CELLS AND HEREDITY
Science Review

When studying for this portion of the test, be sure to review the following:

1. Describe the structures of cells and the structure of their components.
   a. Examine the similarities and differences between prokaryotic and eukaryotic
2. Explain the process of inheritance of genetic traits.
   a. Differentiate between DNA and RNA, recognizing the role of each in heredity.
   b. Demonstrate understanding of Mendel's Laws in genetic inheritance and variability.
   c. Discuss the use of DNA technology in the fields of medicine and agriculture.
3. Analyze the similarities and differences between organisms of different kingdoms.

Assessment will focus on the following:

1. Describe the roles of cell organelles in the following:
   a. information feedback
   b. motility
   c. obtaining, storing, and using energy
   d. protein construction
   e. reproduction
   f. transport of material
   g. waste disposal
2. Differentiating the functions of the macromolecules:
   a. carbohydrates
   b. lipids
   c. nucleic acids
   d. proteins
3. Understanding differences between DNA and RNA
4. Describing how DNA stores and transmits information
5. Understanding Mendel's Laws as they apply to variability between generations and cell division.
6. Understanding how DNA technology is used today in medicine and agriculture, including, but not limited to:
   a. Environmental factors in mutation
   b. Genotype and phenotype
7. Understanding the relationships between single-celled and multi-celled organisms, on a broad conceptual level.
8. Differentiating how organisms from different kingdoms obtain, transform, and transport energy and/or material.

Become Familiar with the following terms:

Cell	Endoplasmic reticulum	Protein	Anaphase	Nondisjunction
Response	Golgi bodies	Double helix	Telophase	Punnett square
Stimulus	Ribosome	Replication	Genetics	Kingdom
Prokaryote	Homeostasis	Translation	Heredity	Phylum
Eukaryote	Isotonic	Transcription	Dominant	Class
Cell wall	Hypotonic	Photosynthesis	Recessive	Order
Cell membrane	Hypertonic	Respiration	Homologous	Family
Cytoplasm	Osmosis	ATP	Alleles	Species
Vacuole	Diffusion	Mitosis	Gametes	Genus
Mitochondrion	Carbohydrate	Meiosis	Species	Pollen
Chloroplast	Lipid	Interphase	Trait	Pollination
Nucleus	Nucleic acid	Prophase	Genotype	
Chromosome		Metaphase	Phenotype	

CELLS AND HEREDITY
GRADUATION TEST REVIEW

THE SIGNIFICANCE OF BIOLOGY

Biology is the study of life and living organisms. An organism is a complete, individual, living thing. All organisms are formed from the same basic building block – cells. Most cells are so small that you cannot see them. Cells are not only the structural units of living things, they are the functional units as well. They are the smallest units that carry on the activities of life.

DIVISIONS OF BIOLOGY

Originally, there were two fields of biology, only botany and zoology. Now there are many. Here are a few:

1. Anatomy - The study of the external and internal structures of organisms.
2. Biochemistry - The study of the chemical make-up and processes of organisms.
3. Botany - The study of plants.
4. Cell Biology - The study of the structure and activities of living cells.
5. Ecology - The study of how organisms interact with one another and with their environments.
6. Evolutionary Biology - The study of how organisms have changed throughout time.
7. Genetics - The study of heredity, or how traits are transmitted from one generation to another.
8. Immunology - The study of infection protection
9. Microbiology - The study of organisms too small to be seen without a microscope.
10. Physiology - The study of how organisms carry on their life processes and how various parts of the organisms perform their special functions.
11. Zoology - The study of animals.

CHARACTERISITICS OF LIVING THINGS

1. Organisms are highly organized. *Every living cell is a highly complex structural and chemical system.*
2. Organism use energy. *All living things need energy because they are constantly building the substances that they need. The sum of this chemical building up and breaking down is known as metabolism.*
3. Organisms grow and develop.
4. Organisms cannot live forever.
5. Organisms reproduce themselves.
6. Organisms respond to stimuli. *Any condition to which an organism responds to is called a stimulus. What an organism does as a result of the stimulus is a response. The ability to respond to stimuli is typical of all living organisms. This property is called irritability.*
7. Organisms adjust to their environment. *To survive, an organism must adjust to changes in its environment. Any change in an organism that makes it better suited to its environment is called an adaptation.*

THE CELL THEORY

1. All organisms are composed of cells. (Schleiden and Schwann)
2. Cells are the basic units of structure and function in organisms. (Schleiden and Schwann)
3. All cells come from preexisting cells. (Virchow)

The virus does not fit this theory. It is a packet of nucleic acid wrapped in a protein coating. It possesses only a few structures of a cell. It relies on a host cell to help it reproduce. It cannot reproduce on its own.

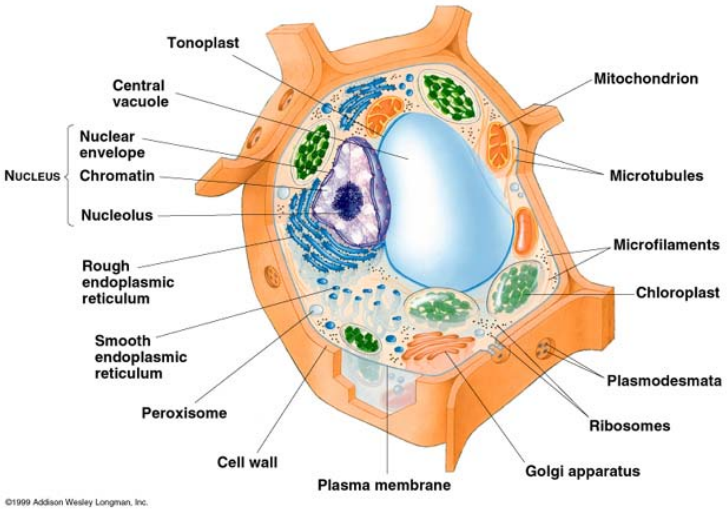
DIFFERENCES IN CELLS

Cells can be grouped according to their similarities and differences. All cells can be divided into two categories – prokaryotes and eukaryotes.

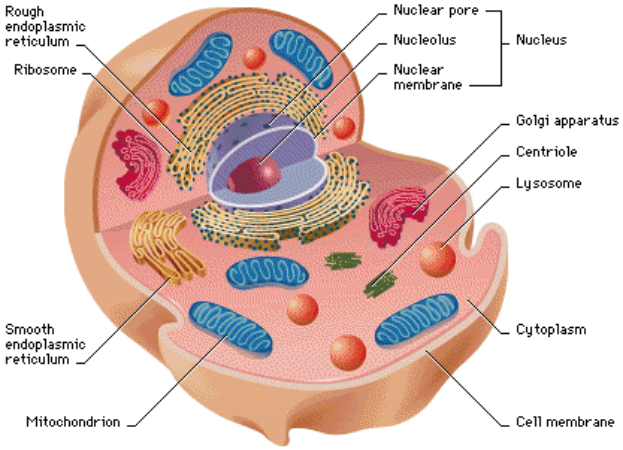
A **PROKARYOTE** is a cell that lacks a true nucleus and does not have membrane-bound organelles. The DNA in a prokaryote is a single circular molecule. They have no mitochondria, chloroplasts, Golgi bodies, lysosomes, vacuoles, or endoplasmic reticulum. They do have a cell wall and a cell membrane. Bacteria and blue-green algae are prokaryotes.

