You CAN Pass Your Biology SOL!

Scientific Method

*****Scientists use the **SCIENTIFIC METHOD** to help them answer questions and solve problems about the natural world.*****

Step 1: Make an **OBSERVATION**. The two types are:

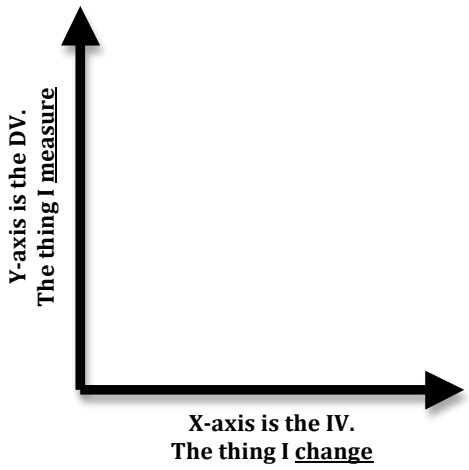
→**QUALITATIVE:** Descriptions without number. (Ex) The book is **heavy**.
→**QUANITATIVE:** Descriptions that use numbers. (Ex) The book has **250** pages.

Step 2: Make a **HYPOTHESIS.** This is an educated guess based on qualitative and quantitative data.

⇒ Scientist should look for 2 variables in trying to find answers to the problem.

◊**INDEPENDENT VARIABLE (IV)**
-The thing I **change**
◊**DEPENDENT VARIABLE (DV)**
-The thing I **measure**

How to Identify Variables on a Graph:



Step 3: Setup a **CONTROLLED EXPERIMENT**. Each has:

1. **CONTROL GROUP:** the group that stays the same (doesn't receive the IV). It's needed to compare.
2. **EXPERIMENTAL GROUP:** the group that is manipulated (the group you are performing the experiment on). This group receives the IV.

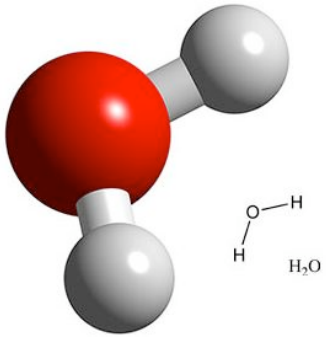
Step 4: Make a **CONCLUSION** or **THEORY**

⇒If the data gathered from your controlled experiment support your hypothesis, you accept your conclusion.
⇒If the data doesn't support your hypothesis, start over!

Water & its Properties

Water makes life possible! It's a universal solvent, comes in three states, and has a high specific heat to regulate temperature

The chemical formula of water is **H_2O.** It has 2 hydrogen and 1 oxygen.

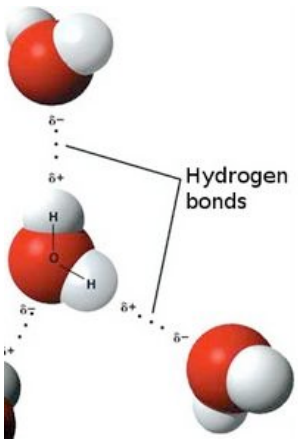


Water has a positive side (hydrogen) and a negative side (oxygen). These charges allow water to stick to other things that also have a charge.

HYDROGEN BONDS hold water to itself and to other charged substances.

When water sticks to other things (like a car window) **ADHESION** is taking place.

When water sticks to itself **COHESION** is taking place



Water comes in 3 states: solid, liquid or gas. In the solid state (ice), water is less dense than the liquid state. Ice floats!

Water has a **HIGH SPECIFIC HEAT**. It can absorb a lot of energy without increasing its own temperature. This is why water takes so long to boil!

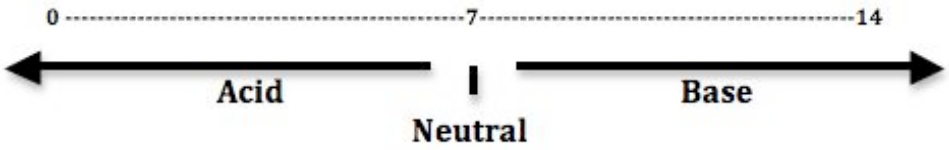
- We use this property to help us regulate our body temperature. When our body temperature gets too high, we start to **PERSPIRE** (sweat).

We do not want our body temperature to fluctuate very much because it would alter chemical reactions (**METABOLISM**). When metabolism is thrown off, **HOMEOSTASIS** (balance) is also thrown off. This can lead to death!!!!

pH Scale

Substances with a pH below 7 are called ***Acids***. Substances with a pH above 7 are called ***Bases***. Substances with a pH of 7 are ***Neutral***. Water is the only neutral substance.

