Evolution Defined…Change over Time

- Change in the gene pool of a population from generation to generation by such processes as mutation, natural selection, and genetic drift.
- This change in the properties of populations of organisms transcends the lifetime of a single individual.
- This change results in a process by which modern organisms have descended from ancient organisms.

Essential Questions…Initial Thoughts:

1. What is life and how do organisms change over time?

2. How does evolution lead to unity and diversity within living things?

3. How does life store, transmit, and respond to information?

You will be able to intelligently answer these essential questions by the end of this course☺

Biology Defined…Study of Living Things

Bio = life *-ology = study of*

Biologists have found over 1 million different kinds (species) of living things on earth. Even though there is a great diversity of life, there is also a great unity of life. All living things are alike in many ways. Each living thing is referred to as an **organism**. All organisms have the following characteristics:

- ❒ They are made up of one or more basic units called cells.
- ❒ They are based on a universal genetic code called DNA.
- ❒ They obtain and use materials to meet constant energy demands.
- ❒ They maintain a stable internal environment (homeostasis)
- ❒ They grow and develop.
- ❒ They reproduce.
- ❒ They can sense, respond and adapt to their environment.
- ❒ Groups of organisms evolve (change) over long periods of time.

Non-living objects may show one or a few of these characteristics, but they never show all of them.

Biology Defined…Study of Living Things

Bio = life *-ology = study of*

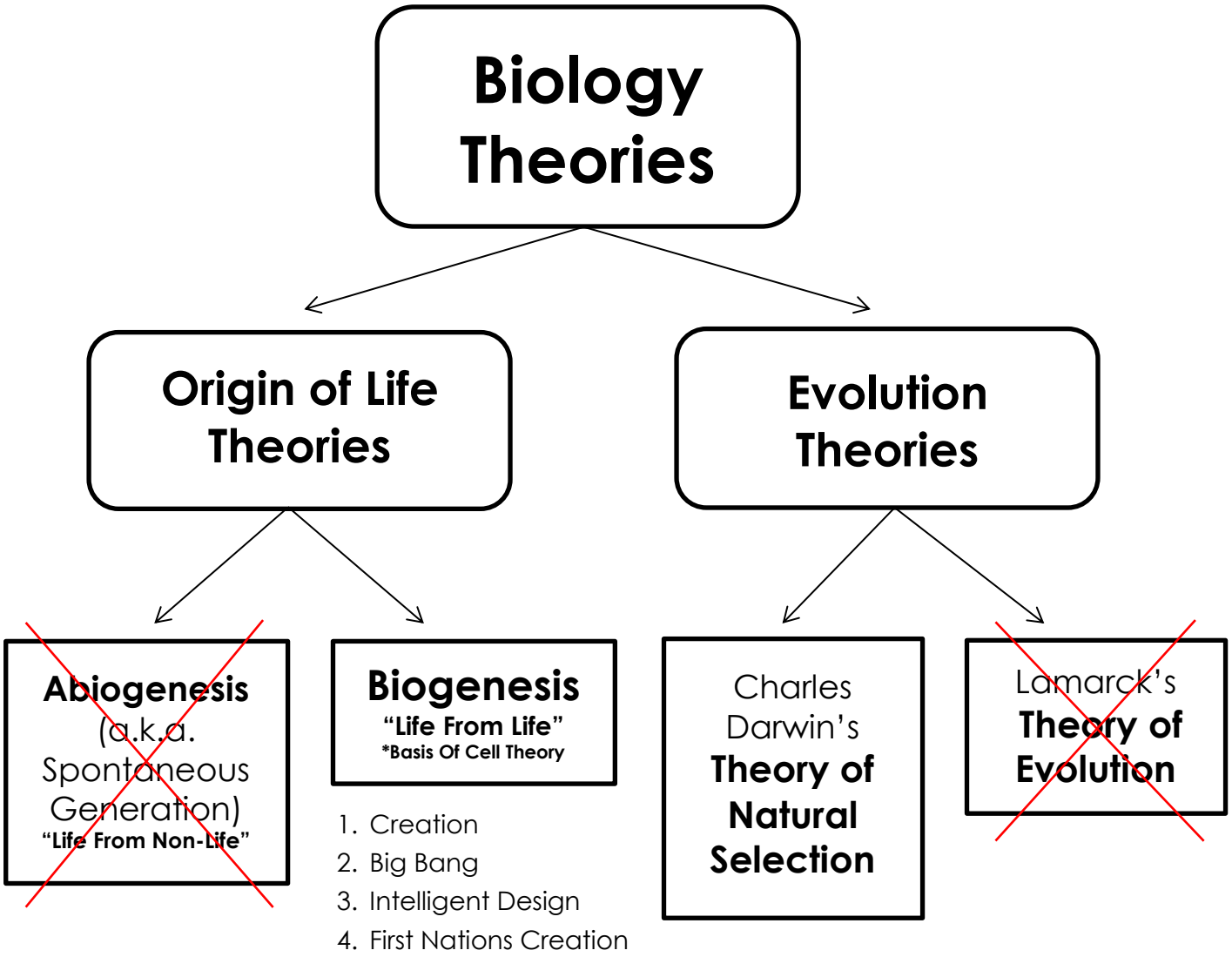
Biologists have found over 1 million different kinds (species) of living things on earth. Even though there is a great diversity of life, there is also a great unity of life. All living things are alike in many ways. Each living thing is referred to as an **organism**. All organisms have the following characteristics:

- ❒ _____
- ❒ _____
- ❒ _____
  _____
- ❒ _____
- ❒ _____
- ❒ _____
- ❒ _____
- ❒ _____
  _____

Non-living objects may show one or a few of these characteristics, but they never show all of them.

Fill in the following chart.

Specimen	Alive? Yes/No	Why or Why Not?
Soil		
Fish		
Rose		
Desk		
Salamander		
Fire		
Your Choice: _____		
Your Choice: _____		



Theory =

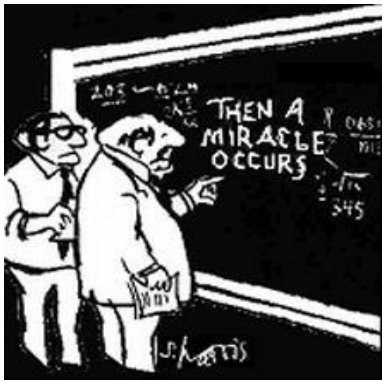
An understanding in our world which always has the possibility of being altered as new information becomes available

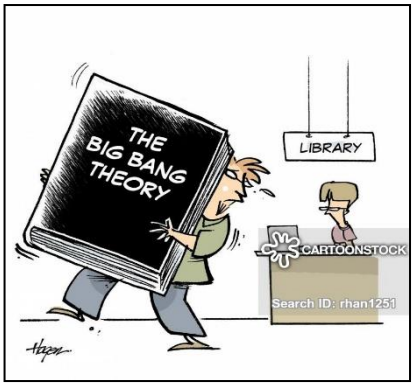
Evidence is collected to give support to the theory, but it can never be completely proven. The more evidence collected to support a theory, the more widely it will be accepted. All theories start out as a hypothesis. *Example:* Cell theory or Charles Darwin's theory of Natural Selection. Unlike a theory, a **scientific law** is a statement or part of a theory that has been undeniably proven to be true. *Example:* Law of Gravity or Newton's Laws of Motion.

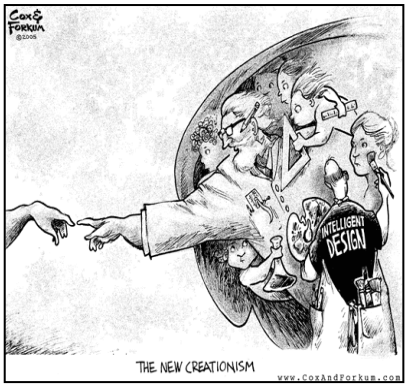
In order to develop a theory, scientists must gather evidence to support it by following the Cycle of Proof. This **Cycle of Proof** is usually carried out by following one of many scientific methods. A **scientific method** is a logical, orderly way to solve a problem or answer a question. The most commonly used scientific method in biology is the **Research Method**. If, after following a scientific method, the scientists find that the results discredit the hypothesis they modify or discard the hypothesis. If they find that it supports the hypothesis, the scientists add it to the pile of "proof" to strengthen the support for their theory. The records & conclusions then go into our ever-growing data base of scientific knowledge.

Origin of Life Theories Position Paper

Creation Theory or Big Bang Theory or Intelligent Design?







TASK ONE:

Research each of the most widely accepted origin of life theories - Creation, Big Bang, First Nations Creation & Intelligent Design. Be sure to record the following information for each of the theories completing the attached notes handout:

- Summary of the main ideas of the theory
- Who discovered, created or promoted the theory initially?
- How long has the theory been supported?
- What are the theory's Strengths? Weaknesses?

TASK TWO:

Choose which researched theory you believe is the most plausible explanation for the origin of life at this point in your life. Write a 1 page (typed, single spaced, 12 Times New Roman font) Position Paper which includes the following:

- Introduce the theory you believe is the most plausible explanation of where life originated
- Explain the main ideas of the theory
- Give the Cons of the theory while providing rebuttal explanations (Counter Arguments)
- Give the Pros of the theory (Your Argument)
- Provide supporting evidence for your position
  - *Factual* – information that is verifiable & agreed upon by almost everyone
  - *Statistical* - interpretation and examples of an accumulation of facts
  - *Informed Opinion* – opinion developed through research &/or expertise of claim
  - *Personal Testimony* – personal experience related by a knowledgeable party
- Provide a conclusion by restating your position/argument

Creation Theory

Summary of Main Points -

Strengths -

Weaknesses -

Who Discovered, Created or Promotes It -

How Long Has It Been Supported -

Big Bang Theory

Summary of Main Points -

Strengths -

Weaknesses -

Who Discovered, Created or Promotes It -

How Long Has It Been Supported -

Intelligent Design Theory

Summary of Main Points -

Strengths -

Weaknesses -

Who Discovered, Created or Promotes It -

How Long Has It Been Supported -

First Nations Creation Theory (Your Choice Of Nation)