A **EUKARYOTE** is a cell that possesses a well-defined nucleus surrounded by a nuclear membrane. The DNA is in the form of complex chromosomes. The organelles are membrane bound. There is a greater division of all the jobs to be done in an eukaryotic cell. These cells are found in plants, animals, fungi, and protists.

Eukaryotic cells also differ between plants and animals. Plant cells contain three structures not found in animal cells – cell walls, large central vacuoles, and plastids. Centrioles are found in some, but not all types of plant cells. They are found in all animal cells.



Plant Cell



Animal Cell

STRUCTURE AND FUNCTION OF CELLS

Cells differ in size, shape, and function. But most share several common traits. There are two main types: animal and plant. Both of these cell types have the following **ORGANELLES** (cell structures):

Nucleus: controls the activities of the cell and holds the DNA. The "brain" of the cell.

Cytoplasm: gel-like substance inside all cells in which most of the cell's life processes take place.

Chromosomes: contain complex genetic information that directs all the cell's activities. Located in the nucleus.

Cell membrane: outer covering of the cell. It regulates what enters or leaves the cell and it allows for all the communication between cells.

Mitochondria: supplies the energy that the cell needs to do work. They release this energy from the nutrients taken up in the cell.

Endoplasmic Reticulum (ER): transports proteins from one part of the cell to another. It is the internal support system for the cell. There are two types – rough ER (contains ribosomes) and smooth ER (no ribosomes)

Ribosome: Attached to ER, they make the proteins. Ribosomes are located either on the endoplasmic reticulum or free within the cytoplasm of the cell.

Lysosomes: storage containers that hold enzymes that break down larger food molecules into smaller ones.

Golgi Bodies areas for the storage and packaging of chemicals. They are formed from pinched off ER. They look like flattened balloons.

Microtubules long, slender tubes that hold the cells more rigid. They support the cell and maintain its shape.

Spindle Fibers	microtubules that appear during cell division. These are temporary structures that help guide the chromosomes through the cytoplasm.
Centrioles	small dark bodies located outside the nucleus in many cells. They exist in pairs and perform a function only during cell division. They appear only in animal cells.
Cilia	short, threadlike projections that stick out on the surface of the cell. They aid in locomotion as well as moving substances along the surface of the cell.
Flagella	Long hairlike projection that sticks out on the surface of the cell. There are usually just one or two per cell. They aid in the locomotion of unicellular organisms.

Plant cells also have:

Cell wall:	rigid wall that supports and protects the cell and is located outside the cell membrane.
Chloroplasts:	stores chlorophyll. It allows plants to make their own food by converting light energy into chemical energy.
Vacuole:	storage containers for food, water, and other materials. Not all animal cells have vacuoles. The interior of plant cells has one large one.
Plastids:	storage containers that hold food or pigments.

CHANGING TO STAY THE SAME

An important property of living things is the ability to maintain a nearly constant internal environment. This is important because cells are extremely delicate. Cells cannot tolerate a change in temperature and the surrounding concentration of chemicals cannot change much. Cells might shrivel up like raisins or swell and burst. You can compare the maintenance of the cell's environment to that of a greenhouse. The internal environment of a greenhouse is maintained so that the conditions are favorable for plant growth.

Not only do cells have to adjust to a changing environment, but they also have to adjust to the activity of the moment. They may need to produce extra fuel to help your muscles run a race, they may have to make your lungs and heart work harder, and they may have to release extra heat generated by the hard work of these cells.

Keeping this delicate balance is called **HOMEOSTASIS**. This is a self-adjusting balance of all the life functions and activities.

THE MOVEMENT OF MATERIALS

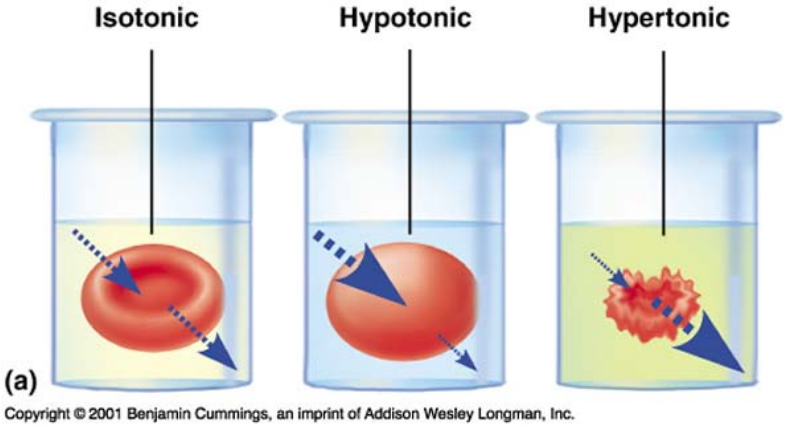
When we study cells, we are primarily concerned with the movement of molecules in a liquid. All the substances important to life are often part of a solution. A solution is a mixture where the molecules of one substance are evenly spread out in the molecules of another. The substance that makes up the greater part of the solution (or the substance doing the dissolving) is called the solvent. The molecules in the smaller amount (or the substance being dissolved) are called the solute. In salt water, water is the solvent and the salt is the solute. Water is the solvent of most solutions involved in cell activities.

DIFFUSION is the process by which molecules of a substance move from area of higher concentration to areas of lower concentration. Think of a drop of food coloring in a beaker of water. The drop is initially very concentrated. Gradually the color molecules move throughout the whole beaker of water until the entire beaker is the same color. The net, or overall, movement of the molecules results in a uniform concentration of food coloring throughout the whole beaker. Diffusion is one of the major mechanisms of molecular transport in cells. Many materials move into, out of, or through the cells due to diffusion. The difference between the concentration of molecules of a substance from the highest to the lowest concentration is called a diffusion gradient. Molecules move from the higher area of concentration to the lower area along this concentration gradient. The steeper the gradient, the faster diffusion occurs.

OSMOSIS is how water diffuses into a cell. Osmosis is the diffusion of water through a membrane. The cell membrane controls what enters and leaves the cell. They are selectively permeable. This means they allow only certain substances to pass through them into or out of the cell. The cell membrane is a lipid bilayer with proteins planted in it. Oxygen and carbon dioxide can pass right through the membrane, but water cannot. Water and other molecules that cannot dissolve in lipids pass through the cell through openings made by proteins in the membrane.

Water diffuses into cells by osmosis. Water makes up 70-95% of a cell. Since water is the most abundant substance in cells, its movement into and out of the cell is very important. The cell has no control over osmosis. It

occurs due to differences in concentrations inside the cell and outside the cell. Water will move back and forth across the cell membrane until equilibrium is reached. Water molecules will always move to the area where they can make the water purer or "fresher".