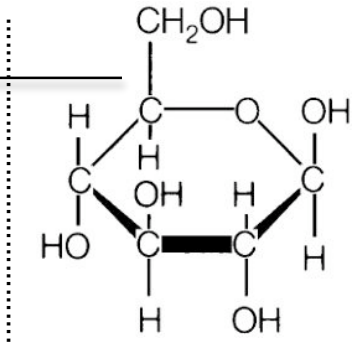
The pH scale actually measures the amount of ***HYDROGEN IONS (H+)*** that are present in a solution. pH could stand for "**THE POWER OF HYDROGEN**." The **lower** the pH value, the **greater** the amount of hydrogen ions (H+) present in the solution

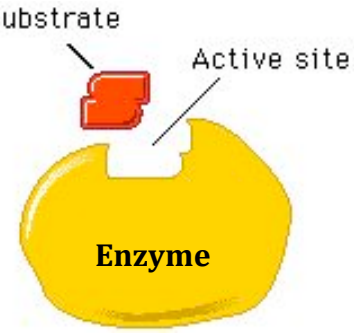


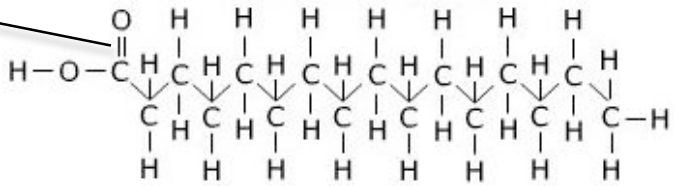
Macromolecules

*All living things are composed of 4 macromolecules. Macromolecules are large **polymers** (the prefix "poly" means "many") that are composed of lots of smaller building blocks called **monomers** (the prefix "mono" means "one"). *

1. **Carbohydrates:** The only macromolecule that is used for **ENERGY**. Carbohydrate is a fancy word for **SUGAR**. The most important sugar is **GLUCOSE ($C_6H_{12}O_6$).** The building blocks of carbohydrates are ***MONOSACCHARIDES***.
2. **Lipids:** The only macromolecule used to **STORE ENERGY** and to provide **INSULATION.** There are three classes of lipids (fats, oils & waxes). The building blocks of lipids are ***FATTY ACIDS.***
3. **Proteins:** The only macromolecule that can **SPEED UP CHEMICAL REACTIONS** and provide **STRUCTURE & SUPPORT.** The building blocks of proteins are ***AMINO ACIDS.***
4. **Nucleic Acids:** The only macromolecules that **TRANSMITS HEREDITY INFORMATION**. There are two types of nucleic acids: **DNA** & **RNA**. Their building blocks are ***NUCLEOTIDES.***







Enzymes

Enzymes are biological catalysts. They speed up chemical reactions and regulate metabolism. Enzymes are proteins that can lower a chemical reaction's activation energy

Enzymes are **CATALYSTS.** Catalysts **SPEED** things up!

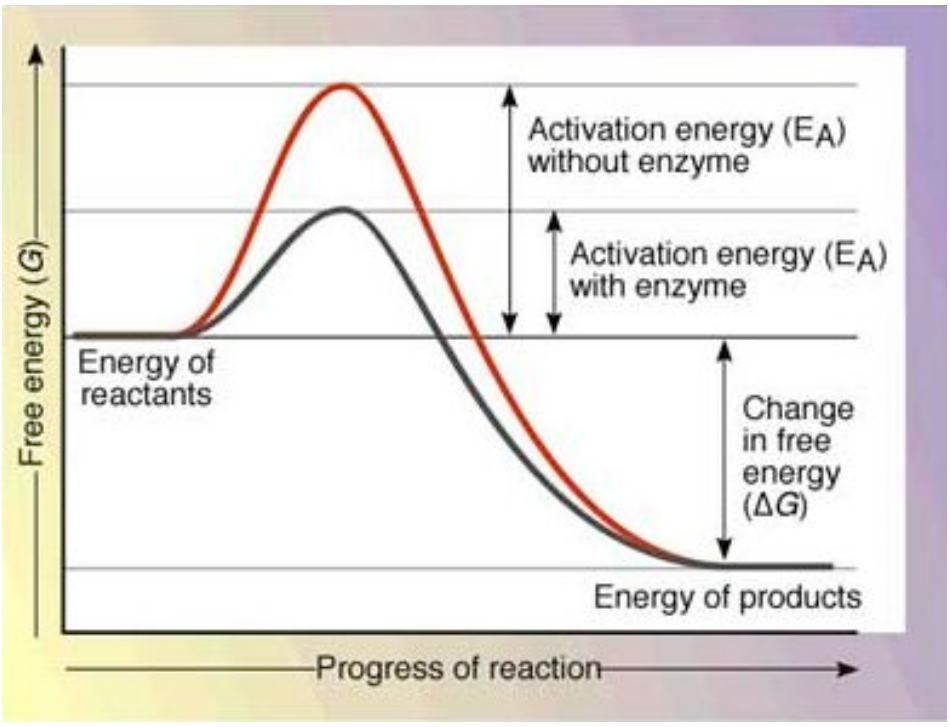
Without enzymes, chemical reactions (metabolism) would happen too slowly to keep you alive.