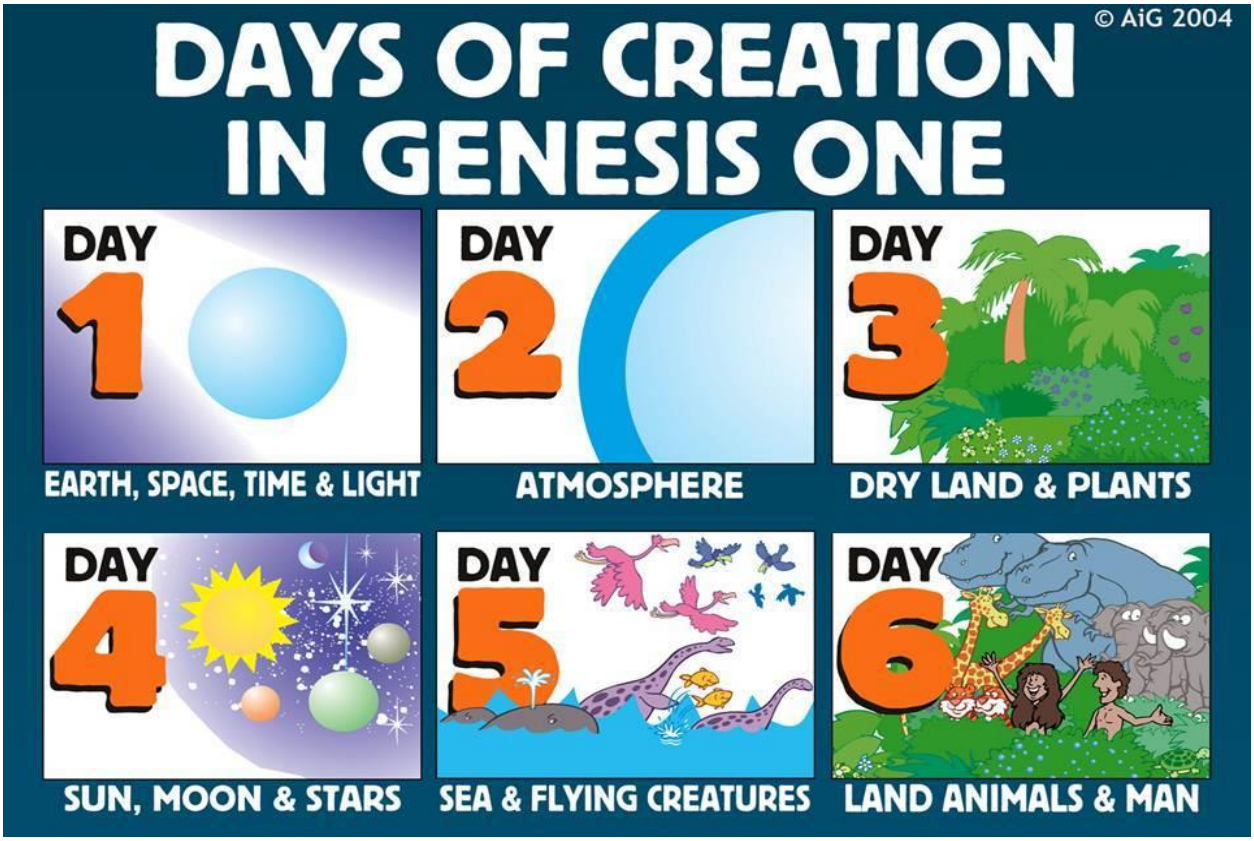
Summary of Main Points -

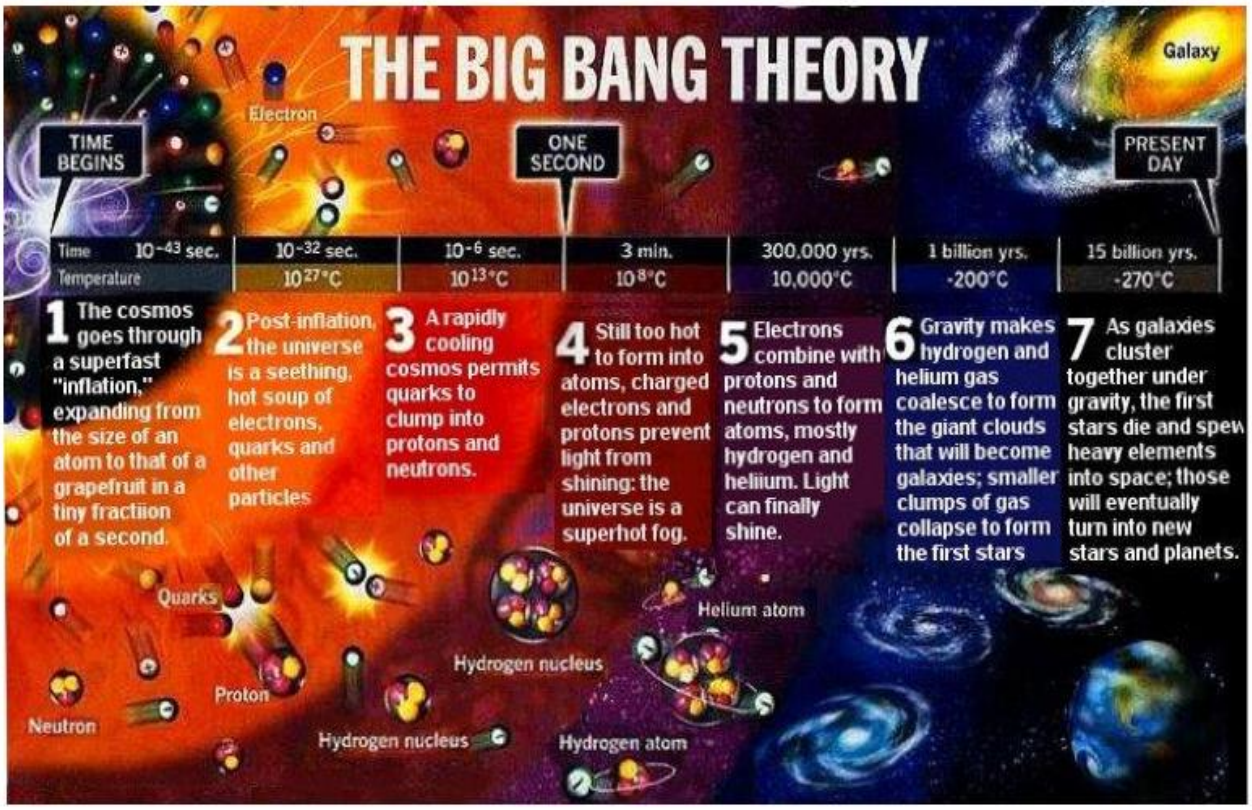
Strengths -

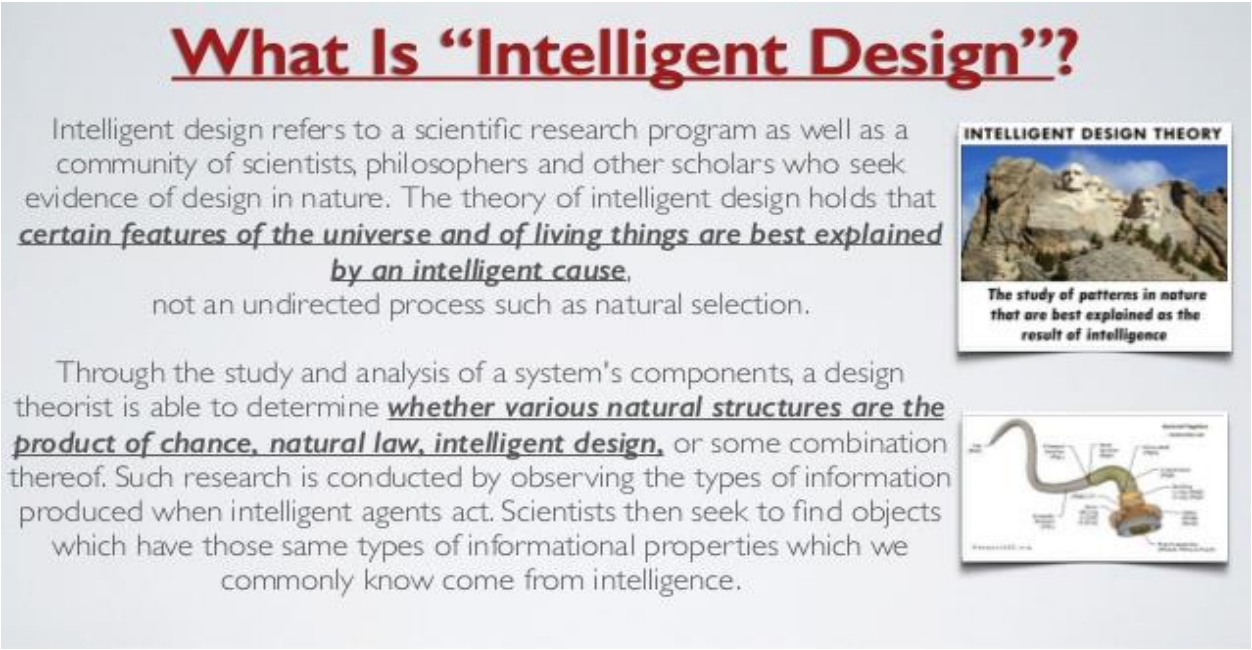
Weaknesses -

Who Discovered, Created or Promotes It -

How Long Has It Been Supported -


© AiG 2004
DAYS OF CREATION IN GENESIS ONE
DAY 1
EARTH, SPACE, TIME & LIGHT
DAY 2
ATMOSPHERE
DAY 3
DRY LAND & PLANTS
DAY 4
SUN, MOON & STARS
DAY 5
SEA & FLYING CREATURES
DAY 6
LAND ANIMALS & MAN


THE BIG BANG THEORY
Galaxy
Electron
TIME BEGINS
ONE SECOND
PRESENT DAY
Time 10-43 sec. | 10-32 sec. | 10-6 sec. | 3 min. | 300,000 yrs. | 1 billion yrs. | 15 billion yrs.
Temperature 1027°C | 1013°C | 108°C | 10,000°C | -200°C | -270°C
1 The cosmos goes through a superfast "inflation," expanding from the size of an atom to that of a grapefruit in a tiny fractiion of a second.
2 Post-inflation, the universe is a seething, hot soup of electrons, quarks and other particles
3 A rapidly cooling cosmos permits quarks to clump into protons and neutrons.
4 Still too hot to form into atoms, charged electrons and protons prevent light from shining: the universe is a superhot fog.
5 Electrons combine with protons and neutrons to form atoms, mostly hydrogen and heliium. Light can finally shine.
6 Gravity makes hydrogen and helium gas coalesce to form the giant clouds that will become galaxies; smaller clumps of gas collapse to form the first stars
7 As galaxies cluster together under gravity, the first stars die and spew heavy elements into space; those will eventually turn into new stars and planets.
Quarks
Proton
Neutron
Hydrogen nucleus
Hydrogen nucleus
Helium atom
Hydrogen atom



Oral Tradition: The Beginning of the Cree World

Several forms of this myth of creation and of the great flood have been recorded from different Algonquian tribes. The Crees were western members of the Algonquian family, which is the largest of the language groups of the North American Indians. This particular version has been selected because it was recorded by the great explorer-geographer, David Thompson, before missionaries had been among the people who related it.

Wisakedjak is the principal character in many Cree tales. His name means "the Flatterer." It is spelled also Weesack-kachack.

After the Creator had made all the animals and had made the first people, he said to Wisakedjak, "Take good of my people, and teach them how to live. Show them all the bad roots, all the roots that will hurt them and kill them. Do not let the people or the animals quarrel with each other." But Wisakedjak did not obey the Creator. He let the creatures do whatever they wished to do. Soon they were quarrelling and fighting and shedding much blood.

The Creator, greatly displeased, warned Wisakedjak. "If you do not keep the ground clean, I will take everything away from you, and you will be miserable."

But Wisakedjak did not believe the Creator, and did not obey. Becoming more and more careless and disobedient, he tricked the animals and the people and made them angry with each other. They quarreled and fought so much that the earth became red with blood. This time the creator became very angry. "I will take everything away from you and wash the ground clean," he said.

Still Wisakedjak did not believe the Creator. He did not believe until the rains came and the streams began to swell. Day after day, and night after night, the rains continued. The water in the rivers and the lakes rose higher and higher. At last they overflowed their banks and washed the ground clean. The sea came up on the land, and everything was drowned except one Otter, one Beaver and one Muskrat.

Wisakedjak tried to stop the sea, but it was too strong for him. He sat down on the water and wept. Otter, Beaver and Muskrat sat beside him and rested their heads on one of his thighs. In time the rain stopped and the sea left the land. Wisakedjak took courage, but he did not dare

to speak to the Creator. After long and sad thoughts about his misery, he said to himself, "If I could get a bit of the old earth beneath the water, I could make a little island for us to live on."

He did not have the power to create anything, but he did have the power to expand what had already been created. As he could not dive and did not know how far it was to the old earth, he did not know what to do. Taking pity on him, the Creator said, "I will give you the power to re-make everything if you will use the old materials buried under the water."

Still floating on the flood, Wisakedjak said to the three animals beside him, "We shall starve unless one of you can bring me a bit of the old ground beneath the water. If you will get it for me, I will make an island for us."

Then he turned to the Otter. "You are brave and strong and active. If you will dive into the water and bring me a bit of earth, I will see that you will have plenty of fish to eat." So the Otter dived, but he came up again without having reached the ground. A second time and a third time Wisakedjak praised Otter and persuaded him to go down once more. When he returned the third time, he was so weary that he could not dive again.

"You are a coward!" exclaimed Wisakedjak. "I am surprised by your weak heart. Beaver, I know, can dive to the bottom of the flood. He will put you to shame." Then he turned to Beaver. "You are brave and strong and wise. If you will dive into the water and bring me a bit of the old earth, I will make a good house for you on the new island I shall make. There you will be warm in the winter. Dive straight down as a brave Beaver does." Twice Beaver dived, and twice he came back without any earth. The second time he was so tired that Wisakedjak had to let him rest for a long time. "Dive once more," begged Wisakedjak when Beaver had recovered. "If you will bring me a bit of earth, I will make a wife for you." To obtain a wife Beaver went down a third time. He stayed so long that he came back almost lifeless, still with no earth in his paws.

Wisakedjak was now very sad. If Otter and Beaver could not reach the bottom of the water, surely Muskrat also would fail. But he must try. He was their only chance.

"You are brave and strong and quick, Muskrat, even if you are small. If you will dive into the water and bring me a bit of the old earth at the bottom, I will make plenty of roots for you to eat. I will create rushes, so that you can make a nice house with rushes and dirt.

"Otter and Beaver are fools," continued Wisakedjak. "They got lost. You will find the ground if you will dive straight down." So Muskrat jumped head first into the water, down and down he went, he brought back nothing. A second time he dived stayed a long time. When he returned Wisakedjak looked at his forepaws and sniffed.

"I smell the smell of earth," he said. "Go again. If you bring me even a small piece, I will make a wife for you, Muskrat. She will bear you a great many children. Have a strong heart now. Go straight down, as far as you can go."

This time Muskrat stayed down so long that Wisakedjak feared he had drowned. At last they saw some bubbles coming up through the water. Wisakedjak reached down his long arm, seized Muskrat, and pulled him up beside them. The little creature was almost dead, but against his breast his forepaws held a piece of the old earth. Joyously, Wisakedjak seized it, and in a short time he had expanded the bit of earth into an island. There he, Muskrat, Otter and Beaver rested and rejoiced that they had not drowned in the flood.

