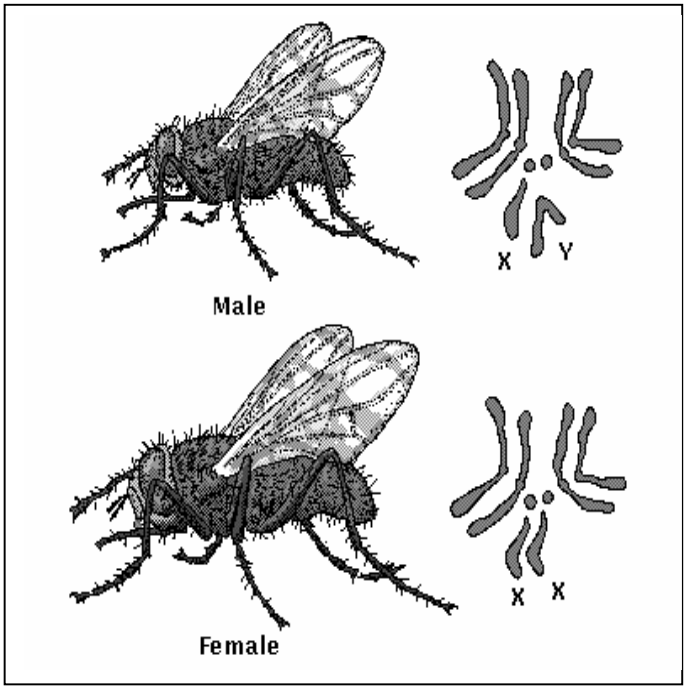
Dominant-Recessive Inheritance

The dominant-recessive pattern of inheritance, a relatively simple pattern, involves paired alleles that influence one trait. In this pattern, one of the two alleles contains information for a certain characteristic—the lavender color of sweet pea flowers, for example—while the second allele directs the production of an alternate characteristic—the white flower color. In sweet peas, if these two alleles occur together, the allele for lavender flowers is expressed, and the flowers are lavender. The allele for lavender is therefore called the dominant allele. The allele for white is known as the recessive allele. Lavender flowers also occur when two alleles for lavender color are paired. Only when two alleles for the recessive characteristic are paired do white flowers appear. This genetic rule applies regardless of the organism or the trait. In the dominant recessive pattern, the recessive trait shows up only when two recessive alleles are paired.

Polygenic Inheritance

A significant number of human traits, such as eye color, skin color, height, weight, and muscle strength are typically regulated by more than one allele in a pattern known as polygenic inheritance. Several thousand alleles, for example, may combine to determine a person's potential for pole-vaulting, and several hundred may play a role in establishing a person's normal weight. Certain diseases may result from mutations in one or more alleles involved in polygenic inheritance. Researchers have identified nearly a dozen mutated alleles that are associated with diabetes mellitus, and a similar number are linked to asthma. Heart disease may be linked to two or three times that number. Some types of cancer may be correlated with more than 100 different genes. Polygenic inheritance is quite complex, and the ways in which multiple genes interact to produce traits are not fully understood.

X-Y Linked Inheritance



Fruit Fly Chromosomes
The chromosomes of the fruit fly, *Drosophila melanogaster,* lend themselves well to genetic experimentation. There are only 4 pairs—one of which, marked here with Xs and Ys, determines the fly's sex—versus the human complement of 23 pairs. In addition, the fly chromosomes themselves are large. Thomas Hunt Morgan and his associates based their theory of heredity on studies using *Drosophila.* They found that chromosomes were passed from parent to offspring in a way that Gregor Mendel ascribed to genes. They proposed, correctly, that genes in fact occupy specific physical locations on chromosomes.

X-Y linked, or sex-linked, inheritance results from the size differences between the X and Y chromosomes. The longer X chromosome carries an estimated 250 genes, which are responsible for critical biochemical functions such as normal blood clotting. The shorter Y chromosome carries 6 genes, which are responsible for other traits, such as producing significant amounts of testosterone, the male sex hormone.

X-Y linked conditions typically occur in a male when the single X chromosome carries a mutated allele, one that prevents normal blood clotting, for example. A male does not have a second X chromosome with a normal allele to override the mutation. As a result, the male in this case will have hemophilia, a disease in which blood does not clot normally. If one of the female's X chromosomes carries the mutated allele, however, her second X chromosome is usually normal. The normal allele is the dominant allele, so the female does not have hemophilia. Thus, females are typically carriers of X-Y linked diseases but do not develop them unless they receive a mutated allele from each parent, an unusual event. Among the genetic disorders typically carried by females but inherited by males are hemophilia, color blindness, and Duchenne's muscular dystrophy.