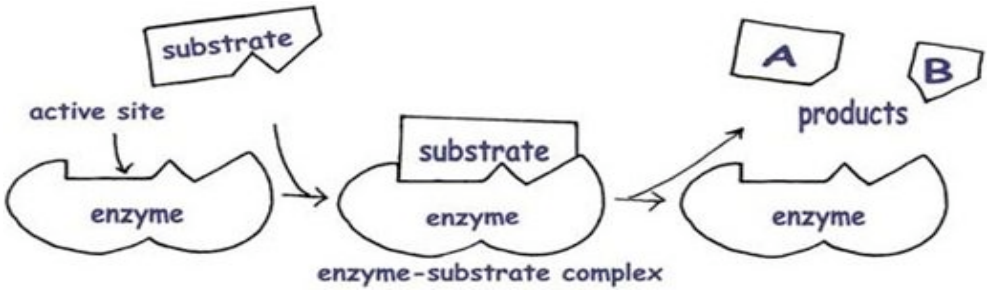
Enzymes are shape specific. Enzymes can only catalyze reactants **(Substrates)** if they can fit inside the enzyme's **ACTIVE SITE**.

Enzymes speed up chemical reactions by **LOWERING ACTIVATION ENERGY**. Activation energy is the amount of energy needed to start a chemical reaction.

Activation Energy works like a speed bump.

- The **bigger** the activation energy the **slower** the chemical reaction
- The **smaller** the activation energy the **faster** the chemical reaction.





Microscopy

The microscope is one of the most important tools in biology. It allowed scientists to discover the cell and all of its structures.

The are only 2 things that you need to know about microscopes:

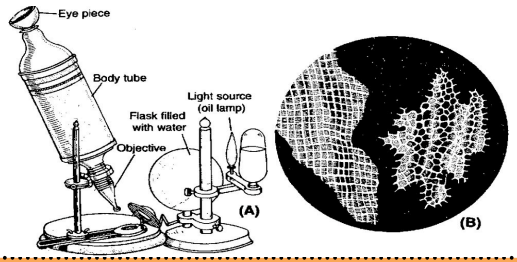
1. **Determining Total Magnification:** Multiply the eyepiece (that is always 10x) by the objective lens (the lenses that can be rotated)

10 x Objective Lens= Total Mag.

2. **Making a Wet-Mount Slide:** Always place the cover slip on at a **45° Angle** to prevent air bubbles.

Microscopes & the Cell

Once the microscope was invented, **ROBERT HOOKE** was able to see and name the tiny structures that make up life while studying cork. He was the first person to use the word **CELL**.



With the help of Hooke and other scientists working with the microscope, the **CELL THEORY** was created.

THE CELL THEORY:

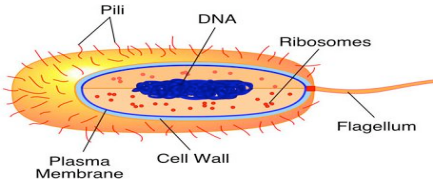
1. All living things are composed of cells.
2. Cells are the basic units of structure and function of life.
3. Cells can only come from pre-existing cells.

Cells: An Overview

****Everything living things is made up of at least one cell. Cells are the lowest level of structure of living things that can still perform all the activities (metabolism).****