In an **ISOTONIC** solution, the concentration of solutes outside the cell is the same as the concentration inside the cell. They are equal.

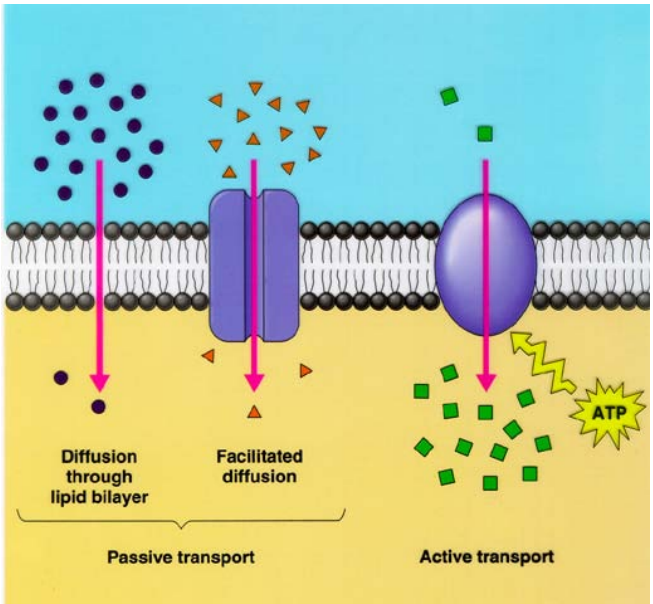
Freshwater plants often exist in **HYPOTONIC** solutions. In hypotonic solutions, the concentration of solutes outside the cell is lower than that inside the cell. ""Hypo-""means less than, so there is less outside the cell. As water flows into the cell, the cell swells and increases its internal pressure. (The cell inside has less fresh water, so the fresh water moves into the cell to try and make it more "fresh".) This is called turgor pressure (pressure built up as a result of osmosis). Excess water is often stored in the large central vacuole. The cell pushes against its cell wall and the cell stiffens. This causes the plant to become more rigid.

In animal cells, if water flows in unchecked, the cell will swell and burst. An example of this would be a red blood cell bursting when placed in fresh water. Cells have ways to get rid of the excess water. Unicellular organisms have a contractile vacuole which pumps excess water out of the cell. Freshwater fish remove excess water through their gills.

In a **HYPERTONIC** solution, cells can shrivel up because more water flows out of the cell than into it. In a hypertonic solution, the concentrations of the solutes outside the cell is greater than that inside the cell. "Hyper-" means more than, so there is more outside. Drinking seawater is dangerous to humans because the ocean is hypertonic with relation to the human body. Drinking salt water causes the body's cells to lose water through osmosis. The cells lose more than they take in.

OTHER MEANS OF TRANSPORT

Carrier molecules are proteins in the cell membrane that transfer large molecules or molecules that cannot dissolve in the lipids that make up the cell membrane. They pick up molecules on one side of the membrane and carry them across to deposit them on the other side of the membrane.



Facilitated diffusion involves the use of a carrier molecule but follows the rules of simple diffusion – the molecules will move from an area of higher concentration to an area of lower concentration. The carrier molecule speeds up the diffusion process. The cell does not expend energy in this process.

Active transport is another transport method using carrier molecules. Active transport is the movement of materials **against** the concentration gradient. In active transport, molecules are moved from an area of low concentration to an area of high concentration. This process requires energy.

ORGANIC COMPOUNDS

There are six elements that are especially important to life: carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur (CHNOPS). There are about twenty others that play lesser roles. Iron, iodine and other trace elements make up less than 0.1% of the human body, but must be present for the body to function normally.

Carbon forms the backbone of all organic molecules. Only carbon is versatile and stable enough to make up the tremendous variety of molecules that are found in living things. There are four main types of molecules containing carbon.

CARBOHYDRATES are organic compounds that contain carbon, and hydrogen and oxygen. Carbohydrates that you are familiar with are sugars and starches, such as glucose and cellulose. Carbohydrates like cellulose are used as structural materials. Carbohydrates like glucose provide quick energy or store energy in cells. The largest carbohydrates are called polysaccharides. These molecules consist of hundreds of units of glucose or simple sugars. Plants store food in the form of starch, a polysaccharide of glucose. Animals store excess sugars as glycogen, another polymer of glucose. Cells break down glycogen or starch and energy is released.

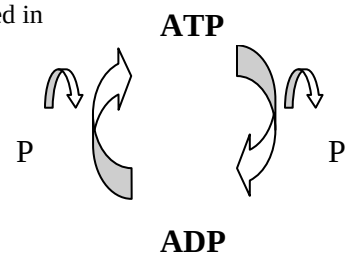
LIPIDS are a chemically diverse group of substances that include fats, oils, and waxes. Examples include butter, beef fat, and olive oil. Lipids also contain carbon, hydrogen, and oxygen like carbohydrates, but lipids are more complex than carbohydrates. All lipids are insoluble in water. They serve mainly as storage of energy in living things. They provide the most stored energy and usually have the most calories. Lipids are also part of the cell membrane and thus help regulate what enters and leaves cells. Many lipids have a backbone that is a three-carbon molecule called glycerol to which three fatty acids are attached.

PROTEINS are basic building materials of all living things. Protein molecules contain carbon, hydrogen, and oxygen. But unlike carbohydrates and lipids, they also contain nitrogen, sulfur, and other elements. All proteins are made of monomers (single molecules) called amino acids. Examples of proteins include egg whites, gelatin, and hair. There are 20 amino acids. These amino acids combine to form polypeptides. All proteins consist of polypeptides.

NUCLEIC ACIDS are a class of organic compounds that carry all instructions for cellular activity. There are two kinds of nucleic acids. Deoxyribonucleic acid, DNA, records the instructions and transmits them from generation to generation. Ribonucleic acid, RNA "reads" the instructions and carries them out.

ENERGY FOR LIVING CELLS

Cells require chemical energy to make tasks necessary for life. This energy is stored in the form of chemical bonds between atoms in food. The energy is taken from the food and stored in molecules that can provide the energy where it is needed in the cell.



Many reactions in the body energy to keep them going (endergonic). In most cases, a molecule called **ATP (adenosine triphosphate)** provides this energy. ATP consists of a sugar, base, and a chain of three phosphates. The bond that holds the second and third phosphate together is easily broken. Enzymes help ATP to transfer this phosphate to another molecule. When this transfer takes place, energy is released that drives the chemical reactions in a cell.

For ATP to be effective, it must lose its final phosphate. The phosphate is returned to ATP by adding a phosphorus (P) to ADP. The series of reactions between ATP and ADP form a cycle. See the diagram to the right. Think of it as a battery that is continually recharging itself. The phosphate group is returned to ATP during a process called cellular respiration. Glucose is broken down and the energy in its bonds is transferred to the energy bonds of ATP.