Some people say that Wisakedjak obtained a bit of wood, from which he made the trees; that he obtained some bones, from which he made the second race of animals. Others say that the Creator made all things again. He commanded the rivers to take the salt water back to the sea. Then he created mankind, the animals of today, and the trees. He took from Wisakedjak all power over people and animals and left him only the power to flatter and to deceive.

After that Wisakedjak played tricks upon the animals and let them into much mischief. That is why the Indians tell many stories about him, to amuse themselves during the long winter evenings.

Writing A Position Paper

A position paper presents an arguable opinion about an issue. The goal of a position paper is to convince the audience that your opinion is valid and worth listening to. Ideas that you are considering need to be carefully examined in choosing a topic, developing your argument, and organizing your paper. It is very important to ensure that you are addressing all sides of the issue and presenting it in a manner that is easy for your audience to understand. Your job is to take one side of the argument and persuade your audience that you have well-founded knowledge of the topic being presented. It is important to support your argument with evidence to ensure the validity of your claims, as well as to address the counterclaims to show that you are well informed about both sides.

Issue Criteria
Ask yourself the following questions to ensure that you will be able to present a strong argument:

- Is it a real issue, with genuine controversy and uncertainty?
- Can you distinctly identify two positions?
- Are you personally interested in advocating one of these positions?
- Is the issue narrow enough to be manageable?

Analyzing an Issue and Developing an Argument
Once your topic is selected, do some research on the subject matter. While you may already have an opinion on your topic and an idea about which side of the argument you want to take, you need to ensure that your position is well supported. Listing out the pro and con sides of the topic will help you examine your ability to support your counterclaims, along with a list of supporting evidence for both sides. Supporting evidence includes the following:

- Factual Knowledge - Information that is verifiable and agreed upon by almost everyone.
- Statistical Inferences - Interpretation and examples of an accumulation of facts.
- Informed Opinion - Opinion developed through research and/or expertise of the claim.
- Personal Testimony - Personal experience related by a knowledgeable party.

Once you have made your pro and con lists, compare the information side by side. Considering your audience, as well as your own viewpoint, choose the position you will take. In considering the audience, ask yourself the following questions:

- Who is your audience?
- What do they believe?
- Where do they stand on the issue?
- How are their interests involved?
- What evidence is likely to be effective with them?

In determining your viewpoint, ask yourself the following:

- Is your topic interesting?
- Can you manage the material within the specifications set by the instructor?
- Does your topic assert something specific and propose a plan of action?
- Do you have enough material to support your opinion?

Miss Foley

Bio 30: LE1Life Defined **Position Paper**

Organization

Your introduction should lead up to a thesis that organizes the rest of your paper. There are three advantages to leading with the thesis:

1. The audience knows where you stand.
2. The thesis is located in the two strongest places, first and last.
3. It is the most common form of academic argument used.

Below is a generic sample outline for a position paper:

I. Introduction

___ A. Introduce the topic
___ B. Provide background on the topic
___ C. Assert the thesis (your view of the issue)

II. Counter Argument

___ A. Summarize the counterclaims
___ B. Provide supporting information for counterclaims
___ C. Refute the counterclaims
___ D. Give evidence for argument

III. Your Argument

___ A. Assert point #1 of your claims - Give your opinion and provide support
___ B. Assert point #2 of your claims – Give your opinion and provide support
___ C. Assert point #3 of your claims – Give your opinion and provide support

IV. Conclusion

___ A. Restate your argument
___ B. Provide a plan of action

Origin of Life Position Paper Evaluation

☐ Introduced the theory they believe is the most plausible explanation of where life originated (1 mark)

☐ Explained the main ideas of the theory (2marks)

☐ Gave the Cons of the theory while providing rebuttal explanations (Counter Arguments) (2marks)

☐ Gave the Pros of the theory (Their Argument) (2marks)

☐ Provided supporting evidence for their position (2marks)

Factual – information that is verifiable & agreed upon by almost everyone

Statistical - interpretation and examples of an accumulation of facts

Informed Opinion – opinion developed through research and/or expertise

Personal Testimony – personal experience related by a knowledgeable party

☐ Provided a conclusion by restating their position or argument (1 mark)

_____ /10 =

Name: _____ Bio 30

Origin of Life Position Paper Evaluation

- ☐ Introduced the theory they believe is the most plausible explanation of where life originated (1 mark)
- ☐ Explained the main ideas of the theory (2marks)
- ☐ Gave the Cons of the theory while providing rebuttal explanations (Counter Arguments) (2marks)
- ☐ Gave the Pros of the theory (Their Argument) (2marks)
- ☐ Provided supporting evidence for their position (2marks)

  Factual – information that is verifiable & agreed upon by almost everyone

  Statistical - interpretation and examples of an accumulation of facts

  Informed Opinion – opinion developed through research and/or expertise

  Personal Testimony – personal experience related by a knowledgeable party
- ☐ Provided a conclusion by restating their position or argument (1 mark)

_____ /10 =

Name: _____ Bio 30

Origin of Life Position Paper Evaluation

- ☐ Introduced the theory they believe is the most plausible explanation of where life originated (1 mark)
- ☐ Explained the main ideas of the theory (2marks)
- ☐ Gave the Cons of the theory while providing rebuttal explanations (Counter Arguments) (2marks)
- ☐ Gave the Pros of the theory (Their Argument) (2marks)
- ☐ Provided supporting evidence for their position (2marks)

  Factual – information that is verifiable & agreed upon by almost everyone

  Statistical - interpretation and examples of an accumulation of facts

  Informed Opinion – opinion developed through research and/or expertise

  Personal Testimony – personal experience related by a knowledgeable party
- ☐ Provided a conclusion by restating their position or argument (1 mark)

_____ /10 =

Miss Foley

Bio 30: LE1Life Defined **Scientist Contributions**

1. Research one of the following scientists and their contribution to our overall understanding of life from a biological perspective:
   - Francesco Redi (1626-1697)
   - Louis Pasteur (1822-1895)
   - Harold Urey (1893-1981)
   - Stanley Miller (1930-2007)
   - Lynn Margulis (1938-2011)
   - Your Choice
2. Be prepared to possibly orally/visually share your findings with the class and hand in your research notes.

Research and Presentation Notes:

Scientist Contributions

Francesco Redi (1626-1697)

Louis Pasteur (1822-1895)

Harold Urey (1893-1981)

Stanley Miller (1930-2007)

Lynn Margulis (1938-2011)

Miss Foley

Bio 30: LE1Life Defined **KEY** Scientist Contributions

Francesco Redi (1626-1697)

- **Meat & maggot experiment provides evidence to start questioning spontaneous generation.**
- **Goes against current societal belief of abiogenesis or spontaneous generation – life from non-living.**

Louis Pasteur (1822-1895)

- **Disproves spontaneous generation with pasteurization experiment - killing disease causing pathogens in broth with heat, sealing jars and proving that pathogens had to have come from the air and not the broth.**

Harold Urey (1893-1981)

- **Discovered Deuterium element**
- **Studied earth's atmosphere while founding planet science**
- **Deducted that early Earth's atmosphere was mainly hydrogen, ammonia, methane and water which would all react to electricity.**

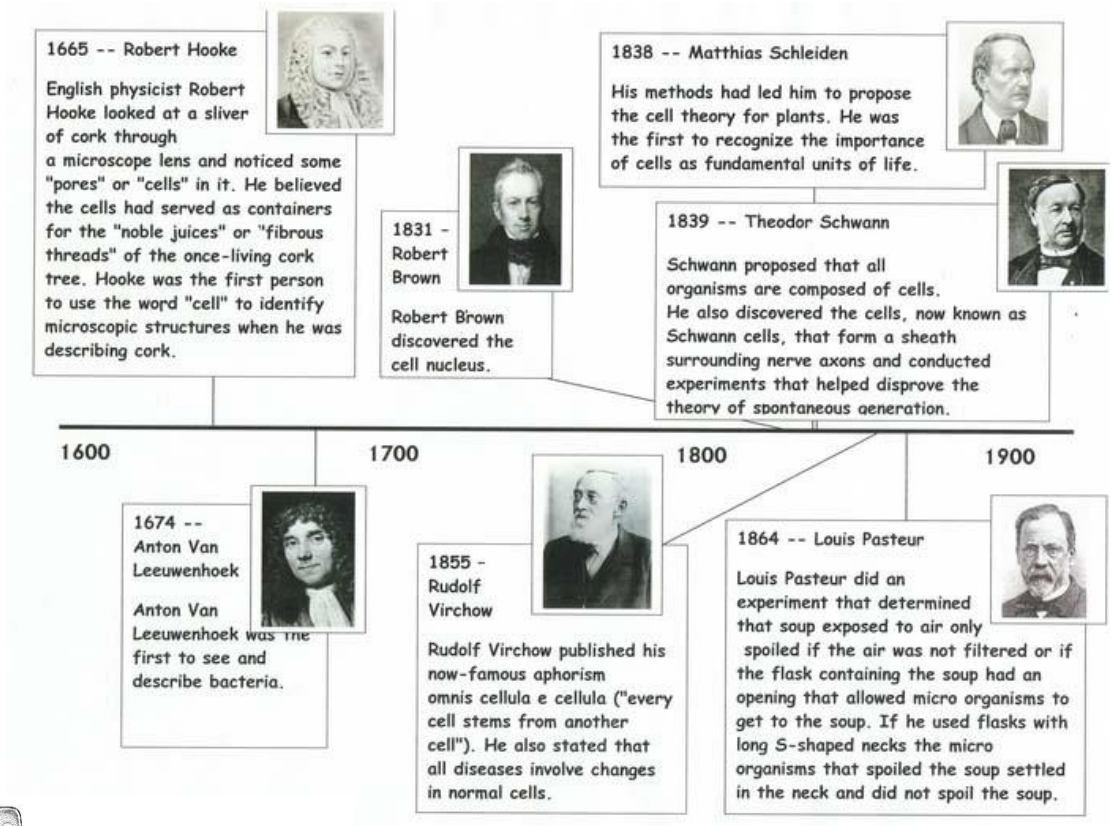
Stanley Miller (1930-2007)

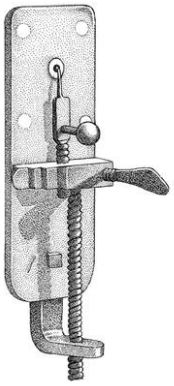
- **Was a graduate student of Harold Urey.**
- **Tested abiogenesis which has been refuted.**
- **Showed compounds could form amino acids (building blocks of life) when zapped with electricity – known as the chemical evolution thesis – 20+ amino acids identified by other scientists still present after his death.**

Lynn Margulis (1938-2011)

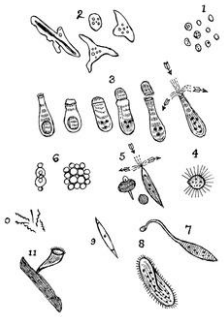
- **Proposed the Endosymbiotic Theory of eukaryote cell development which challenged ideas of how life arose on Earth.**
- **Went against Darwinism and the Theory of Natural Selection.**
- **Focused on symbiosis as origin of cells – eukaryote cells evolved from a symbiotic merging of bacteria – organelles being descendants of once free-living bacteria species.**

Development Of The Cell Theory





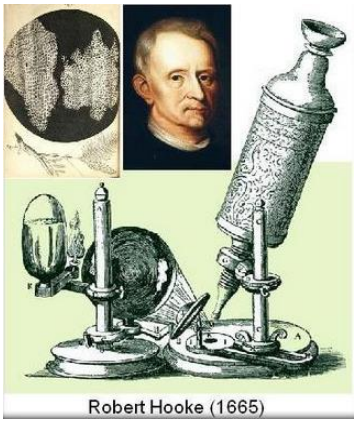
LEEUWENHOEK'S MICROSCOPE



LEEUWENHOEK'S ANIMALCULES

Much of the scientific process that occurred in the 16th century depended on the development of glass lenses. By 1650, the art of grinding and policing pieces of glass into lenses had so developed that it became possible to build good miscroscopes. **Anton van Leeuwenhoek** (1632-1723), a Dutch civil servant, was a master lens maker. Leeuwenhoek placed his lenses into simple microscopes. Using these microscopes, he discovered an amazing, invisible world of "cavorting beasties" known today as protists and bacteria. For 50 years, he described and made careful drawings of baccteria, detailed structures in small insects, and even sperm cells from humans, dogs, frogs and insects.

In the late 1600's, an Englishman named **Robert Hooke** made conpound microscopes and used them to examine small objects. When Hooke examined the cork layer of bark from an oak tree, he observed rows of compartments. The compartments reminded him of the small cells in which monks lived in medieval monasteries. For that reason, he called the compartments **cells**.