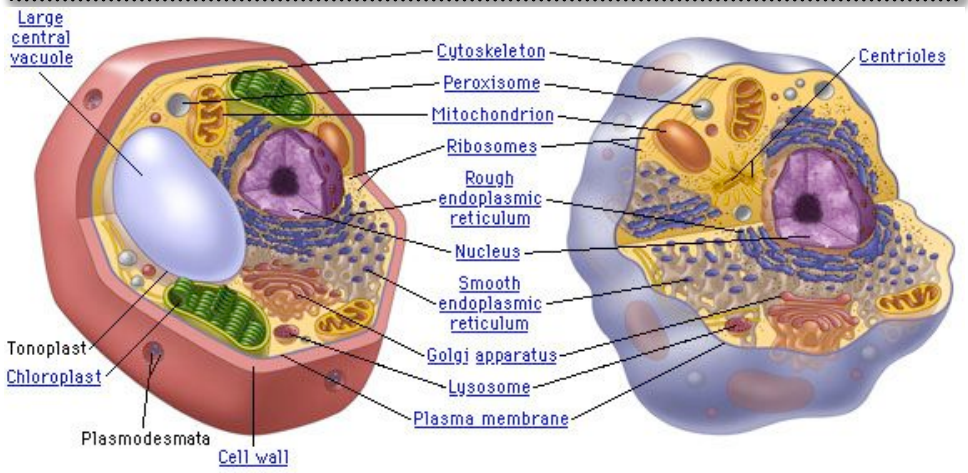
All living things are made up of only one of two type of cells: **PROKARYOTIC CELLS** or **EUKARYOTIC CELLS**.

- **Prokaryotes** are simple, small, and lack a nucleus. The only example of a prokaryote is **BACTERIA**.



- **Eukaryotes** are complex, large, and contain a nucleus and lots of organelles. All protists, fungji, plants and animals are made up of eukaryotic cells.

Cell of Eukaryotes

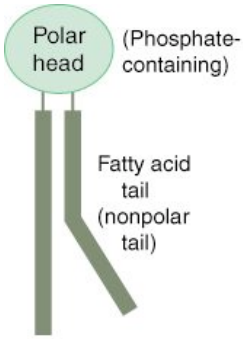


Plant Cell **Animal Cell**

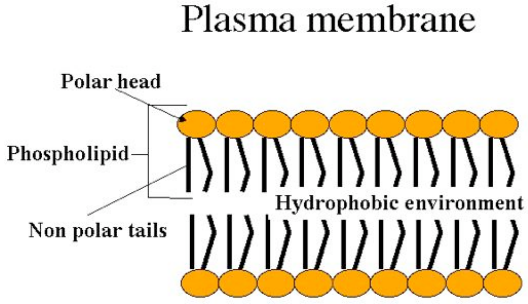
Cell Structures

****Eukaryotes** contain membrane-bound **ORGANELLES**. Each organelle performs a specific job in the cell to help maintain **metabolism** and **homeostasis.****

1. **NUCLEUS**: This is the control center of the cell. It contains the cell's DNA and controls the cell's metabolism and homeostasis.
2. **MITOCHONDRIA**: This is the power plant of the cell. The cell's energy supply (**ATP**) is made here via **CELLULAR RESPIRATION**.
3. **RIBOSOMES**: These are the sites of protein synthesis for the cell.
4. **GOLGI APPARATUS**: This is the post office of the cell. It packages and exports materials in and around the cell.
5. **ENDOPLASMIC RETICULUM**: There are two kinds: smooth and rough. Both help to move things around the cell. They work like a system of roads in the cell.
6. **LYSOSOMES**: These are the garbage cans of the cell. They break down waste.



7. **CHLOROPLAST:** This is found in plants and is the site of photosynthesis.
8. **CELL WALL**: This is a rigid layer found on the outside of plant cells. It gives plant cells their unique rectangular shape.
9. **CELL MEMBRANE**: This surrounds all cells. It maintains homeostasis by controlling what can enter and leave the cell.
   - It's composed of two layers of **PHOSPHOLIPIDS.**
   - The **PHOSPHOLIPID BILAYER** has a polar head and two non-polar tails. This allows things that are **<u>small</u>** and **<u>non-polar</u>** to cross the membrane without asking for permission.



- Food and raw materials for chemical reactions must be able to cross the membrane.
- Waste must be able to leave the membrane.

Transport

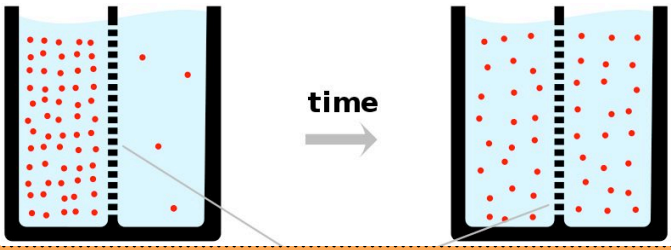
****Substances need to be able to travel into and out of cell across the cell membrane. This movement can either happen spontaneously (by itself) or with the input of energy (ATP)****

There are two types of transport: **PASSIVE** & **ACTIVE**

1. **PASSIVE TRANSPORT:** This moves substances across membranes from regions of high concentration to low concentration without energy.
2. **ACTIVE TRANSPORT:** This moves substances across membranes from regions of low concentration to high concentration with energy (ATP)
   - Examples: **Endocytosis** & **Exocytosis**

There are 3 types of **PASSIVE Transport:**

1. **DIFFUSION:** the movement of substances from a region of high concentration to low concentration.
2. **OSMOSIS:** the movement of water from a region of high concentration to low concentration.
3. **FACILITATED DIFFISION:** the movement of substances from high to low with the help of a transport protein.