PHOTOSYNTHESIS

The ultimate source of the energy that powers cells is the sun. Green plants and other organisms (**AUTOTROPHS)** capture the light energy of the sun through the process of photosynthesis. Photosynthesis requires light, chlorophyll, and raw materials. Enzymes are also needed for the reactions to proceed. Chlorophyll in the plants traps the light of the sun. Carbon dioxide from the air and water from the ground are the raw materials for the process of photosynthesis. Glucose is the end product. Oxygen and water are also given off.

PHOTOSYNTHESIS

$$6CO_2 + 12H_2O \xrightarrow[\text{light, chlorophyll}]{\text{enzymes,}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

The purpose of photosynthesis is to store the energy of the sun in the bonds of the glucose molecules. These molecules are then used by organisms to provide energy for cellular activities. The energy is removed from the glucose in a process called respiration.

RESPIRATION

Cellular respiration involves breaking the chemical bonds of organic food molecules and releasing energy that can be used by the cells. The food molecules were the ones produced in plants during the process of photosynthesis.

Respiration involves several steps. Glycolysis is the first step where glucose is broken down into a compound, pyruvic acid, and energy for 2 ATP. From there, the pyruvic acid goes through Krebs cycle and releases energy for 36 ATP. Glycolysis occurs in the cell's cytoplasm and Krebs cycle occurs in the mitochondria.

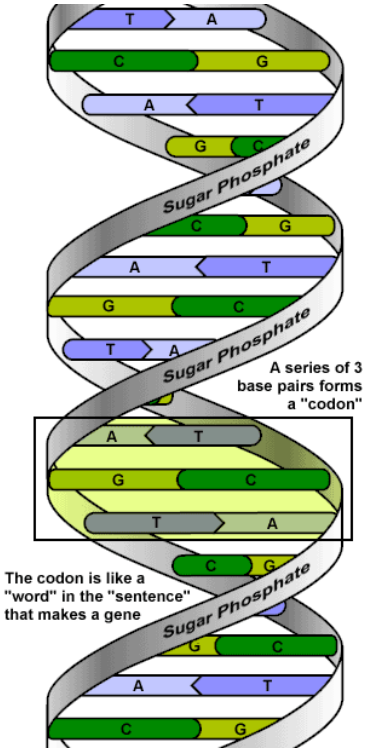
Respiration requires glucose and oxygen and it produces carbon dioxide, water, and energy.

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{enzymes}} 6CO_2 + 6H_2O + \text{energy}$$

The end result of respiration is the energy gain of 38 ATP. Remember that plant and animal cells use ATP to run the chemical reactions they need to survive.

DNA

1. DNA is the genetic material of living things. It is contained in the nucleus of most organisms.
2. DNA stands for **D**eoxyribo**N**ucleic **A**cid. DNA contains three parts - nitrogen bases, a five carbon sugar, and a phosphate group. Each of these bases are attached to a sugar – (deoxyribose), and a phosphate group. Each unit that includes a base, sugar, and phosphate is called a nucleotide.
3. The nitrogen bases are called adenine, guanine, thymine, and cytosine.
4. DNA is shaped in a double-helix. A double-helix looks like a spiral staircase or a twisted ladder. The sides of the helix are the phosphate groups and sugar molecules and the rungs on the helix are the nitrogen-carrying bases.
5. The bases pair up in a specific pattern. Adenine always pairs with thymine and guanine always pairs with cytosine.
6. The pairs of nucleotides that appear on the helix can appear in any order**. The sequence of the nucleotides is the code that controls the production of all the proteins of an organism.** A gene is a sequence of nucleotides that controls the production of a polypeptide (large protein) or an RNA molecule. To give you an idea of size, all 46 of the human chromosomes are composed of more than 5 billion nucleotides.



RNA

1. RNA stands for **R**ibo**N**ucleic **A**cid.
2. RNA acts as a messenger between DNA and the ribosomes. If DNA is located in the nucleus and the synthesis of proteins takes place in the ribosomes located in the cytoplasm, then there must be a way for DNA to instruct the ribosomes in protein production without leaving the nucleus. RNA is the way.
3. The sugar in RNA is ribose, not deoxyribose like DNA.
4. Also, uracil replaces thymine as a nitrogen base in RNA.
5. RNA is usually a single strand unlike DNA's double-helix.
6. There are three types of RNA.
    1. Messenger RNA (mRNA) carries the sequence of nucleotides from the DNA in the nucleus to the ribosomes in the cytoplasm.
    2. Transfer RNA (tRNA) picks up individual amino acids and brings them to the ribosome. The amino acids are then joined together in proper order to form a protein.
    3. Ribosomal RNA (rRNA) is contained in the ribosome and contributes to the structure of it.

STORING AND TRANSMITTING INFORMATION

REPLICATION

Replication is the process in which DNA makes a copy of itself. Remember that each new cell gets a copy of the genetic code. DNA replicates before cell division starts. During replication several steps take place. The DNA upzips and then the bases pair up with the exposed nucleic acids. Each completed DNA molecule contains one old strand and one new strand. ATP and the action of the enzymes power the entire process.

TRANSCRIPTION

Transcription is the process whereby mRNA is copied from DNA. This process transfers the DNA code to molecules of mRNA. Several steps occur. First, the DNA unzips. One strand of DNA serves as a template for the RNA. The bases attach to the exposed nucleic acids. Once the RNA is made, it detaches from the DNA and the DNA zips back up. The code in the mRNA allows the cell to collect the right amino acids and assemble them in the correct sequence to make a particular protein. Each code is a three letter word with a base standing as a letter. Each three letter code is called a codon.

TRANSLATION

The mRNA carries the codon information to the ribosome in the cytoplasm. Translation is the process where the ribosome attaches to mRNA and carries out the formation of a protein. Several ribosomes are involved in translation thus allowing one mRNA molecule to repeatedly produce a specific protein molecule.

The ribosome is made up of two parts. The smaller part attaches to the mRNA. The larger part contains a enzyme that helps to link amino acids together to form a protein. The tRNA brings specific amino acids to the ribosome to be joined to a forming protein strand. Each tRNA has an amino acid attached and an anticodon. The anticodon pairs with a codon on the mRNA and thus amino acids are added in proper sequence.

MITOSIS VERSUS MEIOSIS

MITOSIS is a type of cell division, which generates two identical cells and DNA of the mother cell. It occurs in body cells – somatic cells. Mitosis maintains the chromosome number and generates cell replacement, maintenance, and repair of the organism. Mitosis requires one DNA replication and one nuclear division.

MEIOSIS is a process in which the normal number of chromosomes in a cell is reduced by half or a HAPLOID number. Chromosomes in cells occur in pairs called homologous chromosomes. Cells that have homologous chromosomes are said to have DIPLOID (2n) number of chromosomes. Sex cells or **GAMETES** must have a haploid number of chromosomes. When two gametes combine (sperm fertilizes egg), then the cell has a full compliment of needed chromosomes.

Meiosis requires two cell divisions one after another. The DNA only replicates once. In Meiosis I, the homologous (paired) chromosomes separate. During Meiosis II, the chromatids of each chromosome separate. Meiosis I is just like mitosis.