Robert Hooke (1665)

Scientists gradually began to realize that cells are the fundamental units of living organisms. Two German biologists, **Matthias Schleiden** (botanist) and **Theodor Schwann** (zooligist) proposed the cell theory in 1838.

M.J. Schleiden

Theodor Schwann

According to the cell theory, all organisms consist of cells and cell products, and one can understand how living creatures are built and how they function if cells can be understood. Until the development of the cell theory, the emphasis had been on the cell walls. Schwann had been unable to find the box-like cells seen in plants while looking at animal cells. Schwann interpreted his observations in a new way, emphasizing what was *inside* the box rather than the box itself. Further studies showed that certain structures are common to plant and animal cells as well as those of microorganisms. Once the contents of cells began to be studied, ideas about the origins of organisms began to change.

For hundreds of years, people thought that organisms could come from non-living matter - an idea known as **abiogenesis** or **spontaneous generation** - life coming from non-living. Several different studies started to disprove the idea, including **Fransesco Redi's** meat and maggot experiment in 1668.

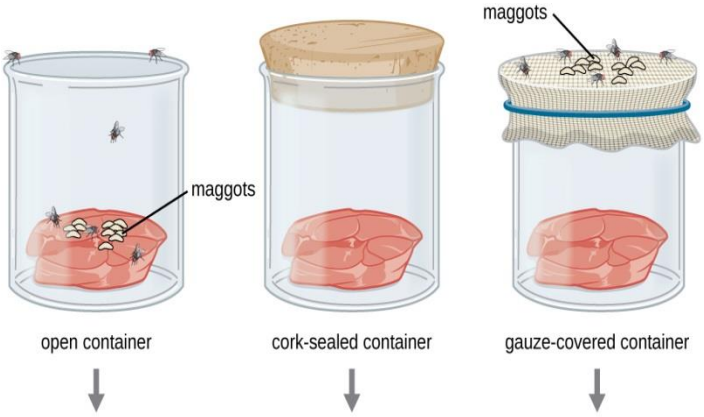
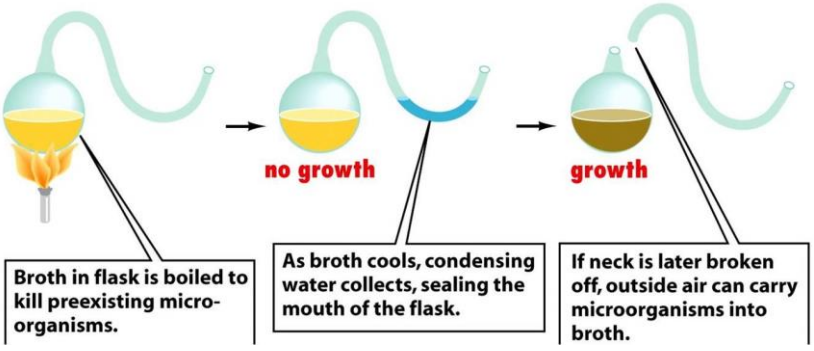


Figure 1: Francesco Redi's Experiment

In 1855, **Rudolph Virchow**, a physician and biologist, proposed that all cells produce more cells through time, but his idea was not accepted by everyone. An idea known as **biogenesis** - life coming from life.

In 1864, **Louis Pasteur**, a French scientist working with yeast cells, demonstrated that microorganisms cannot arise from completely non-living matter, finally disproving abiogenesis or spontaneous generation. This process of pateurization is still used today to kill pathogenic (disease-causing) microorganisms making food safer to eat.



By the 1880s, the work of French and German scientists showed how cells divide and produce more cells. Organisms, therefore, come from existing organisms and their cells arise from existing cells.

Today, the cell theory is summarized in two main ideas:

1. **Cells are the units of structure and function of all living organisms.**
2. **All new cells come from pre-existing cells.**

Miss Foley

Bio30: OL1 Cells Intro **Cells Parts & Function**

Cell – basic structural & functional unit of life

Prokaryote Cell (Pro carry oat)	**Eukaryote Cell** (You carry oat)
Only Example: Bacteria	Examples: Fungi, Protista, Plants, Animals
• Has DNA strands for genetic information therefore ***lacks*** a nucleus and other membrane-enclosed organelles. • Simplest & smallest cell	• Has membrane-enclosed organelles therefore has a nucleus for genetic information. • Most complex & larger cell

Cell Theory:

1. **Cells are units of structure & function of all living things.**
2. **All cells come from pre-existing cells.**

Organelle – a tiny organ with a specific job/function within a cell surrounded by a membrane.

DNA – Deoxyribonucleic Acid; contains genetic information for cells…the "blueprint for life".

Prokaryotic vs Eukaryotic Cells

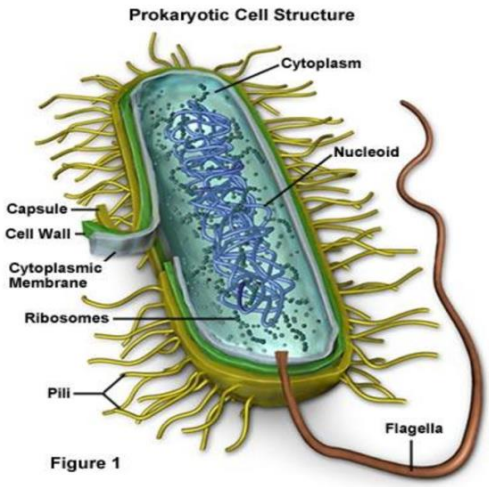
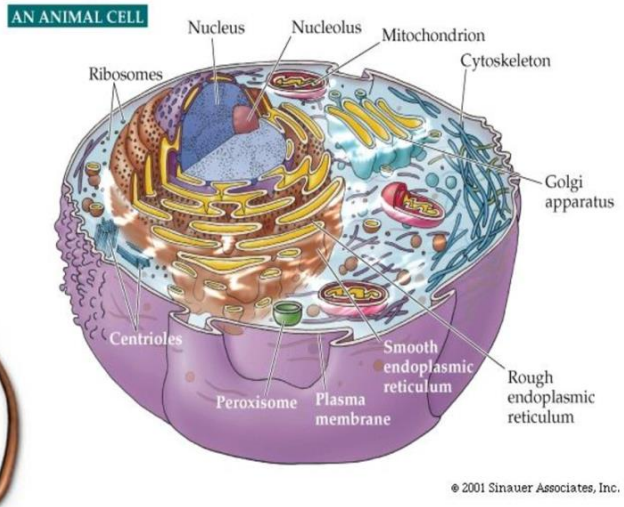


Figure 1



Cell Parts & Function

Sketch	Cell Part	Function
	Vacuole	
	Chloroplast	
	Centrioles	
	Cytoplasm	
	Golgi Apparatus	
	Lysosome	
	Cytoskeleton	
	Endoplasmic Reticulum	
	Nucleus	
	Mitochondria	
	Plasma Membrane	
	Ribosomes	
	Cell Wall	

Prokaryote Only – DNA in Strand Form, Capsule
Animal Only – Lysosomes, Centrioles, Vacuole (movement)
Plant Only – Chloroplast, Cell Wall, Vacuole (storage)

Cell Parts & Function

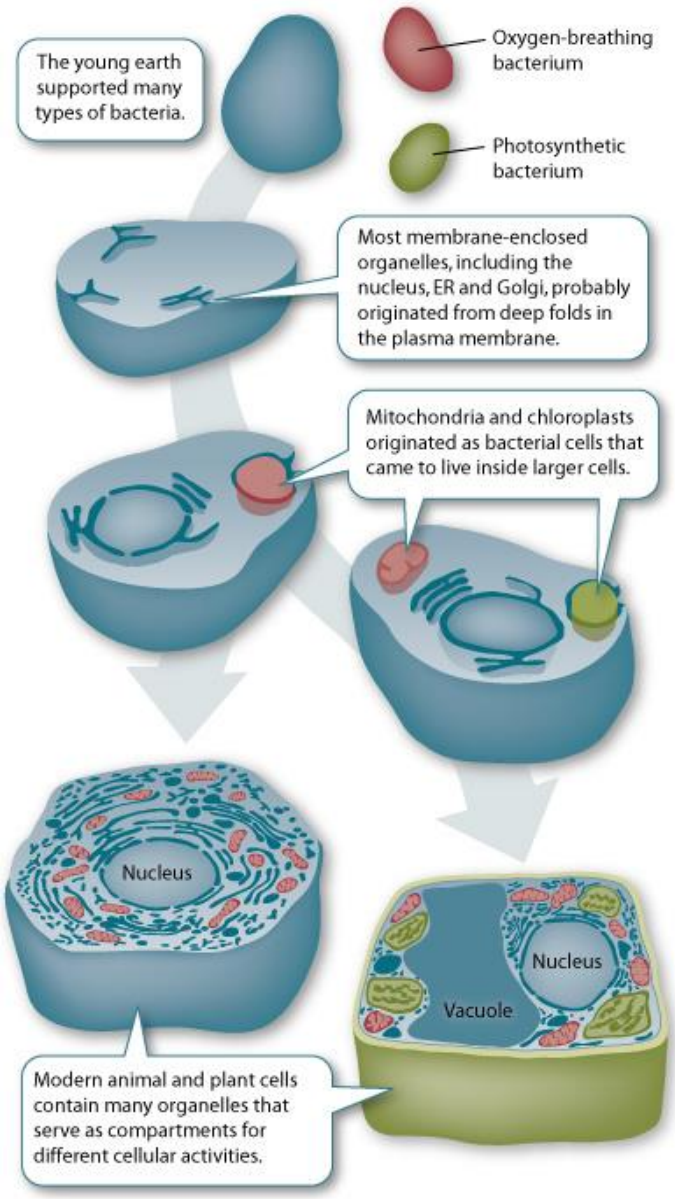
Sketch	Cell Part	Function
	Vacuole	Stores nutrients and waste products.
	Chloroplast	Site where photosynthesis happens.
	Centrioles	Duplicate prior to mitosis and produce the spindle apparatus during cell division.
	Cytoplasm	Semi-fluid material surrounding organelles.
	Golgi Apparatus	Sorts, modifies & packages vesicles for delivery to other organelles.
	Lysosome	Site of digestion within the cell.
	Cytoskeleton	Network of hollow tubes that provides shape & internal organization.
	Endoplasmic Reticulum	Compartmentalizes the cytosol/cytoplasm. There are 2 types; one with ribosomes & one without.
	Nucleus	The control center of the cell containing DNA (genetic information).
	Mitochondria	Site where cellular respiration happens.
	Plasma Membrane	The semi-fluid boundary that controls what passes in and out of the cell.
	Ribosomes	Site where proteins are made.
	Cell Wall	Provides rigidity to plant cells allowing turgor pressure to develop.

Prokaryote Only – DNA in Strand Form, Capsule
Animal Only – Lysosomes, Centrioles, Vacuole (movement)
Plant Only – Chloroplast, Cell Wall, Vacuole (storage)

Endosymbiosis = different organisms live together one inside the other

Endosymbiotic Theory

There is compelling evidence that mitochondria and chloroplasts were once primitive bacterial cells. This evidence is described in the **endosymbiotic theory**. How did this theory get its name? Symbiosis occurs when two different species benefit from living and working together. When one organism actually lives inside the other it's called **endosymbiosis.** The endosymbiotic theory describes how a large host cell and ingested bacteria could easily become dependent on one another for survival, resulting in a permanent relationship. Over millions of years of evolution, mitochondria and chloroplasts have become more specialized and today they cannot live outside the cell. **This theory** was **advanced and substantiated** with microbiological evidence in 1967 by **Lynn Margulis**.



A **theory** is a well-established explanation based on extensive experimentation and observation. Scientific theories are developed and verified by the scientific community and are generally accepted as fact.

Mitochondria and **chloroplasts** have striking similarities to bacteria cells. **They have their own DNA, which is separate from the DNA found in the nucleus of the cell.** And both organelles use their DNA to produce many proteins and enzymes required for their function. A double membrane surrounds both mitochondria and chloroplasts, further evidence that each was ingested by a primitive host. The two organelles also reproduce like bacteria, replicating their own DNA and directing their own division.

Cell Structure & Function Questions

1. Where did the term "cells" come from?
2. State the cell theory.
3. Define eukaryote.
4. Define prokaryote.
5. Contrast two (2) main types of cells.
6. List two (2) types of eukaryote cells.
7. Be able to draw, label & list the function of each of the cell parts.

Vacuole	Chloroplast	Centrioles
Cytoplasm	Golgi Apparatus	Lysosome
Cytoskeleton	Endoplasmic Reticulum	Capsule
Nucleus	Mitochondria	Cell Wall
Ribosomes	DNA Strands	Plasma Membrane

8. What functions do cell walls serve?
9. Describe how plant, algae, fungal and bacterial walls differ.
10. Describe how Diagram & label the plasma membrane.
11. Define selectively/differentially permeable.