Metabolism

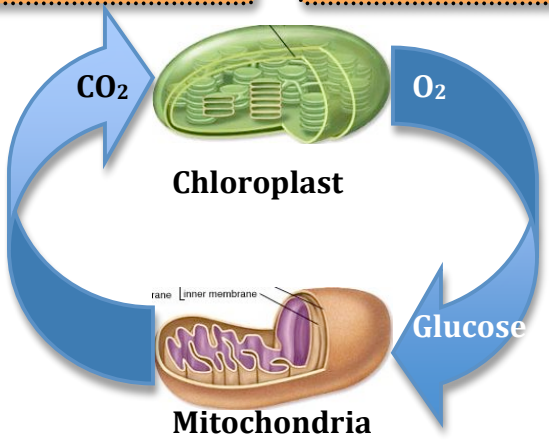
****CELLULAR RESPIRATION** and **PHOTOSYNTHESIS** are processes that allow cells to use and make energy to keep the cell alive. They have a cyclical relationship with one another. They depend on one another!****

Cellular Respiration

CELLULAR RESPIRATION is a process that turns sugar (**glucose $C_6H_{12}O_6$**) into usable energy for the cell (**ATP**).

HETEROTROPHS (organisms who cannot make their own food) use this process to release ATP from food in the **MITOCHONDRIA**.

- **INPUT (Reactants)**: Mitochondria take in **oxygen** and **glucose**
- **OUTPUTS (Products)**: Mitochondria release **carbon dioxide** and **ATP!!!!**



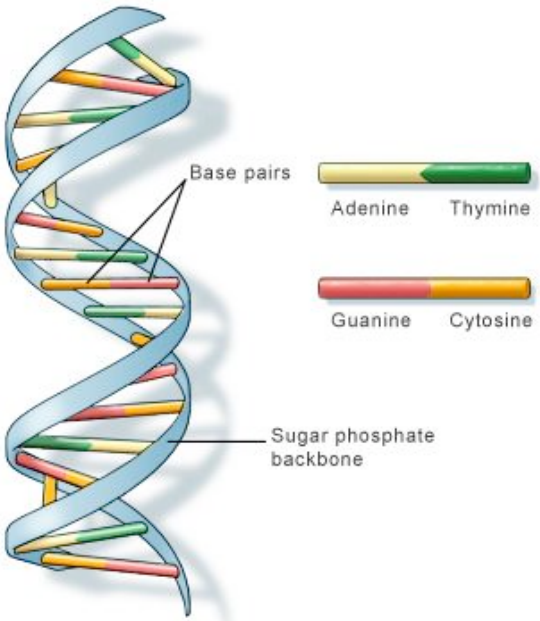
Photosynthesis

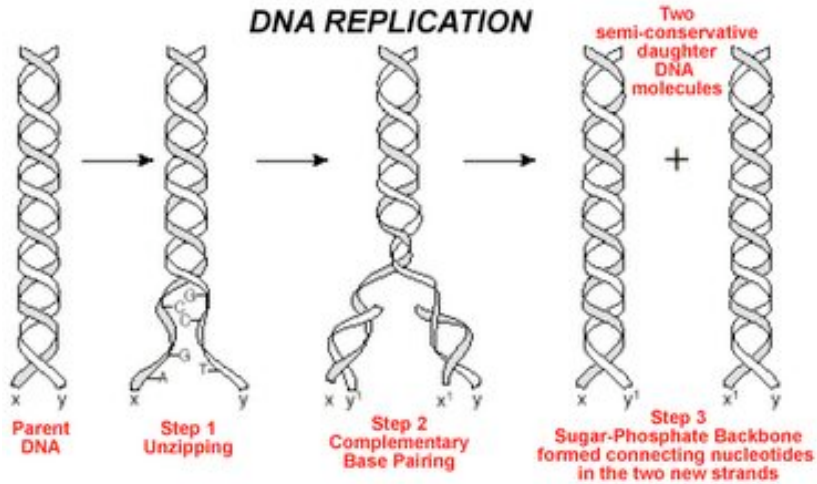
PHOTOSYNTHESIS is a process that turns light energy from the sun into food (**glucose**) for plants. Plants and organisms that make their own food are called **AUTOTROPHS**. Autotrophs perform photosynthesis in their **CHLOROPLASTS.**

- **INPUT (Reactants)**: Chloroplasts take in **carbon dioxide** and sunlight.
- **OUTPUTS (Products)**: Chloroplasts release **oxygen** and **glucose**.