There are several stages involved in cell division:

1. **INTERPHASE** – this is the time between the formation of a cell through cell division and the beginning of the next mitosis. DNA is replicated; more organelles and other structures are made.
2. **PROPHASE** – this phase takes up 60% of the total time for mitosis. During this stage, the chromosomes coil up into short rods called chromatids. The nuclear membrane breaks down and disappears. Spindle fibers appear between the centrioles and the chromosomes attach to the spindle fibers at their centromere.
3. **METAPHASE** – Chromosomes become arranged along the cell's equator or middle. Each centromere is attached to a separate spindle fiber.
4. **ANAPHASE** – Each chromatid separates in each pair. Spindle fibers shorten and pull the two chromatids apart. The single chromatids move to the opposite ends of the cell.
5. **TELOPHASE** – After the chromosomes have reached opposite ends of the cell, the spindle fibers disappear. The nuclear membrane reforms and the chromosomes uncoil. The cell membrane pinches together and a groove or furrow forms. The cell then separates into two daughter cells. This portion of cell division is called cytokinesis. In plant cells, a cell wall forms in the middle of the cell and extends outward to the cell membrane until it separates the two daughter cells.

During meiosis, the cell goes through this cycle twice. The only exception is that the DNA is not duplicated before the second cell division. The result is four cells are formed, each with half the number of chromosomes.

GENETICS AND HEREDITY

The study of **HEREDITY** is called **GENETICS**. Modern genetics is based on the knowledge that traits are transmitted by means of chromosomes. Offspring resemble their parents because they carry their parent's genetic material in units called **GENES**. Genes are located on the **CHROMOSOME**; they are the units of heredity. You have blue eyes because your parents gave it to you in their genes.

Gregor Mendel is the father of genetics and he studied the inherited traits in pea plants. He knew nothing about chromosomes and yet he was able to discover the basic principles of heredity. Mendel had logical experimental methods and he had careful record keeping. From his study, we can predict the percent of characteristic traits that will be passed off to offspring.

Remember that you have traits from your mom and your dad. No one person is like any other person in their genes except for identical twins, triplets, etc.

Here are some things you should know:

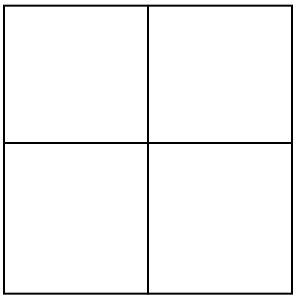
1. For each inherited trait, an individual has two copies of the gene – one from each parent.
2. There are alternate versions of genes – for example, blue, green, and brown eyes. These different versions are called **ALLELES**. If the two alleles in a person are the same it is called **HOMOZYGOUS** (such as TT or tt). If they are different, it is called **HETEROZYGOUS** (such as Tt).
3. When two alleles occur together, one of them may be completely expressed, while the other may have no observable effect on the organisms appearance. **DOMINANT** alleles are traits that express themselves. **RECESSIVE** alleles are traits that are hidden. For every pair of traits, like purple flowers and white flowers, one trait is always dominant and one is recessive.
4. The physical appearance of the trait is called the **PHENOTYPE** (example: brown eyes). The set of alleles and individual receives is called the **GENOTYPE** (example: BB).
5. The **PRINCIPLE OF DOMINANCE** is when one gene in a pair prevents the other gene from being expressed. A dominant gene masks another gene. A recessive gene is masked by a dominant gene. Dominant traits are given capital letter and recessive genes are given lower case letters.

   B = brown b = blue BB = brown Bb = brown bb = blue

6. The **PRINCIPLE OF INCOMPLETE DOMINANCE** is when one gene in a pair does not prevent the other gene from being expressed. There is an intermediate trait shown. For instance, snapdragons have red (RR) and white (rr) flowers, but with incomplete dominance, they can have pink flowers (Rr). Neither red or white is completely dominant.

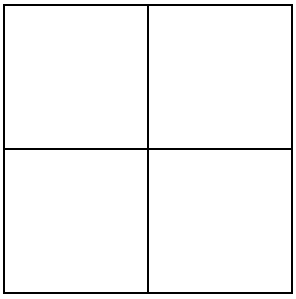
THE PUNNET SQUARE

The Punnett Square is a grid to help scientists show all the possible gene combinations for a cross of parents. Dominant traits are symbolized by capital letters and lower case letters symbolize recessive traits. Place one parent's genes at the top of the square and the other parent's genes on the left side of the square.



Let's try a cross where there is complete dominance. Seeds can have bumpy shells or smooth shells. Bumpy is dominant, B and smooth is recessive, b. Show the cross of BB and Bb in the box to the left. What are the offspring?

Now let's try is again with incomplete dominance. Red (RR) are crossed with white (rr) snapdragons. Show the cross in the box to the right. What are the offspring?



GENETIC DISORDERS

Abnormal chromosomes determine some human genetic disorders. Abnormalities can occur due to **NONDISJUNCTION**. Nondisjunction is the failure of a chromosome pair to separate during meiosis. When nondisjunction occurs, half of the gametes produced lack one chromosome and the other half have an extra chromosome. Several serious problems result from cells with the wrong number of chromosomes (too many or too few). Down's syndrome can result from having three copies of chromosome 21 (instead of just two).

Abnormalities and diseases can also be a result of **MUTATION**. The gene mutates (it has different nucleic acids) and can no longer function normally. This abnormality can be passed onto the offspring. Mutations result in diseases like sickle cell anemia, Huntington's disease, and cystic fibrosis.

Colorblindness and hemophilia are sex-linked traits. These traits are carried on the 'X' chromosome. The mother acts as a **CARRIER**. She carried the defective gene but does not show the disease. She can then pass the defective gene on to her children. If the child is a boy, then he will express the disease because he does not have another "X" chromosome to mask the defect.

GENETIC ENGINEERING

Genetic engineering involves different approaches, but share the same four basic steps:

1. Cutting the DNA from an organism containing the gene of interest.
2. Making a combination of the original DNA fragment and DNA fragments from the organism that is going to carry the new gene (both DNA together is called recombinant DNA).
3. Cells are treated to make many copies of the recombinant DNA.
4. Cells are then screened to remove the cells that did not take up the recombinant DNA.

This technique has been used to produce insulin and other needed drugs. Bacteria are given the gene for the protein insulin and then the bacteria produce it. In addition, vaccines for diseases can be produced. The genes for the disease-causing virus' surface proteins can be inserted into a harmless virus and then put into a vaccine.