12. Define concentration gradient.
13. Define equilibrium.
14. Contrast two (2) types of transport over plasma/cell membranes.
15. Which type of transport requires energy?
16. Explain what happens when cells are placed in an isotonic solution and why.
17. Explain what happens when cells are placed in a hypotonic solution and why.
18. Explain what happens when cells are placed in a hypertonic solution and why.
19. Explain how osmosis creates turgor pressure.
20. Define endocytosis.
21. List and define two (2) types of endocytosis.
22. Define exocytosis.

Cell Walls Compared: Structure & Composition

The cell wall is a rigid layer that surrounds some types of cells. It is located outside the cell membrane whose main function is to provide rigidity, strength, protection against mechanical stress and infection. It also provides the cell with limited plasticity that prevents the cell from rupturing due to the turgor. A cell wall is a **characteristic feature to cells of plants, bacteria, fungi, many algae and some archaeabacteria**. Protozoans and animals do not have a cell wall.

Functions of Cell Walls:

1. Gives the cell a definite shape and provides structural support.
2. Protects against infection and mechanical stress while providing protection from insects and pathogens.
3. Separates interior of the cell from the outer environment while enabling transport of substances and information across plasma/cell membranes.
4. Also helps in osmotic-regulation preventing water loss.
5. The physiological and biochemical activity of the cell wall helps in cell-cell communication.
6. It prevents the cell from rupturing due to tugor pressure.
7. Aids in diffusion of gases in and out of the cell.

Plant Cell Walls

Plant cell walls have a primary membrane, and may have a secondary membrane as well. The primary membrane is made mostly of polysaccharides cellulose, pectin and hemicellulose. It is flexible, which allows the plant to grow properly, yet at the same time it is sturdy enough to establish **turgor pressure**, which is necessary to support the plant's stability (i.e. water inside the cell presses up against the cell wall). The secondary membrane, if present, contains lignins, which are complex natural polymers, and one of the main classes of structural materials in the support tissues of vascular plants (as well as some algae). Lignins play an important role in making the cells waterproof and supporting xylem.

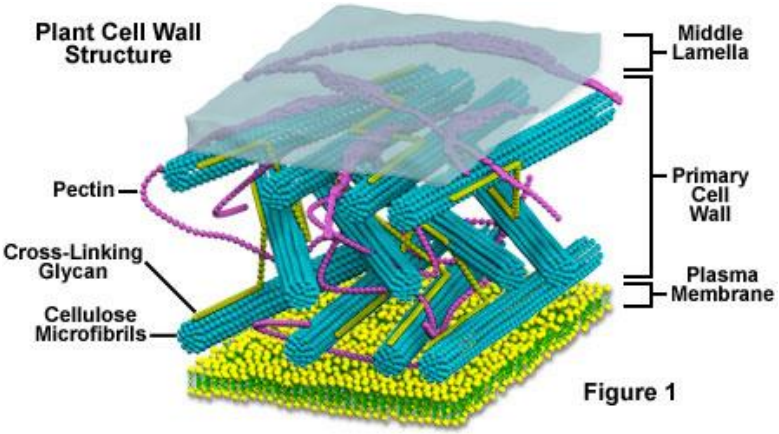
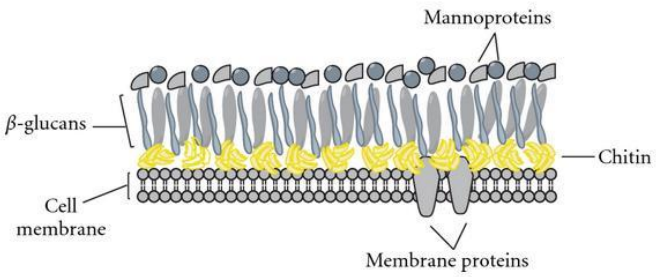


Figure 1

Algae Cell Walls

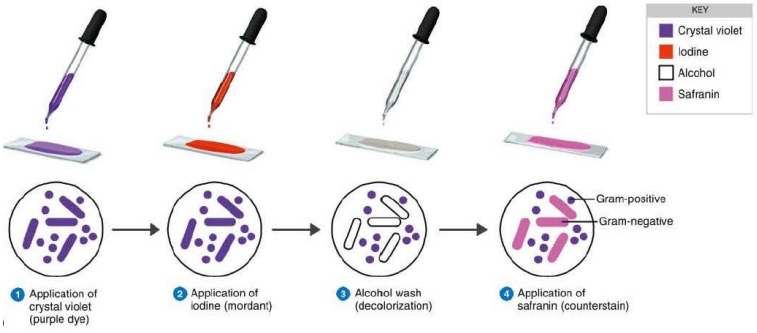
Algal cell walls are made primarily of polysaccharides. They can also contain cellulose, mannan or xylan. In addition, some algal cell walls -- such as those of brown algae -- contain alginic acid that is capable of absorbing water, and form a kind of gum that is used by researchers in the cosmetics and food industry.

Fungal Cell Walls

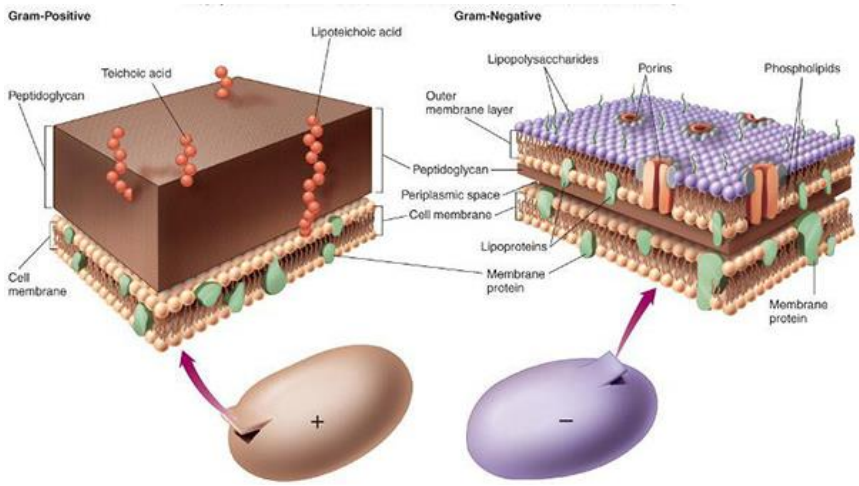


Fungal cells walls are made of the polysaccharide chitin, which is somewhat similar to cellulose, but contains acetyl-amine (nitrogen) groups rather than hydroxyl-groups. True fungi cells walls also contain glucans (glucose polymers) and proteins, which support cell wall synthesis and lysis.

Bacteria Cell Walls



Bacteria cells walls are comprised mainly of peptidoglycan, which is a polymer of amino acids and sugars. The result is a structure that looks something like a chain link fence, which is strong enough to support the cell, yet porous enough to allow particle movement. There are two types of bacteria cell walls: Gram-positive and Gram-negative. Gram staining is used to distinguish between them.

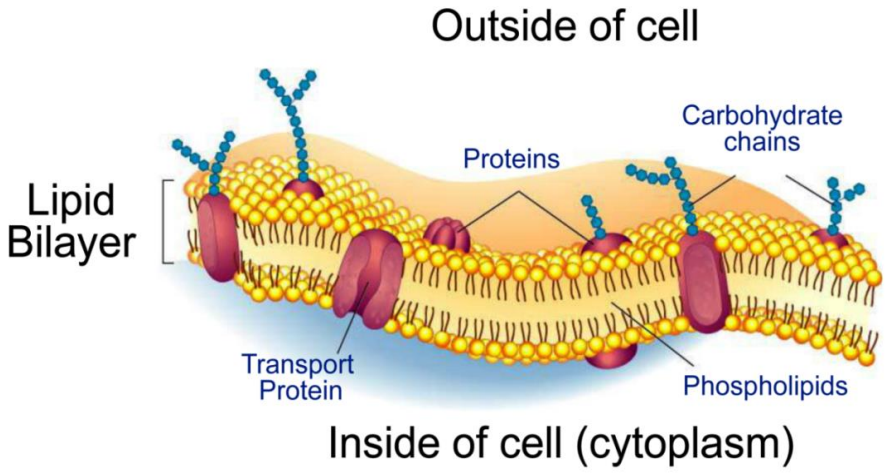


Fluid-Mosaic Model =

Describes membranes as a fluid combination of phospholipids, cholesterol, & proteins

The plasma membrane that surrounds cells has a **bilayer** (two layers) of **phospholipids** (a.k.a. fats with phosphorous attached). These bilayers at body temperature are like vegetable oil (fluid). And the structure of the plasma membrane supports the old saying, "Oil and water don't mix." Plasma membranes are both **differentially permeable** (they allow the passage of small molecules but not of large molecules) and **selectively permeable** (they allows certain molecules or ions to pass through it by means of active or passive transport).

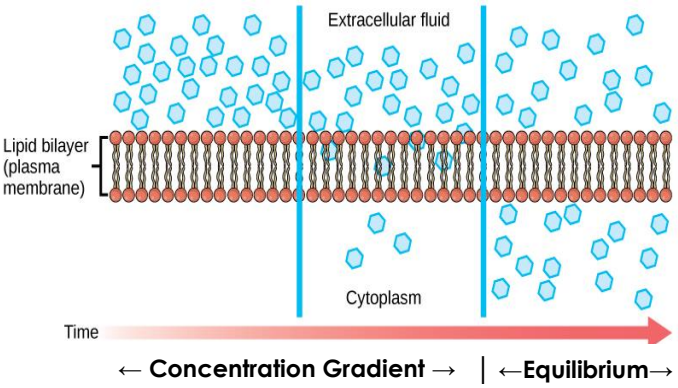
Each phospholipid molecule has a **hydrophilic head** (attracted to water) and a **hydrophobic tail** (repels water). Both layers of the plasma membrane have the hydrophilic heads pointing toward the outside; the hydrophobic tails form the inside of the bilayers.



Proteins and substances such as cholesterol become embedded in the bilayer, giving the membrane the look of a mosaic. Because the plasma membrane has the consistency of vegetable oil at body temperature, the proteins and other substances are able to move across it. That's why the plasma membrane is described using the *fluid-mosaic* model.

The molecules that are embedded in the plasma membrane also serve a purpose. For example, the **cholesterol** that is stuck in there makes the membrane more stable and prevents it from solidifying when your body temperature is low. It keeps you from literally freezing when you're "freezing." **Carbohydrate chains** attach to the outer surface of the plasma membrane on each cell. These carbohydrates are specific to every person, and they supply characteristics such as the antigens on red blood cells for your blood type.

Mechanisms of Transport



Concentration Gradient (c.g.) = the process of particles moving from an area of **high** concentration **to** an area of **low** concentration, usually across a membrane.

Equilibrium = concentrations of solute and solvent are equal on both sides of the membrane

Passive Transport
(DO NOT require energy)

High → Low Concentration
a.k.a. Goes Down c.g.

Diffusion
(movement from high to low c.g.)

Osmosis
(movement of H_20 from high to low c.g.)

Active Transport
(Requires ATP Energy)

Low → High Concentration
a.k.a Goes Up c.g.

Exocytosis
(Exiting Cell)

Endocytosis
(Entering Cell)

Pinocytosis (Liquids entering)

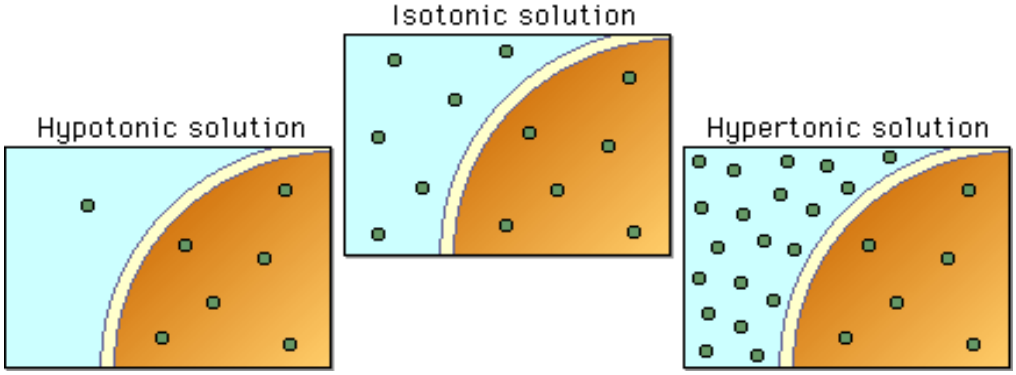
Phagocytosis (Solids Entering)

Types of Solutions

Hypotonic – concentration of solutes are higher inside than outside = water moves in & solutes move out = cell swells
Animal cells – burst Plant cells – increase turgor pressure

Isotonic – solute concentrations are equal inside & outside of cell = no movement of water or solutes

Hypertonic – Concentration of solutes lower inside than outside = water moving out & solutes moving in = cell shrinks Ex. Too Much Fertilizer



Legend
Green = solute
Brown = inside cell
Blue = outside cell
White = cell/plasma membrane

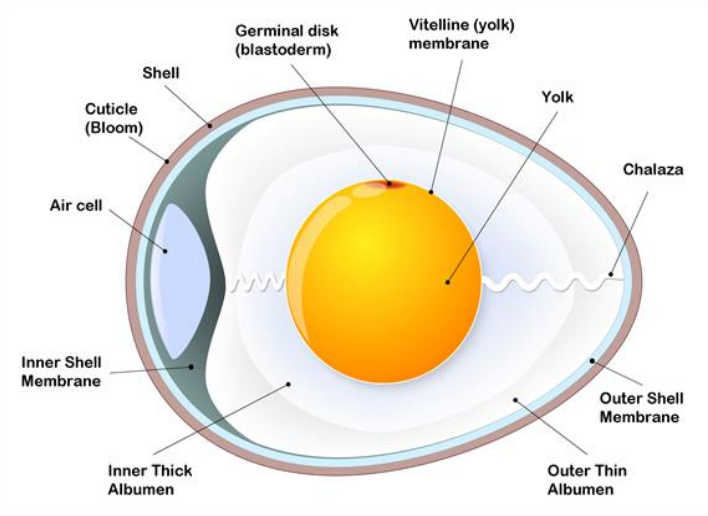
Name: _____ Date: _____

Bio30: OL1 Cells Intro **Egg Osmosis Lab**

Eggcellent Osmosis & Diffusion Lab

Purpose:

To investigate concepts of osmosis & diffusion by observing movement of water across a selectively permeable membrane.