DNA

****DNA** is a double-helix composed of 2 complementary strands. It has 4 nucleotides composed of either A, T,C,or G: A pairs with T, G pairs with C. This structure makes **DNA REPLICATION** and **PROTEIN SYNTHESIS** possible.!****





When DNA needs to divide, **DNA REPLICATION** begins. The weak **hydrogen bonds** that are holding the two strands of DNA together break apart and the DNA "unzips." The two original strands of DNA then become templates for new daughter strands of DNA that will form.

DNA (continued)

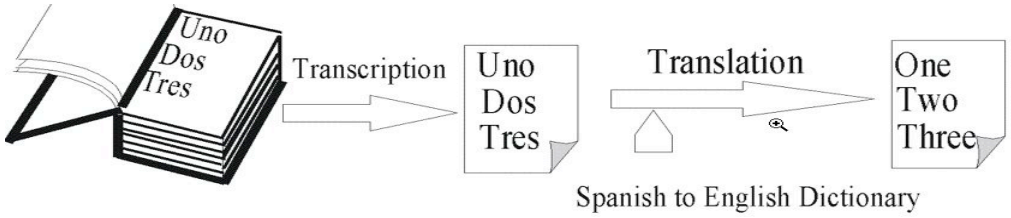
****The process of turning DNA into proteins follows a specific order. It starts in the nucleus and ends at the ribosome.****

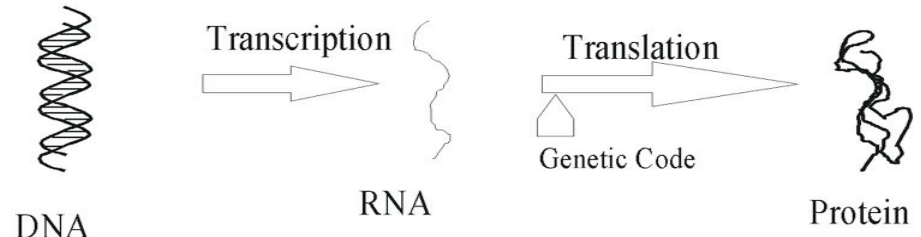
Frst, DNA is turned into **MESSENGER RNA (mRNA).** RNA is the skinny cousin of DNA which means it can leave the nucleus. RNA is single-stranded. It one strand looks almost identical to DNA with the exception of the nitrogen base **URACIL**. Uracil takes the place of thymine., so **U** pairs with **A**.

- Making RNA from DNA is called **TRANSCRIPTION**.

Next, the message transferred from DNA to mRNA makes it way to the ribosome (the site of protein synthesis).