DNA technology has been used to develop new strains of plants, which in turn can be used to increase food crop yields. For example, by transferring genes for enzymes that are harmful to hornworms into tomato plants,

scientists can make tomato plants toxic to hornworms, and thus protect these plants from these pests, which otherwise would seriously damage them

KINGDOMS OF ORGANISMS

Taxonomy

Scientists these days study chromosome structure, reproductive potential, biochemical similarities, and embryology to determine the relationships among organisms. Organisms are then given classification names. The classification levels are:

Kingdom-Phylum-Class-Order-Family-Genus-Species

(to remember order, say: King Philip Came Over For Great Spaghetti)

For instance, here is the classification for a tiger: Kingdom Animalia, Phylum Chordata, Class Mammalia, Order Carnivora, Family Felidae, Genus *Panthera*, Species *tigris.* The scientific name for tiger is *Panthera tigris.*

Currently there are five kingdoms, but some scientists talk about six kingdoms. Six kingdoms will be discussed here, although you should also know the five. In the five kingdom arrangement, there is a kingdom Monera. In the six kingdom arrangement every kingdom is the same except Kingdom Monera is replaced by Kingdom Eubacteria and Kingdom Archaebacteria.

KEY CHARACTERISTICS OF THE KINGDOMS

CHARACTERISTICS	**EUBACTERIA**	**ARCHAE-BACTERIA**	**PROTISTA**	**FUNGI**	**PLANTAE**	**ANIMALIA**
CELL TYPE	Prokaryote	Prokaryote	Eukaryote	Eukaryote	Eukaryote	Eukaryote
CELL STRUCTURE	Cell wall, with peptidoglycan	Cell wall, no peptiodoglycan	Mixed	Cell wall, chitin	Cell wall	No cell wall
BODY TYPE	Unicellular	Unicellular	Unicellular, multicellular	Unicellular, multicellular	Multicellular	Multicellular, with organs
NUTRITION	Autotrophic and heterotrophic	Autotrophic and heterotrophic	Autotrophic and heterotrophic	Heterotrophic	Autotrophic	Heterotrophic
EXAMPLE	*Bacillus subtilis*	*Methano-microbium mobile*	*Euglena gracilis*	*Pennicillium notatum*	*Pinus radiata* (pine tree)	*Loxodonta Africana* (elephant)

The key characteristics listed above are explained below:

1. Cell Type: Organisms are either prokaryote or eukaryote. Two of the kingdoms are prokaryotic and the other four include eukaryotes.
2. Cell construction: Cells are built differently. Some cells have cell walls made of different compounds, and some cells have no cell walls at all.
3. Body Type: Organisms can be unicellular or multicellular and may have tissue or organs. Only one kingdom includes organisms that have organs; organisms in the other kingdoms vary in body type.

4. Nutrition: Organisms obtain their nutrition through photosynthesis or by heterotrophic means. Some kingdoms have organisms that use both methods; but organisms in other kingdoms use strictly one method.

EUBACTERIA

Characteristics:	prokaryote, microscopic, lives as a single cell or in colonies in water. Most are autotrophic (producers), a few are heterotrophic (consumers); have the same kind of lipid (peptidoglycan) in their cell walls; found in practically every environment on earth.
Structures:	flagella, capsules
Growth:	cell membrane and availability of food set growth limit; keep moist and warm for optimal conditions
Reproduction:	binary fission (splits in two)
Beneficial:	decomposers of matter, in digestive system, nitrogen-fixers
Harmful:	can cause diseases like strep throat, pneumonia
Examples:	Bacteria, blue-green bacteria

ARCHAEBACTERIA

Characteristics:	prokaryote, microscopic, lives as a single cell or in colonies in water. Most are autotrophic (producers), a few are heterotrophic (consumers); do not have peptidoglycan in their cell walls; found in extreme environments on earth – swamps, hydrothermal vents, very salty places. Also found in soil and seawater. Most receive their energy from inorganic sources.
Structures:	flagella, capsules
Growth:	cell membrane and availability of food set growth limit; methane (methanogens) and sulfur (thermophiles) are two types of nutrients used for energy.
Reproduction:	binary fission (splits in two)
Beneficial:	unknown
Harmful:	unknown
Examples:	Methanogens, Thermophiles, Halophiles

PROTISTA

Characteristics:	Most diverse kingdom; Animal-like organism, distinguished by method of locomotion, eukaryotes, mainly microscopic, single celled or multicellular; some are autotrophic (algae) and many are heterotrophic (protozoans); All single celled eukaryotes are protists except yeast.
Structures:	flagella, pseudopodia, capsules, cell organelles, membrane bound, some are photosynthetic
Growth:	cell membrane, availability of food set growth limit.
Reproduction:	asexual or sexual
Beneficial:	some are harmless
Harmful:	sleeping sickness, malaria
Examples:	Most unicellular organisms - protozoa, amoeba, zooplankton, euglena, paramecium, and algae

FUNGI

Characteristics:	Animal-like organism, cannot move, eukaryotes, mainly multicellular, parasitic, symbiotic, heterotrophic,
Structures:	root-like, caps, filaments called hyphae
Growth:	based on food source and availability; obtain nutrients by secreting digestive enzymes into their environment and the absorbing the digested organic molecules.
Reproduction:	asexual, sexual
Beneficial:	yeast, penicillin, decompose organic material
Harmful:	cereal rusts, ringworm, athlete's foot,
Examples:	mushrooms, bread molds, slime molds, rusts and smuts, yeast

PLANTAE

Characteristics:	eukaryotes, mainly multicellular, can't move, autotrophic
Structures:	cellulose cell walls
Functions:	based on cell and tissue chemistry
Systems:	all present and functioning
Growth:	determined by available nutrients
Reproduction:	asexual, sexual by spores, seeds, flowers, and cones
Examples:	All multicellular plants - Mosses, ferns, gymnosperms (pine cone plants), angiosperms (flower-bearing plants)

ANIMALS

Characteristics:	eukaryotes, multicellular, heterotrophic, most are motile at some point in their lifetime
Structures:	all present and unique to the organism
Functions:	based on nutrition, cell and tissue chemistry, and individual demands
Systems:	all present and functioning
Growth:	based on hormone action and nutrition
Reproduction:	asexual, sexual
Examples:	All multicellular animals - Invertebrates (sponges, jellyfish, coral, sea anemones, planarian, fluke, tapeworm, hookworm, earthworm, mollusks, starfish, insects, crustacean); vertebrates (fish – cartilaginous and bony); amphibians – frogs, salamanders; reptiles – snakes, lizards, turtles; birds; and mammals

MORE ON PLANTS

One of the major ways that land plants differ is the way they transport water and nutrients throughout the plant body. The majority of land plants have an internal system of connected tubes and vessels called vascular tissues. These plants, called vascular plants, are the plants that you are the most familiar with –maple trees, grasses, roses, and house plants. Vascular plants have roots, stems, and leaves.

The other group of plants lack vascular tissue. They transport water and nutrients by osmosis and diffusion.

VASCULAR PLANTS AND THEIR TISSUES

Plants with vascular tissue have true roots, stems, and leaves. They have an internal network of tubes that carry water, nutrients and glucose made from photosynthesis throughout the plant.

The **ROOTS** absorb water and nutrients from the soil and they anchor the plant. The roots also store food that was made in the leaves. The **STEM** contains vascular tissue that transports substances between the roots and the leaves. The stem also supports plant growth above the ground. It is the backbone of the plant. There are two types of vascular tissue: xylem and phloem. **XYLEM** transports water and minerals absorbed by the roots up to those parts of the plant that are above the ground. The **PLOEM** carries sugar and other soluble organic materials produced by photosynthesis from the leaves to the rest of the plant.