Materials:

2 Beakers, 200 mL	Digital Scale
Corn syrup	Vinegar
2 Chicken eggs, raw	Water, distilled
Beaker Cover	Toothpick
Food Coloring (3-5 drops)	Paper Towel

Safety Precautions:

The materials in this activity are considered nonhazardous. Normal laboratory safety procedures should be followed. Once food grade items are brought into the laboratory they are considered chemicals and should not be consumed.

Procedure – Day 1:

1. Carefully measure and record the mass of the raw eggs in Table 1.
2. Place eggs in separate beakers. Pour 150 ml vinegar into each beaker. If needed, add more vinegar to cover the entire egg. Record the vinegar volumes in Table 1.
3. Cover beakers to prevent evaporation. Label the beakers and store in a safe place.

$$CaCO_{3\,(s)} + 2HC_2H_3O_{2\,(aq)} \rightarrow Ca(C_2H_3O_2)_{2\,(aq)} + H2O_{(l)} + CO_{2\,(g)}$$

calcium carbonate + acetic acid (vinegar) → calcium acetate salt + water + carbon dioxide

Procedure – Day 2:

4. After 24 hours, carefully remove the egg from the beaker. Note the bubbles on the shell. What is happening to the shell? If the egg is completely soft, and the shell is gone, go on to Step 5. If the shell is not completely dissolved, change the vinegar, and return the egg to the beaker for another 24 hours.
5. When the shell is completely dissolved, remove the egg CAREFULLY from the beaker and rinse off any excess vinegar. Observe the egg. Determine the mass of each egg and the record it in Table 1. Be sure to handle the shell-less egg carefully.
6. Clean beakers thoroughly with soap and water. Place Egg #1 into a beaker. Pour enough corn syrup (approx. 150 ml) into the beaker to cover the egg. Place Egg #2 into a beaker. Pour water into the beaker (approx. 150 ml) to cover the egg. Add 3-5 drops of food coloring to the water. Cover the beakers and store for 24 hours.

Name: _____ Date: _____

Bio30: OL1 Cells Intro **Egg Osmosis Lab**

Procedure – Day 3:

7. After the "shell-less" eggs have soaked 24 hours, examine the eggs. Record the observations in Table 1. Carefully remove the eggs from the beaker, rinse them off, and weigh the eggs again. Take note of the volume of liquid remaining in the beakers. Record measurements in Table 1.
8. Place egg on generous amount of paper towel. Use a toothpick to pop each egg membrane. Record your observations.

Observations:

Table 1	Initial	Final	Observations
Egg #1 Mass			
Egg #1 Vinegar Volume			
Egg #2 Mass			
Egg #2 Vinegar Volume			
Egg #1 Corn syrup			
Egg #2 Food coloring			

Name: _____ Date: _____

Bio30: OL1 Cells Intro **Egg Osmosis Lab**

Analysis:

1. After 24 hours in the vinegar, was there an increase or decrease in the mass of the egg? Increase or decrease in the volume of liquid in the beaker? Explain.

2. After 24 hours in the dyed water solution, did the mass of the egg increase or decrease? Explain.

3. What color was the fluid of the egg when you popped the membrane? Explain the color change.

4. Did the mass of the egg increase or decrease after sitting in molasses/corn syrup for 24 hours? Use and example of observable evidence (i.e. volume of liquid sitting in beaker) that you saw to explain.

Applications:

5. Why do grocery stores spray fresh fruits and vegetables with water? What type of solution is this?

6. Roads are sometimes salted to melt ice. What does this do to plants around the roadside and why? What type of solution is this?

7. If a shipwrecked crew drinks sea water, they will probably die. Why? What type of solution is this?

8. If a bowl of fresh strawberries is sprinkled with sugar, a few minutes later the berries will be covered with juice. Why? What type of solution is this?

Name: _____ Date: _____

Bio30: OL1 Cells Intro **Egg Osmosis Lab**

Analysis: ANSWER KEY

1. After 24 hours in the vinegar, was there an increase or decrease in the mass of the egg? Increase or decrease in the volume of liquid in the beaker? Explain.

   There was a slight increase in mass of egg and decrease in volume of beaker liquid. Once shell was removed, water produced from chemical reaction or remaining vinegar moved across plasma membrane into cell.

2. After 24 hours in the dyed water solution, did the mass of the egg increase or decrease? Explain.

   Mass of the egg increased due to water moving into the egg.

3. What color was the fluid of the egg when you popped the membrane? Explain the color change.

   Color inside egg was light green with runny liquid. Dye particles passed across the membrane.

4. Did the mass of the egg increase or decrease after sitting in molasses/corn syrup for 24 hours? Use an example of observable evidence (i.e. volume of liquid sitting in beaker) that you saw to explain.

   Mass of the egg decreased with area around the egg watery compared to the viscosity of the corn syrup. It has also shrunk in size, is visually wrinkly/leathery with the inside yolk denser than normal.

Applications:

9. Why do grocery stores spray fresh fruits and vegetables with water?

   Hypotonic – water moves into the cells

10. Roads are sometimes salted to melt ice. What does this do to plants around the roadside and why?

    Hypertonic – salt moves in while water moves out of the cell causing dehydration & shrinking

11. If a shipwrecked crew drinks sea water, they will probably die. Why?

    Hypertonic – salt moves in while water moves out of the cell causing dehydration & shrinking

12. If a bowl of fresh strawberries is sprinkled with sugar, a few minutes later the berries will be covered with juice. Why?

    Hypertonic – sugar moves in while juices move out of the cell

Atoms + Atoms = ELEMENTS

Element + Element = COMPOUND

*If they act as a single particle = MOLECULE

Attractions Between Atoms = Chemical Bonds

Covalent Bond = Electrons are SHARED

Ionic Bond = Electrons are TRANSFERRED

When bonds are formed, energy is STORED.
When bonds are broken, energy is RELEASED.

Ion – an atom that has an excess charge

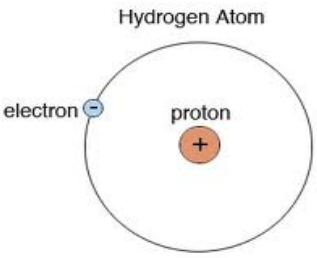


Figure 1: Hydrogen Atom

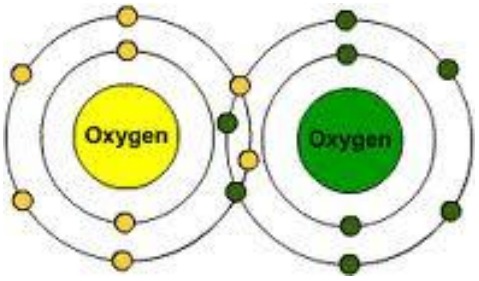


Figure 2: Oxygen Atom

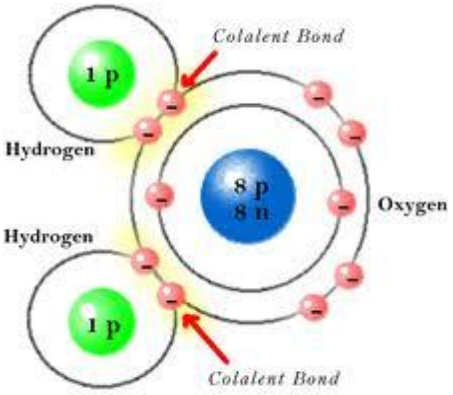


Figure 3: Bohr Model of Water

Law of Conservation of Mass -

In a chemical reaction, the total mass of the reactants will always equal the total mass of the products.

"On the street A.K.A. – What goes in must come out!"

Types of Compounds

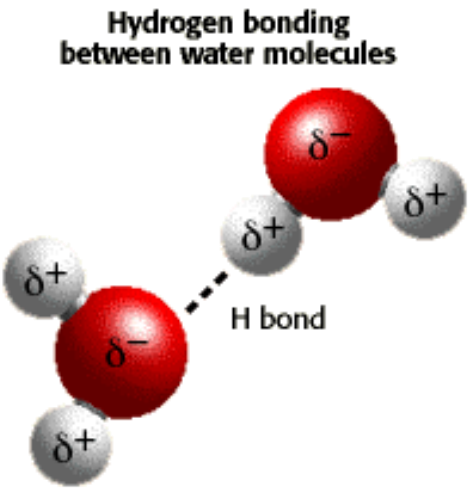
(Held together with hydrogen bonds)

Organic = **Contains carbon & usually living/ recently living**	**Inorganic =** **DOES NOT contain carbon**
Exception: CO_2 is NOT an organic compound	Exception: CO_2

Hydrogen Bonds

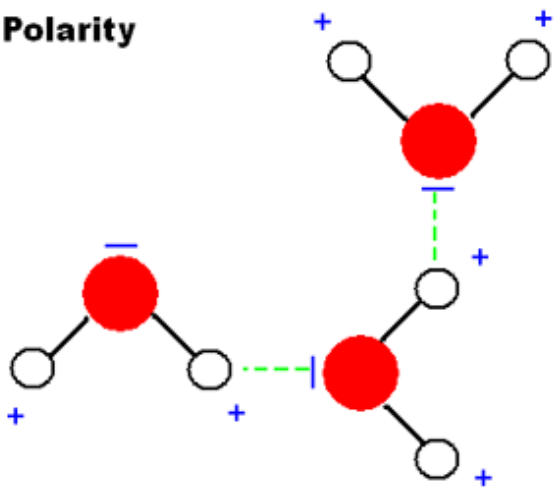
Beneficial & hugely popular in molecules because:

1. Easy to make and easy to break because of only having one electron
2. Can create 3-D molecules
3. Found in large #'s in DNA



Covalent bonds form H_2O molecule

Ionic bonds form between H_2O molecules



Miss Foley

Bio30: OL1 Cells Intro **Biochemistry Foundation**

Chemical Reactions

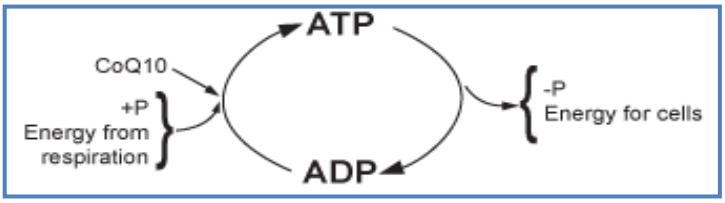
Synthesis (Building Up)	**Decomposition** (Breaking Down)
Ex. Photosynthesis	Ex. Cellular Respiration
$6H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2$	$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2 + 36\ ATP$
Reactants Products	Reactants Products

Energy Carriers

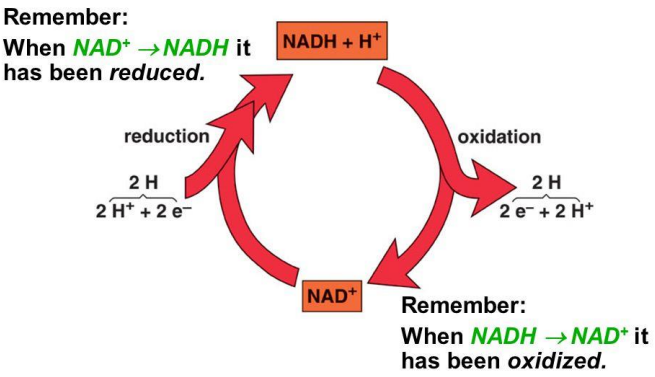
When bonds are formed, energy is STORED.
When bonds are broken, energy is RELEASED.