- Making proteins from mRNA is called **TRANSLATION.**

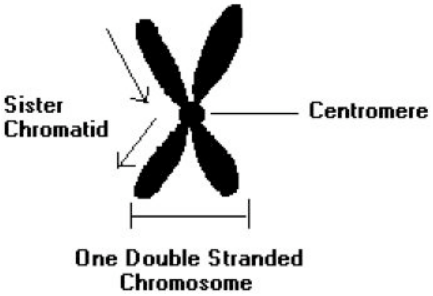


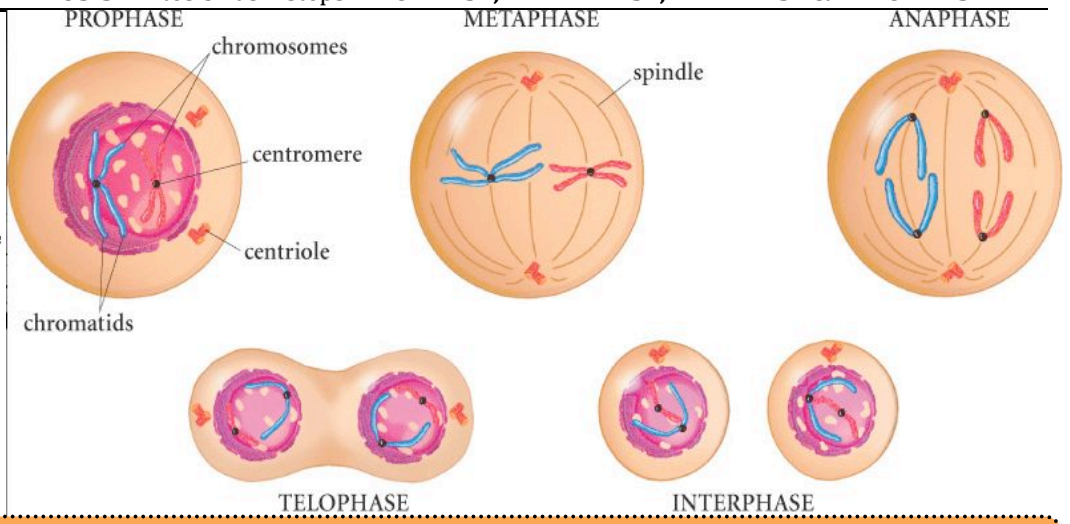


Cell Division

****DNA is the cell's genetic material. It must be copied before the cell can divide. To help with this, the DNA is packaging into structures called **CHROMOSOMES**. Humans have 46 chromosomes that must be copied exactly before the cell can divide. The process of cell division is called **MITOSIS**. Mitosis has 4 steps: **PROPHASE, METAPHASE, ANAPHASE & TELOPHASE.****

Chromosome Structure:





Genetics

****GENETICS** is the study of heredity. A **GENE** is a basic unit of heredity. An **ALLELE** is one of two or more alternative forms of a specific gene. Two alleles make up a gene. **GREGOR MENDEL** crossed peas to develop the genetic theory we still use.****

There are two types of alleles:

-**DOMINANT ALLELES:** The expressed trait. Represented by a capital letter.

-**RECESSIVE ALLELES:** The unexpressed trait. Represented by a lowercase letter.

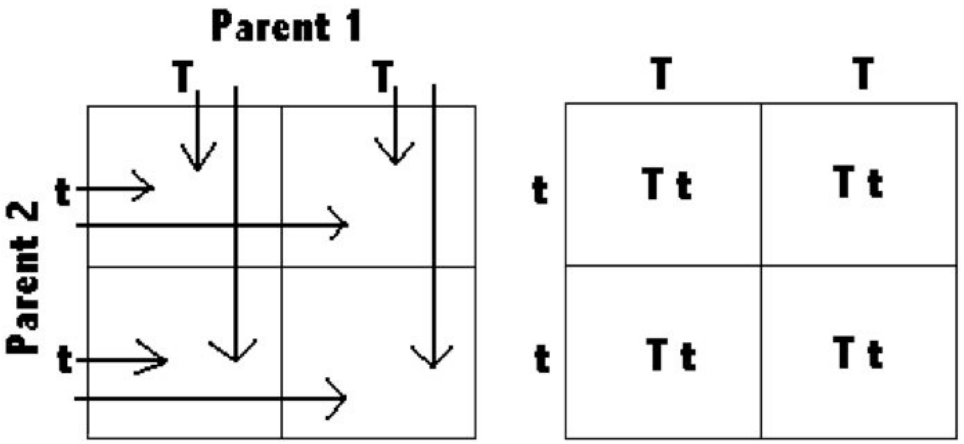
The two letters (representing two alleles) represent an organism's **GENOTYPE.** There are two types of genotypes:

-**HOMOZYGOUS**: two identical alleles (TT) or (tt)
-**HETEROZYGOUS**: two different alleles (Tt)

The expression of the genotype (physical appearance of the gene) is the **PHENOTYPE.**

We can use the parent genotypes to predict what offspring might look like. **Monohybrid crosses** can be completed by using a **PUNNET SQUARE.**

Example of a monohybrid cross: Consider a cross between a true breeding tall plant (TT) and a true breeding short plant (tt).



Classification

****All of life can be classified in one of 6 kingdoms. Each kingdom can be broken down into even smaller units for classification. The modern day classification system is based on a two-word naming system called **BINOMIAL NOMENCLATURE**. This naming system involves an organism's **GENUS** and **SPECIES.****

Taxonomic Ranking System:

- Kingdom — Kings
- Phylum — Play
- Class — Chess
- Order — On
- Family — Fridays
- Genus — Generally
- Species — Speaking

Remember...

⇒ Similar genera are united into a **family**
⇒ Similar families are combined into an **order**
⇒ Similar orders are collected into a **class**
⇒ Similar classes are united into a **phylum**
⇒ Similar phyla are collected into a **kingdom**

The 6 kingdoms of the life are:

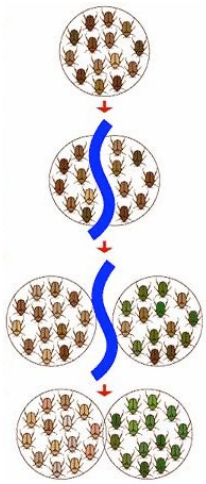
1. **Archaebacteria:** Prokaryotic organisms that are only found in extreme environments.
2. **Eubacteria:** Single-celled, prokaryotic organisms that can cause sickness (Example: streptococcus & salmonella)
3. **Protist:** Single-celled, eukaryotic organisms that can be either heterotrophic (protozoa) or autotrophic (algae).
4. **Fungi:** Multicellular eukaryotic organisms with cell walls composed of **chitin**. These organisms are external digesters (heterotrophic).
5. **Plant:** Multicellular eukaryotic autotrophs with cell walls composed of **cellulose**.
6. **Animal:** Multicellular eukaryic heterotrophs that do not have cell walls.