The **LEAVES** use sunlight, water, and carbon dioxide to carry out photosynthesis. They also transport the food they produce to the rest of the plant in a process called translocation. In addition leaves exchange gases and water vapor with the atmosphere. The outside of the leaf is covered with a waxy layer that slows the evaporation of water from the leaf. The leaf has openings called stomata. Each **STOMATE** controls the exit and entry of water and gases. Most stomata are located on the underside of the leaf where the surface is shaded. Ninety percent of the water that enters the roots is lost through the leaves in a process called transpiration. The middle portion of the leaf contains the chlorophyll and other pigments.

The vascular plants can be divided into those that have seeds and those that have spores. Ferns, horsetails, whisk ferns, and club mosses all have spores. All other plants have seed – either in a cone or in a fruit.

DIFFERENT GROUPS OF PLANTS

Ferns are seedless plants that contain vascular tissue. Fern fronds spread out over a large area and so ferns are able to survive in dim sunlight.

Gymnosperms produce their seeds in cones and generally keep their leaves throughout the year (evergreen). Conifers means "cone-bearer". Pines, spruce, fir, and other conifers are characterized by their stiff cones and needle-like leaves. Conifers can thrive in harsh conditions because they have special adaptations. Their needles are covered in a hard waxy outer coating and have little exposed surface area. This means that they do not lose much water. They shed their needles throughout the year instead of once a year. They send their roots out into a wide area of soil instead of deep into the soil. This allows them to survive in areas where the soil is not very deep.

Angiosperms are flowering plants. They produce seeds enclosed in fruits. (Gymnosperm seeds are uncovered in their cones.) Angiosperms are deciduous plants. That means that they lose their leaves every fall.

During pollination, pollen grains stick to the top of the stigma. From there, the pollen grain grows a pollen tube down through the style to the ovary where it fertilizes the egg.

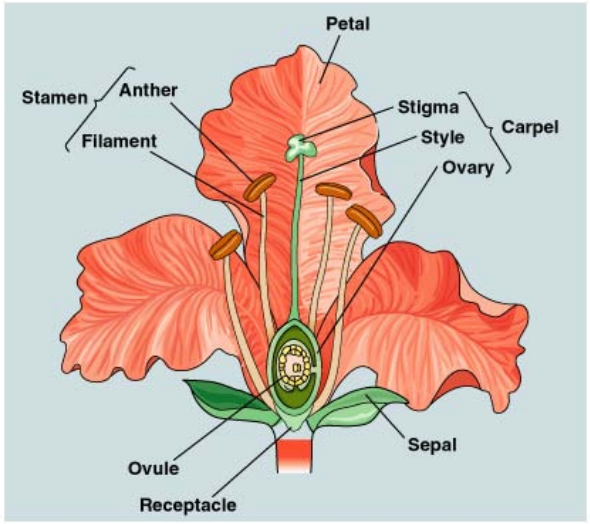
Animals, wind, and water all transport pollen from flower to flower. The nonessential flower parts are modified to aid the specific type of pollination a plant undergoes. In flowers that are pollinated by animals, the stem and receptacle hold the flower out where its colors and scent are most obvious. Some flowers produce nectar, a sweet liquid.

Fruits are formed when the egg is fertilized and the ovary begins to swell and ripen. It changes color and becomes fleshy or dry. Animals eat the fruit and pass the seed out to new places through their waste.

SEXUAL REPRODUCTION IN FLOWERS

In plants that produce them, the flower functions in sexual reproduction. The parts are as follows:

1. Stamen: male part of flower. Many flowers have 3-5 stamens.
2. Filament: the thin stem-like portion of a stamen.
3. Anther: pollen is produced at the tip of the filament.
4. Pistil (labeled carpel in drawing): the female part of the flower. Most flowers have a single pistil. The pistil contains three parts.
5. Ovary: The swollen base of the pistil. Within the ovary, one or more ovules produce the egg cells.
6. Style: The slender middle part of the pistil.
7. Stigma: At the tip of the style. The stigma produces a sticky substance to which pollen grains become attached.



SEEDS

Seeds gave the animal world a new high-energy food source. They provide food for mammals that need lots of energy to help maintain their body temperature. People have depended upon angiosperms for food, lumber, fibers, clothing, and medicines.

The development of plants that have seeds really helped plants to survive in a variety of places. Seeds can lie dormant (asleep) if the conditions aren't right for growing. Some seeds, because they have burrs or stickers, can travel a long way on animals or in the wind before falling to the ground and sprouting. This spreading of seeds, called dispersal, is good for plants. It helps to spread the plant's genes over a wider area.

INVERTEBRATES

The major difference between animals and plants is that animals can move. Animals cannot produce their own food so they must move to find it. The arrangement of body parts is related to how a particular animal meets the challenges of living, which includes gathering food, protecting itself, and reproducing. Differences in body structure are useful in classifying animals. Invertebrates make up 97% of the animal kingdom. There are 15 invertebrate phyla and some of them will be discussed below.

PHYLUM PORIFERA

Sponges have the simplest body organization of any phlya. They have no head, mouth, or any organized systems like digestion and circulation. The cells are not organized into tissues and organs. They live in shallow seas. They are all shapes and sizes, as well as colors.

They do not move around, attaching themselves to a rock, shell, or other substance. They feed by filtering food and nutrients out of the water. Their bodies consist of two layers of cells with a jelly-like layer in between.

PHYLUM COELENTERATA

Coelenterates are bag-like animals with long flexible tentacles. Most live in seawater, but hydras live in freshwater. Coelenterates include jellyfish, sea anemones, and corals. Coelenterates have a digestive gut with only one opening. They have radial symmetry (Symmetry where body parts are arranged around a central point - like a wheel.) Their bodies consist of two layers of cells, separated by a jelly-like substance. They also have special stinging cells called cnidocytes.

PHYLUM PLATYHELMINTHES

This is the group of flatworms which includes the flatworm, the fluke, and the tapeworm. They have a digestive cavity with only one opening. They have no circulatory or respiratory system. Flukes are parasites and pose a serious health problem. Many can cause serious and even fatal diseases. They live off the fluid of their host (blood or mucus). Most flukes are endoparasites which means they live inside the body of their hosts. Their life cycle generally involves two or more hosts. For instance, the oriental lung fluke infects crabs which are eaten raw by humans who then get infected with the worms. To not get infected, humans could cook the crab meat! Tapeworms live in the intestines of vertebrates where they feed by absorbing food that has already been digested by their host.

PHYLUM NEMATODA

This phylum includes roundworms, also called nematodes. Different types include Ascaris (intestinal roundworm), hookworms, trichina, and pinworm. They have tubular bodies and have a digestive tract open at both ends. Most roundworms are parasites. They feed on plants by sucking the juices from them. They can infect humans, usually from poor sanitation and cause diseases. These roundworms are pinworms, hookworms, or intestinal roundworms. Trichina infects pigs and can cause trichinosis in humans who eat raw or undercooked pork.