ADP + P ↔ ATP (Used in Photosynthesis & Cellular Respiration)
$NAD^+ + H^+ + 2e^- \leftrightarrow NADH$ (Used in Cellular Respiration)
$FAD + 2H^+ + 2e^- \leftrightarrow FADH_2$ (Used in Cellular Respiration)
$NADP^+ + H^+ + 2e \leftrightarrow NADPH$ (Used in Photosynthesis)

ATP = Adenosine Triphosphate
ADP = Adenosine Diphosphate



The NAD^+ cycle



NADPH Cycle??

FADH2 Cycle??

Miss Foley

Bio30: OL1 Cells Intro **Biochemistry Foundation**

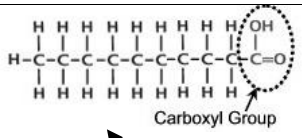
Organic Macromolecules

Charac-teristic	Carbohydrates	Lipids	Polypeptides	Nucleic Acids
A.K.A	Sugars	Fats	Proteins	Nucleic Acids
Testing				
Easy I.D.				
Function				
Elements				
Building Blocks				
Size Order				
Other				

Miss Foley

Bio30: OL1 Cells Intro **Biochemistry Foundation**

Organic Macromolecules

Charac-teristic	Carbohydrates	Lipids	Polypeptides	Nucleic Acids
A.K.A	Sugars	Fats	Proteins	Nucleic Acids
Testing	*Benedict's Solution* - blue to orange with heat = sugars *Iodine* – light brown to black = starch	*Sudan IV* dyes fats orange which then separates out in an emulsion	*Buiret's Solution* – clear to purple = peptides	Every cell has nucleic acids = no test
Easy I.D.	Always ends with –ose Ex. Glucose, Fructose, Sucrose (Glucose & Fructose), Lactose, Glycogen, Starch	Waxes, steroids, triglycerides *slippery, both hydrophilic (= loves water) and hydrophobic (= hates water) areas	Usually end with –ine with many exceptions Ex. Hormones, antibiotics, enzymes * ***Enzymes*** *always end in -ase*	Always end with -ribonucleic acid
Function	Stores Energy (4 kcal/g)	Stores Energy (9 kcal/g)	Cell Structure & Enzymes (4 kcal/g)	Genetic Information
Elements	C, H, O Always 1:2:1 ratio	C,H,O (less O)	C, H, O, N	C, H, O, N, P
Building Blocks	Saccharides (most common is glucose = $C_6H_{12}O_6$)	 Fatty Acid and a Carboxyl Group	Amino Acids	Nucleotides (Contains Phosphate, 5-carbon sugar & a nitrogen base)
Size Order	saccharide → disaccharide → polysaccharide → starch	***Saturated*** – bonds saturated with hydrogen; ↑ bad cholesterol; solid at room temp; animal sources ***Unsaturated*** – still room for hydrogen bonds; ↓ bad cholesterol; liquid at room temp; plant sources ***Trans Fats*** – unsaturated fats have additional hydrogen bonds added on; body CAN NOT metabolize = they float around causing damage forcing the body to make constant repairs	Amino acid → dipeptide → polypeptide → Protein Polypeptides involving more than about 100 amino acids = **PROTEIN**	***DNA*** - Deoxyribonucleic Acid (guanine – cytosine, adenine – thymine), deoxyribose sugar & phosphate ***RNA*** – Ribonucleic Acid (same nitrogen bases except uracil replaces thymine, ribose sugar & phosphate) *Purines (adenine & guanine) always bond with Pyrimidines (cytosine, thymine/uracil)*
Other	***Dehydration Synthesis*** – removing water to build more complex sugars. ***Hydrolysis*** – putting water back into the molecule to separate them.		*Only **20** known amino acids Human body ***CAN NOT MAKE*** **8 = essential amino acids =** must come from diet	

Name: _____ Date: _____

Bio30: OL1 Cells Intro **Carbohydrate/Starch Lab**

See Powerpoint Notes

Finish adding in carbohydrate/starch lab!!!

Name: _____ Date: _____

Bio30: OL1 Cells Intro **Amino Acid/Protein Lab**

Finish adding in protein/amino acid lab!!!

Name: _____ Date: _____

Bio30: OL1 Cells Intro **Fat Lab**

Finish adding in fat lab!!!

Properties of Organic Molecules:
Carbohydrates, Lipids & Proteins

1. Define organic compound.
2. Contrast organic and inorganic compounds.
3. Explain why the carbon atom is the central element for all living things.
4. List four (4) basic types of organic compounds.
5. Explain why hydrogen bonds are used so often for chemical bonds.

6. What is a saccharide?
7. What elements are saccharides always made up of?
8. Contrast monosaccharide, dissacharide and polysaccharide.
9. Explain how sugar molecules are bonded together.
10. Explain how sugar molecules are broken apart.
11. How do plants store extra sugars? Humans?

12. Compare and contrast the chemical makeup of lipids to carbohydrates.
13. How much energy do lipids store compared to carbohydrates.
14. Diagram a lipid molecule labeling the chain of carbon atoms with hydrogen atoms AND the carboxyl group.
15. Contrast saturated fats with unsaturated fats in regards to their chemical bonds.
16. How can you tell what kind of fat you are eating?
17. Which type of fat increases cholesterol? Which decreases cholesterol?

18. What are the building blocks of proteins?
19. Which elements make up amino acids?
20. Define peptide.
21. Can humans make all 20 amino acids needed for all proteins? Can plants?
22. Contrast dipeptide with polypeptide.

Properties of Organic Molecules:
Enzymes & Nucleic Acids

1. What type of organic substance are enzymes made up of?
2. Define catalyst.
3. Define enzyme.
4. What is a substrate?
5. How do you know by the name if a substance is an enzyme?
6. a) Where is an active site found?
   b) Why is it important?
7. What is an enzyme-substrate complex?
8. List and explain the two (2) theories of how an enzyme-substrate complex forms.
9. List 2 factors that affect the rate at which enzyme-substrate complexes form.
10. Define coenzyme.
11. Are coenzymes proteins?

12. What does DNA stand for?
13. What does RNA stand for?
14. Define nucleic acid.
15. a) What role does DNA play?
    b) What role does rNA play?
16. What elements are nucleic acids made up of?
17. What are the "building blocks" of nucleic acids?
18. What parts make up a nucleotide?
19. Which bases always pair up bonding together?
20. What shape does DNA take?
21. List two ways how rNA is chemically different from DNA?

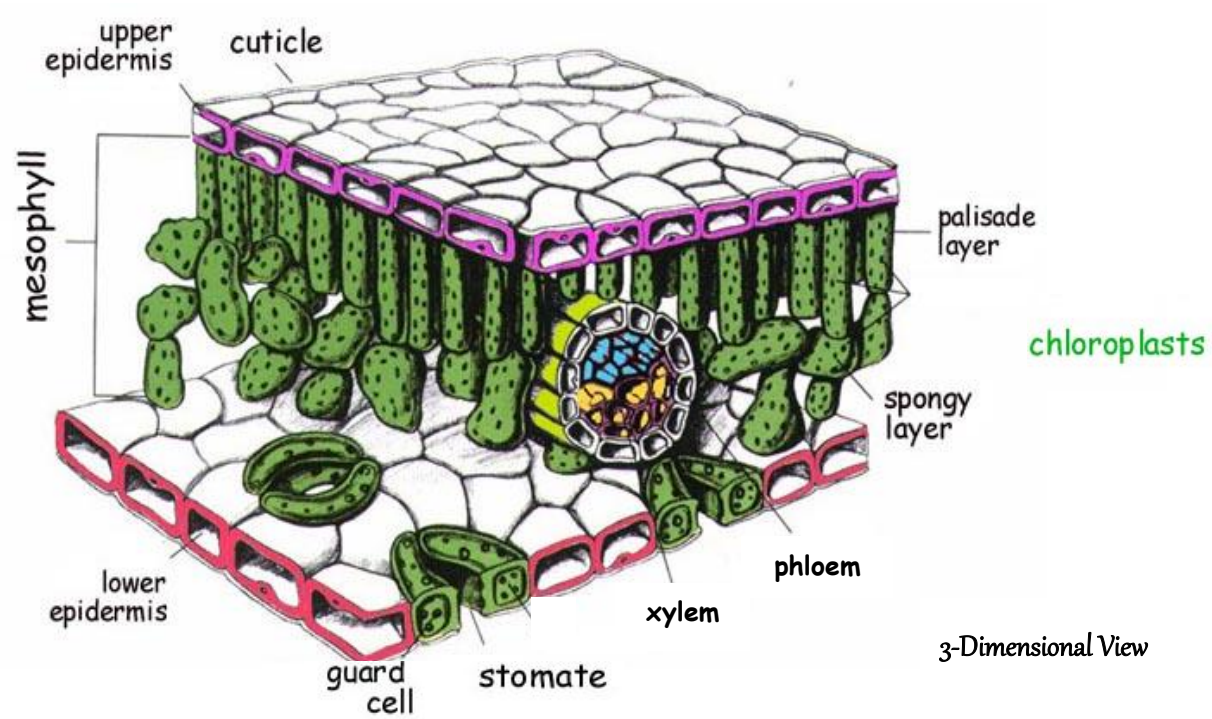
W5 of Photosynthesis

W5's	Light Reaction	Calvin Cycle/Dark Reaction
WHO	Water → ½ O_2 + $2H^+$ NADP → NADPH ADP ↔ ATP Photosystems & Electron Carriers	CO_2, RuBP, PGA, G3P NADPH ↔ $NADP^+$ ATP ↔ ADP
WHAT	Light energy is absorbed & converted to chemical energy. Water is split. Oxygen escapes through stomates. Hydrogen ions (H^+) stay inside the thylakoid. Electrons are used to store energy as ATP and NADPH.	To fix carbon in order to store chemical energy as glucose.
WHERE	Thylakoid Membrane	Stroma
WHEN	Whenever sunlight, $C0_2$ and H_20 are available.	Anytime the fuel (ATP & NADPH) is available; sunlight NOT required.
WHY	To Produce and Store Energy as ATP and NADPH	To produce 1 molecule of glucose ($C_6H_{12}O_6$) for every six carbon dioxide ($C0_2$)

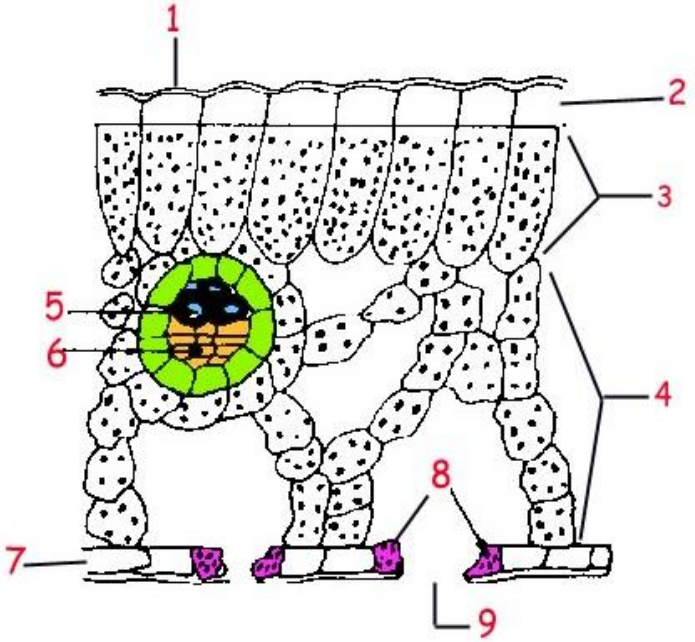
W5 of Photosynthesis

W5's	Light Reaction	Calvin Cycle/Dark Reaction
WHO		
WHAT		
WHERE		
WHEN		
WHY		

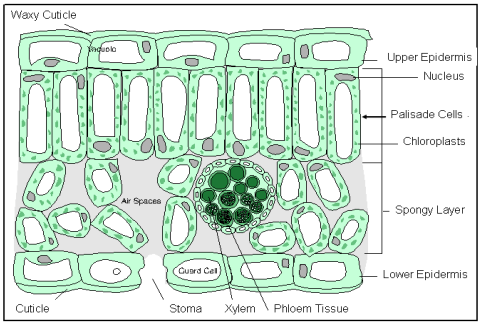
C3 Plant Leaf Cross Section



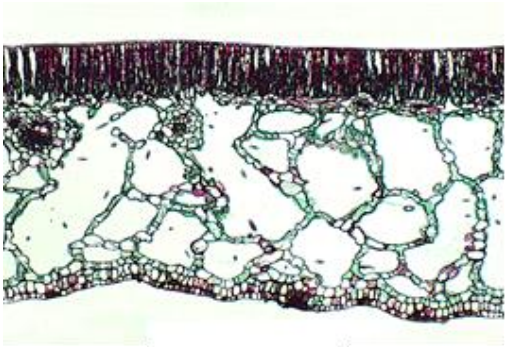
3-Dimensional View



Can You Label Me?