Evolution

****EVOLUTION** is the process by which species change over time. It's brought on by the process of **NATURAL SELECTION**. Natural selection allows for individuals with certain traits to successfully survive and reproduce, passing those traits to the next generation.****

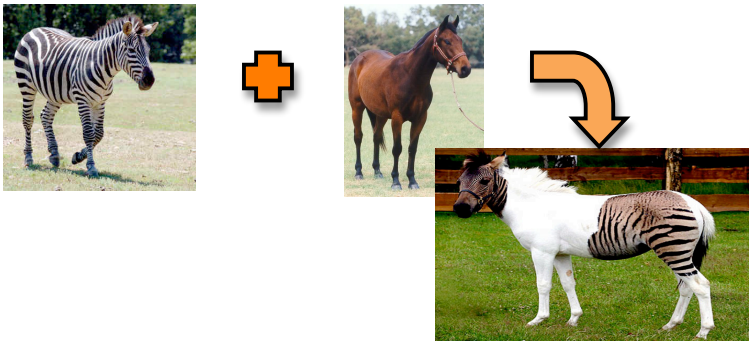
SPECIATION is the process by which new species arise.

- There are two mechanisms that can lead to new species:
  - **Geographic Isolation:** the physical separation of species populations by geographic barriers (Example: oceans and mountains)
  - **Reproductive Isolation:** Isolation **WITHOUT** the presence of a physical barrier. (Example: One group of individuals only mates in the fall, and another only reproduces in the spring.)



A **SPECIES** is a group of individuals that can interbreed and produce fertile offspring.

-The horse and zebra are both members of their own species. How do we know? When we force them to mate, their off-spring (a zebroid) is not fertile.



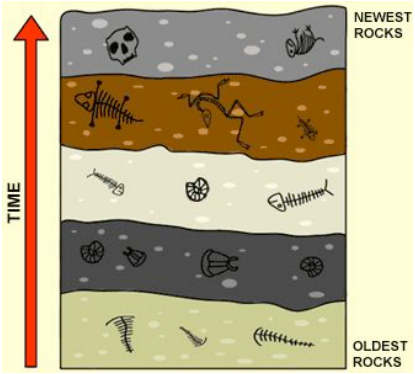
Evidence for Evolution

****Scientists have 3 areas of focus that provide evidence for evolution.****

1. Fossils

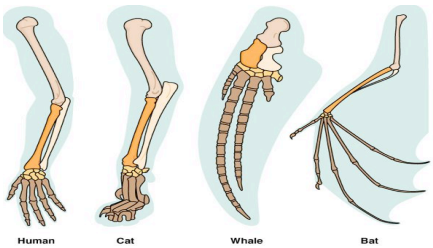
Scientists can use layers of undisturbed rock to determine the relative age of fossilized organisms. The **OLDEST** fossils will always be at the bottom of the column and the **YOUNGEST** at the top.

- This technique is called the **PRINCIPLE OF SUPERPOSITION.**



2. Anatomy

HOMOLOGOUS STRUCTURES: Structures that look **SIMILAR** to one another. These demonstrate descent from a **COMMON ANCESTOR** (**Divergent Evolution**)



ANALOGOUS STRUCTURES: Different structures that perform similar functions. The environment forces unrelated individuals to develop structures to perform similar function. **NO COMMON ANCESTOR! (Convergent Evolution)**

3. Biochemistry

Remember: Organisms that have more DNA in common are closely related! This means that organisms that have more proteins in common are also closely related.

Look at the amino acid chain of unknown animal:

Met-Gly-Ser-Tyr-Tyr-Arg-His-His-Glu-Lys

It most closely resembles?

Horse: Met-Gly-Ser-Ser-Tyr-Arg-Arg-Asp-His-Glu
Dog: Met-Gly-Ser-Tyr-Tyr-Arg-His-Asp-Glu-Lys
Cat: Met-Gly-Ser-Tyr-Tyr-Arg-His-His-Arg-Cys
Mouse: Met-Gly-Ser-Tyr-Tyr-Arg-His-Glu-Val-Val

Our unknown animal is most closely related to the **dog**! There's only 1 difference in the protein sequence.

Met-Gly-Ser-Tyr-Tyr-Arg-His-**Asp**-Glu-Lys