Ecology

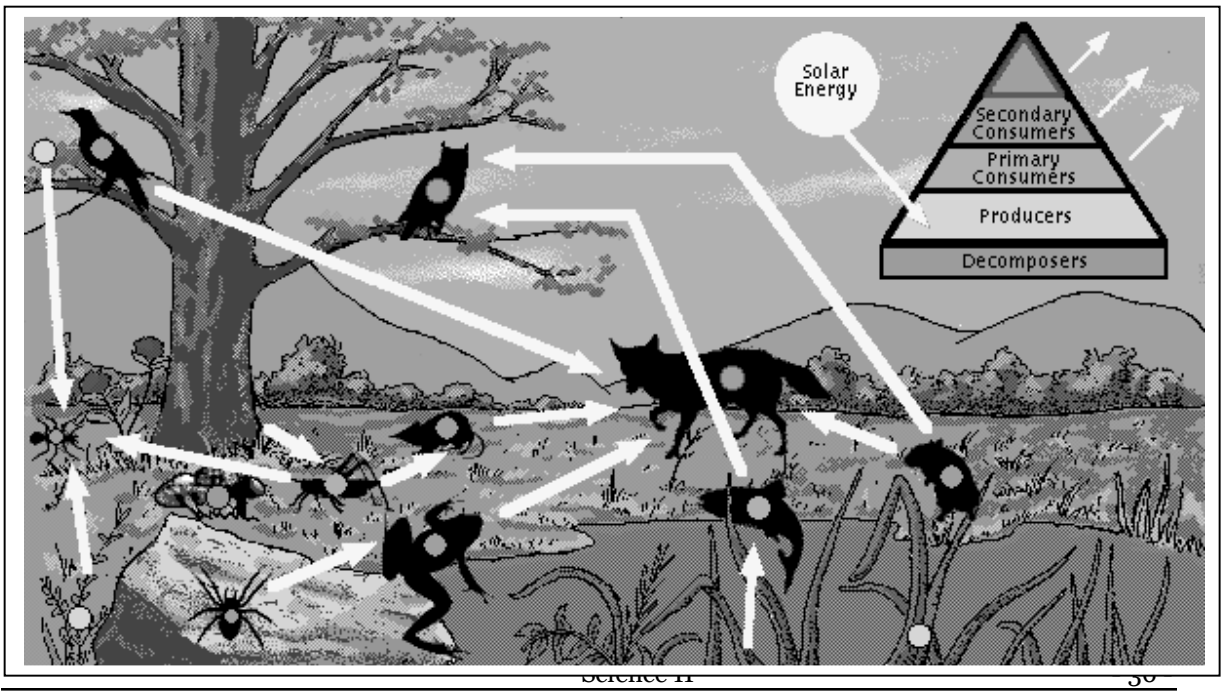
The study of the relationship of plants and animals to their physical and biological environment. The physical environment includes light and heat or solar radiation, moisture, wind, oxygen, carbon dioxide, nutrients in soil, water, and atmosphere. The biological environment includes organisms of the same kind as well as other plants and animals.

Food Chain

A succession of organisms in an ecological community that constitutes a continuation of food energy from one organism to another as each consumes a lower member and in turn is preyed upon by a higher member.

Food Web

A set of interconnected food chains by which energy and materials circulate within an ecosystem (see Ecology). The food web is divided into two broad categories: the grazing web, which typically begins with green plants, algae, or photosynthesizing plankton, and the detrital web, which begins with organic debris. These webs are made up of individual food chains. In a grazing web, materials typically pass from plants to plant eaters (herbivores) to flesh eaters (carnivores). In a detrital web, materials pass from plant and animal matter to bacteria and fungi (decomposers), then to detrital feeders (detritivores), and then to their predators (carnivores).



Food Web

The sun is the original source of energy in virtually all ecosystems. Producers (plants) convert the light energy into chemical energy, storing it in their cells. When primary consumers (herbivores) eat the producers, the energy changes into a form that can be stored in animal cells. Secondary consumers (carnivores) transform the energy once again. Decomposers may occupy several positions in the pyramid, both receiving energy from decaying plants and animals and supplying it to detrivores and fungus-eaters.