PHYLUM ANNELIDA

This phylum is the segmented worms - they have bodies that are divided into a series of segments which often look like visible rings on the outside of the body. They are also called annelids. They include earthworms, leeches, and a variety of marine worms. They have three tissue layers and a body that has bilateral symmetry (symmetry where body parts are identical on both sides – like humans). Annelids have a true coelom (internal organs are suspended by double layers of a membrane). Annelids also have a more complex circulatory, nervous, and respiratory systems than other worms.

PHYLUM MOLLUSCA

This phylum is the soft bodied mollusks. They live in fresh as well as seawater. They come in a variety of sizes. Many are protected by one or more shells. They are classified according to what kind of shell that they have. They include the two-shelled mollusks (clams, scallops, oysters), one-shelled mollusks (snails) and no-shelled

mollusks (squid, octopuses, cuttlefish). Mollusks have bilateral symmetry and they have a true coelom. They have three distinct body parts - head-foot, visceral mass, and mantle. Clams obtain both food and oxygen from the water that flows through their bodies. They are filter feeders. They have gills that absorb the oxygen from the water. They have an open circulatory system and a three chambered heart.

PHYLUM ECHINODERMATA

Echinoderms are spiny-skinned and include starfish, sand dollars, brittle stars, and sea urchins. They live only in ocean/marine habitats. Echinoderms have an endoskeleton that is covered by a thin skin. They are considered the most advanced form of invertebrates and are classified closest to vertebrates due to a larva stage that is bilaterally symmetrical. They are radially symmetrical as adults. They have no brain. They breathe through skin gills that are protected by the spines. The starfish has a remarkable ability to regenerate body parts. So if a starfish loses an arm, it will regrow.

PHYLUM ARTHROPODA

The Arthropod phylum has more species than any other. Three quarters of all species on earth are insects. Their great success is due in part to their body structure. They are characterized by having jointed appendages, a segmented body, and an outer skeleton (exoskeleton). It is made of chitin. They have a well developed open circulatory system with a long dorsal tube for a heart. The nervous system consist of two long ventral chains of nerves and a simple brain.

The five major classes of Arthropods are insects (bees, beetles, mosquitos), arachnids (spiders, scorpions, ticks, mites), crustacean (crayfish, lobsters, crabs, shrimp), Diplopoda (millipedes), and Chilopoda (centipedes).

Insects are the only arthropods that can fly. They are both beneficial (pollination) and harmful (crop destroyers). They have three distinct body parts and three pairs of legs. They include grasshoppers, crickets, termites, aphids, flies, mosquitoes, butterflies, moths, beetles, ants, wasps, and bees.

VERTEBRATES

PHYLUM CHORDATA

This phylum is the most complex of all animals. The vertebrates (animals with backbones) make up the largest subphylum in the phylum Chordata. At some point in their development, all chordates possess four distinctive structures: a notochord, a nerve chord, gill slits, and a tail.

SUBPHYLUM VERTEBRATA

Vertebrates have a strong flexible backbone. Three classes live entirely in water - jawless fish, cartilaginous fish, and bony fish. Amphibians are adapted to life on land as well as the water. Reptiles and mammals are primarily land animals. All but a few birds can fly.

Vertebrates have a number of characteristics in common. They have bilateral symmetry. The major sense organs are located in the head. All vertebrates have a closed circulatory system and a coelom (large central body cavity that contains the important organs). They all have an endoskeleton which supports and protects them. The endoskeleton can be made of cartilage or bone. A distinctive feature of the skeleton is the backbone - vertebral column. They have pairs of muscles that work in opposite directions to push and pull the bones.

Their bodies are covered with scales, skin, feathers, or hair. They have a digestive tube that goes from mouth to anus. They have gills or lungs for breathing and have a closed circulatory system with two-, three-, or four-chambered hearts. They have arteries to take the blood from the heart and veins to take it back to the heart.

Their excretory (waste) system consist of kidneys, and associated tubes. Their nervous system includes a spinal cord, brain, nerves, and sense organs. There are male and female sexes.

CLASS AGNATHA

They do not have jaws but use a sucker-like mouth to latch onto their prey. They have smooth, cylinder-like bodies with flexible skeletons of cartilage. They are ectothermic (cold-blooded). The only two surviving members of this class are the hagfishes and lampreys.

CLASS CHONDRICHTHYES

These are the cartilaginous fishes. Their skeletons are made of cartilage. They have hinged jaws lined with rows of teeth. They are ectothermic. The class includes sharks, rays, and skates.

CLASS OSTEICHTHYES

Most of the world's fishes are in this class. They have skeletons made of bone, and have jaws and scaly skin. They get their oxygen from the water through gills. They are ectothermic.

CLASS AMPHIBIA

Amphibians live on land and in the water. They have internal lungs that are not very efficient and they also get oxygen through their moist skin. They keep their skin moist with a mucus and they can never venture too far from water. They return to the water to lay their eggs and their young pass through a larval stage in the water before beginning their life on land. They are **ectothermic.** Amphibians include frogs, toads, and salamanders.

In frogs, the young are called tadpoles and live in the water. The tadpole goes through metamorphosis, or change, as it develops into an adult. A tadpole begins life with a short tail and breathes through gills. Gradually it develops arms and legs and its tail begins to disappear. The lungs replace the gills and the frog leaves the water.

CLASS REPTILIA

Reptiles were the first animals that were truly independent of the water. They do not need to keep their body moist for their skin is thick and covered with scales. They do not need to return to water to have babies for their young are laid in eggs. These eggs hold food for the embryo to live off of while it is growing. They are **ectothermic.** Reptiles include the extinct dinosaurs, turtles, tortoises, alligators, crocodiles, lizards, and snakes.

CLASS AVES

This is the class of all birds. Birds arose from reptiles and they grew feathers instead of scales to insulate themselves. The feathers distinguish birds from other classes of vertebrates. Birds are **endothermic** (warm-blooded) which means their body temperature remains constant.

CLASS MAMMALIA

Mammals have several characteristics not found in other vertebrates. They nurse their young using milk from mammary glands. Mammals have live births - the young are born live after spending time developing in their mother's body.

They have body hair that acts as insulation and also protects the body from injury. Mammals have a large well-developed brain and they are the only animals that have an external outer ear for hearing. Their body is divided into two parts - the chest and the abdomen. The diaphragm separates the two parts. They are **endothermic**.

Mammals include monotremes (duck-billed platypus, spiny anteater). They have mammary glands which make them mammals, but they lay eggs. Mammals also include marsupials (kangaroos, koalas, opossums). They bear live young, but the young are not as developed as other mammals. These babies complete their development inside a pouch attached to the mother.

Placental mammals include 95% of all mammals. The embryo of a placental mammal is implanted in the mother's uterus - the mother's reproductive organ. The placenta forms, connecting the young mammal directly to the mother providing nutrients and oxygen.