Ecosystem

Organisms living in a particular environment, such as a forest or a coral reef, and the physical parts of the environment that affect them. A community of interacting living and nonliving things. Producers, consumers, decomposers, and abiotic matter form an integrated, functioning whole driven by the Sun's energy.

Symbiosis

(Greek symbioun, "to live together"), in biology, term for the interdependence of different species, which are sometimes called symbionts. There are three main types of symbiosis, based upon the specific relationship between the species involved: mutualism, parasitism, and commensalism.

MUTUALISM

Symbiosis that results in mutual benefit to the interdependent organisms. An example of mutualism is the coexistence of certain species of algae and fungi that together compose lichens. Their close association enables them to live in extreme environments, nourished only by light, air, and minerals. Living separately, the alga and fungus would not survive in such conditions. Another example is the relationship between most mycorrhizae and certain plants. Mycorrhizae are fungal growths on the roots of such plants as heaths, orchids, and many conifers. The fungi penetrate the roots of the plants and make soil nutriments such as nitrogen available to the plants, receiving carbohydrates in return.

PARASITISM

Also known as antagonistic symbiosis, one organism receives no benefits and is often injured while supplying nutrients or shelter for the other organism (see Parasite). Parasites include viruses and bacteria that cause many diseases; certain protozoans that can infect plants and animals; tapeworms and flukes that infest the intestinal tracks and internal organs of animals; and external parasites such as lice and ticks. There are also parasitic plants like mistletoe that draw their nourishment from the branches of other plants.

COMMENSALISM

Is an association between two different kinds of nonparasitic animals, called commensals, that is harmless to both and in which one of the organism benefits. Many commensals are free to separate. Other commensals function together so completely that they cannot separate. They are not considered parasitic, however, because they do not harm each other. An example is a polyp found in deep water off the coast of Newfoundland and

Labrador. It attaches itself to the shell of a certain species of hermit crab and, by budding, covers the entire shell with a colony that dissolves the original shell. Because the colony grows at the same rate as the crab, it furnishes continuous protection, and the crab does not shed its shell at periodic intervals as it normally would. The polyp, in turn, benefits by moving about with the crab, thereby obtaining a greater food supply than it would if attached to a stationary object. Commensalism is most common among marine invertebrates, but it often occurs among land animals—for example, in the association of ants with other insects such as aphids and beetles. The association of colon bacteria with humans and other animals, especially plant-eating animals, is also a type of commensalism.

COMPETITION

When a shared resource is in short supply, organisms compete, and those that are more successful survive. Within some plant and animal populations, all individuals may share the resources in such a way that none obtains sufficient quantities to survive as adults or to reproduce. Among other plant and animal populations, dominant individuals claim access to the scarce resources and others are excluded. Individual plants tend to claim and hold onto a site until they lose vigor or die. These prevent other individuals from surviving by controlling light, moisture, and nutrients in their immediate areas.

PREDATION

One of the fundamental interactions is predation, or the consumption of one living organism, plant or animal, by another. While it serves to move energy and nutrients through the ecosystem, predation may also regulate population and promote natural selection by weeding the unfit from a population. Thus, a rabbit is a predator on grass, just as the fox is a predator on the rabbit. Predation on plants involves defoliation by grazers and the consumption of seeds and fruits. The abundance of plant predators, or herbivores, directly influences the growth and survival of the carnivores. Thus, predator-prey interactions at one feeding level influence the predator-prey relations at the next feeding level. In some communities, predators may so reduce populations of prey species that a number of competing species can coexist in the same area because none is abundant enough to control the resource. When predators are reduced or removed, however, the dominant species tend to crowd out other competitors, thereby reducing species diversity.

COEVOLUTION

The joint evolution of two unrelated species that have a close ecological relationship—that is, the evolution of one species depends in part on the evolution of the other. Coevolution is also involved in predator-prey relations. Over time, as predators evolve more efficient ways of capturing or consuming prey, the prey evolves ways to escape predation. Plants have acquired such defensive mechanisms as thorns, spines, hard seed-coats, and poisonous or ill-tasting sap that deter would-be consumers. Some herbivores are able to breach these defenses and attack the plant. Certain insects, such as the monarch butterfly, can incorporate poisonous substances found in food plants into their own tissues and use them as a defense against predators. Other

animals avoid predators by assuming an appearance that blends them into the background or makes them appear part of the surroundings. The chameleon is a well-known example of this interaction. Some animals possessing obnoxious odors or poisons as a defense also have warning colorations, usually bright colors or patterns, that act as further warning signals to potential predators. See Adaptation; Mimicry.