2-Dimensional View



2-Dimensional View

Photosynthesis = Building Glucose Using Light

Photo = light Synthesis = building up

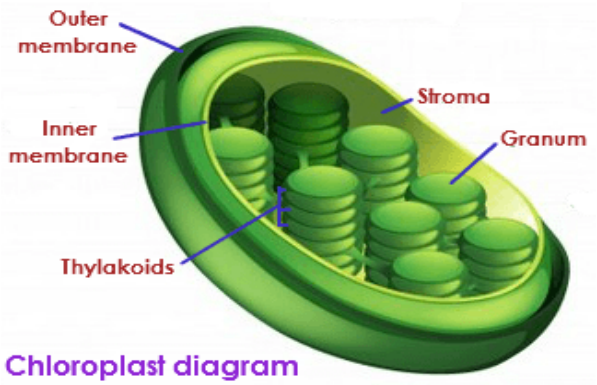
$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Photosynthesis takes place in organelles called **chloroplasts.** Chloroplasts are filled with **chlorophyll** (photoreceptors) that captures the solar/radiant energy of the sun. Photosynthesis will not occur until the chlorophyll develops.

Three Main Steps to Photosynthesis:

1. Absorption of solar energy in the form of light = LIGHT REACTION
2. Transformation of light energy into chemical energy as NADPH & ATP = LIGHT REACTION
3. Chemical energy is stored as glucose sugar ($C_6H_{12}O_6$) = DARK REACTION

Inside A Chloroplast



Stroma – aqueous substance surrounding thylakoids containing enzymes for the DARK REACTION/CALVIN CYCLE.

Thylakoid – structure containing chlorophyll pigments & enzymes for LIGHT REACTIONS.

Grana/Granum – stack of thylakoids

Chlorophyll a is the most prevalent type of chlorophyll mainly found in plants, & algae. This type of chlorophyll absorbs red, blue and violet wavelengths. It gets its color by reflecting green, giving plants their green color. **Chlorophyll b** is found primarily in plants as well, but this type absorbs blue light only and is yellow in pigment. **Chlorophyll c** and **chlorophyll d** are less common and are found in different algae and dinoflagellates. **Chlorophyll e** is a very rare type of chlorophyll that is found in some golden algae, and, as the name suggests, **bacterio-chlorophyll** is found in certain bacteria.

Carotenoids (a.k.a. accessory pigments) are usually red, orange, or yellow pigments. Carotenoids cannot transfer sunlight energy directly to the photosynthetic pathway, but **must pass their absorbed energy to chlorophyll found in the photosystems.** One very visible accessory pigment is the brown pigment which colors kelps and other brown algae as well as diatoms.

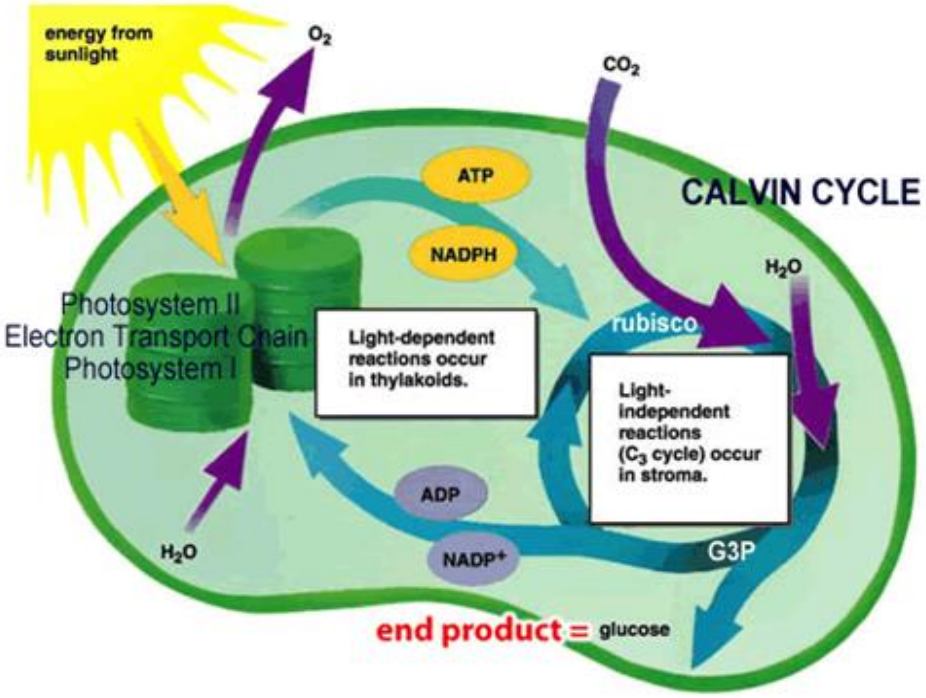
Photosynthesis Overview

Light Reactions

1. The light energy strikes the leaf, passes into the leaf and hits a chloroplast inside an individual plant cell.
2. The light energy, upon entering the chloroplasts, is captured by the chlorophyll inside a grana.
3. Inside the grana some of the energy is used to split water into hydrogen and oxygen.
4. The oxygen product is released into the air through the underside of the leaves.
5. The hydrogen is taken to the stroma along with the grana's remaining light energy.

The Calvin Cycle/Dark Reactions

6. Carbon dioxide enters the underside of the leaf and passes into the chloroplast.
7. In the stroma, the remaining light energy is used to combine hydrogen and carbon dioxide to make carbohydrates ($C_6H_{12}O_6$).
8. The energy-rich carbohydrates are carried to the plant's cells.
9. The energy-rich carbohydrates are used by the cells to drive the plant's life processes as cellular respiration breaks the glucose down to release the stored energy.



Photosynthesis: Light Reactions

Absorbing & Converting Light Energy

Players: Uses 6 Water ➜ Oxygen & Hydrogen Ions
Produces 12 $NADP^+$ ➜ NADPH
Produces 12 ADP ➜ ATP

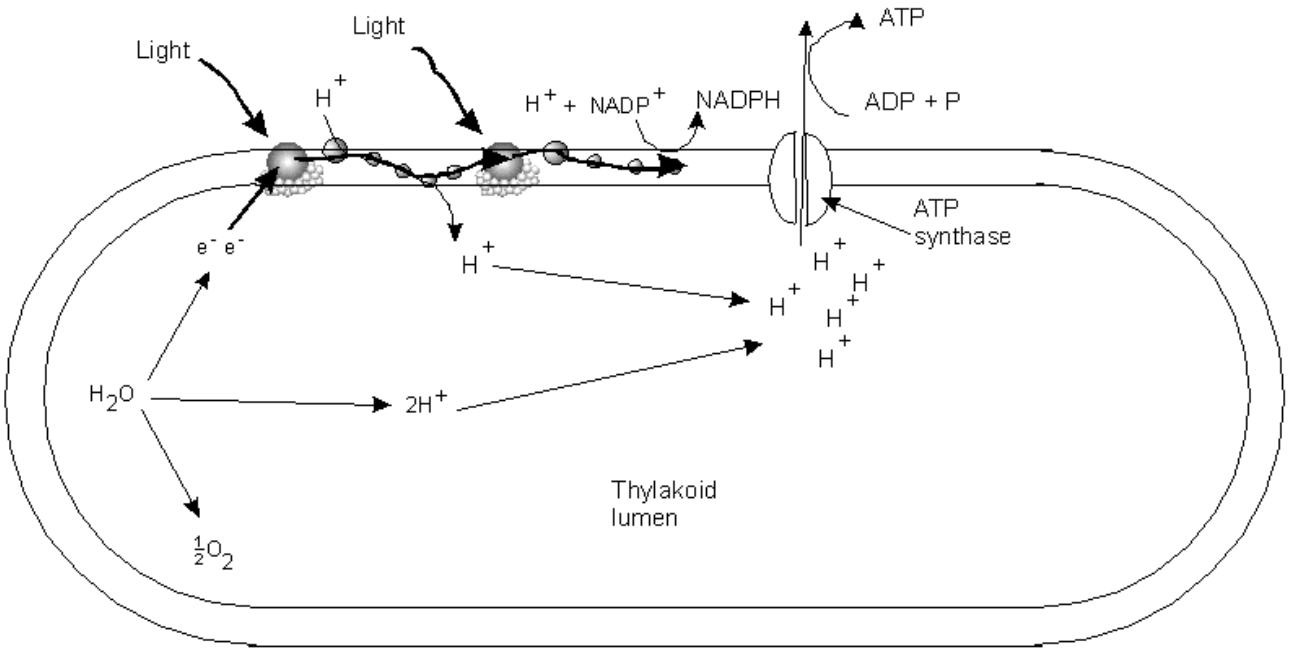
When: Sunlight Required

Where: Thylakoid membranes

What: Light energy is absorbed & converted to chemical energy.

(Chlorophyll and other pigments (carotenoids) in the thylakoid absorb light energy to split water molecules into hydrogen ions and oxygen. The oxygen gas is released to the atmosphere and the light energy is stored as chemical energy in the form of ATP and NADPH for the Dark Reaction.

Produces: 12 ATP, 12 NADPH, 12 H_2O and 6 O_2



Photosystem II

Step 1 - Chlorophyll & pigments (other than chlorophyll a) absorb light energy and transfer it to chlorophyll a within each of the photosystems

Step 2 - Light energy is used to split water into oxygen, hydrogen ions & energized electrons. Oxygen is released through stomates in the leaves. The concentration of hydrogen ions increases inside the thylakoid membrane to create a concentration gradient.

Electron Transport Chain/System

Step 3 - Electron carriers transport the energized electrons through the Electron Transport Chain/System towards Photosystem I

Step 4 - The energized electrons (-) attract hydrogen ions (+), in the stroma outside the thylakoid membrane, losing energy as they pull them across further increasing the concentration of hydrogen ions inside the thylakoid.

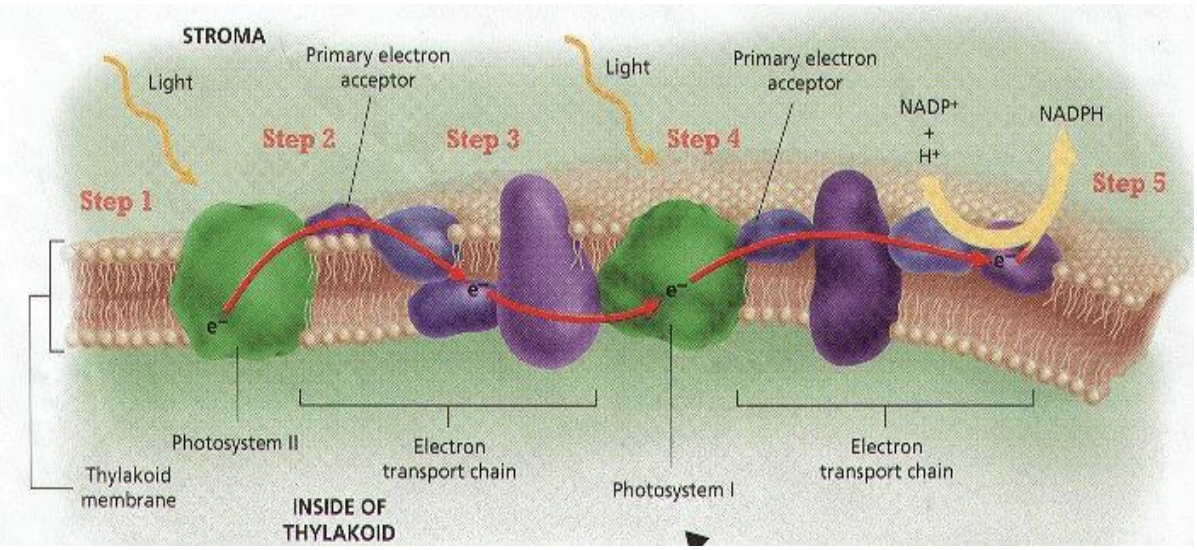
Photosystem I

Step 5 - At the end of the electron transport system, electrons are re-energized. Enzymes in the membrane use 2 electrons and a hydrogen ion from the split water to combine with an energy carrier $NADP^+$ forming NADPH. This compound is used as the energy source to drive the dark reactions (Calvin Cycle).

ATP Synthase/Formation

Step 6 - Hydrogen ions travel down the concentration gradient through synthase enzymes in the membrane regenerating ATP from ADP as they cross over the thylakoid membrane back into the stroma.

What Step of the Light Reaction is Missing Below?



C3 Plants Photosynthesis: Dark Reactions/Calvin Cyle

Storing Converted Chemical Energy

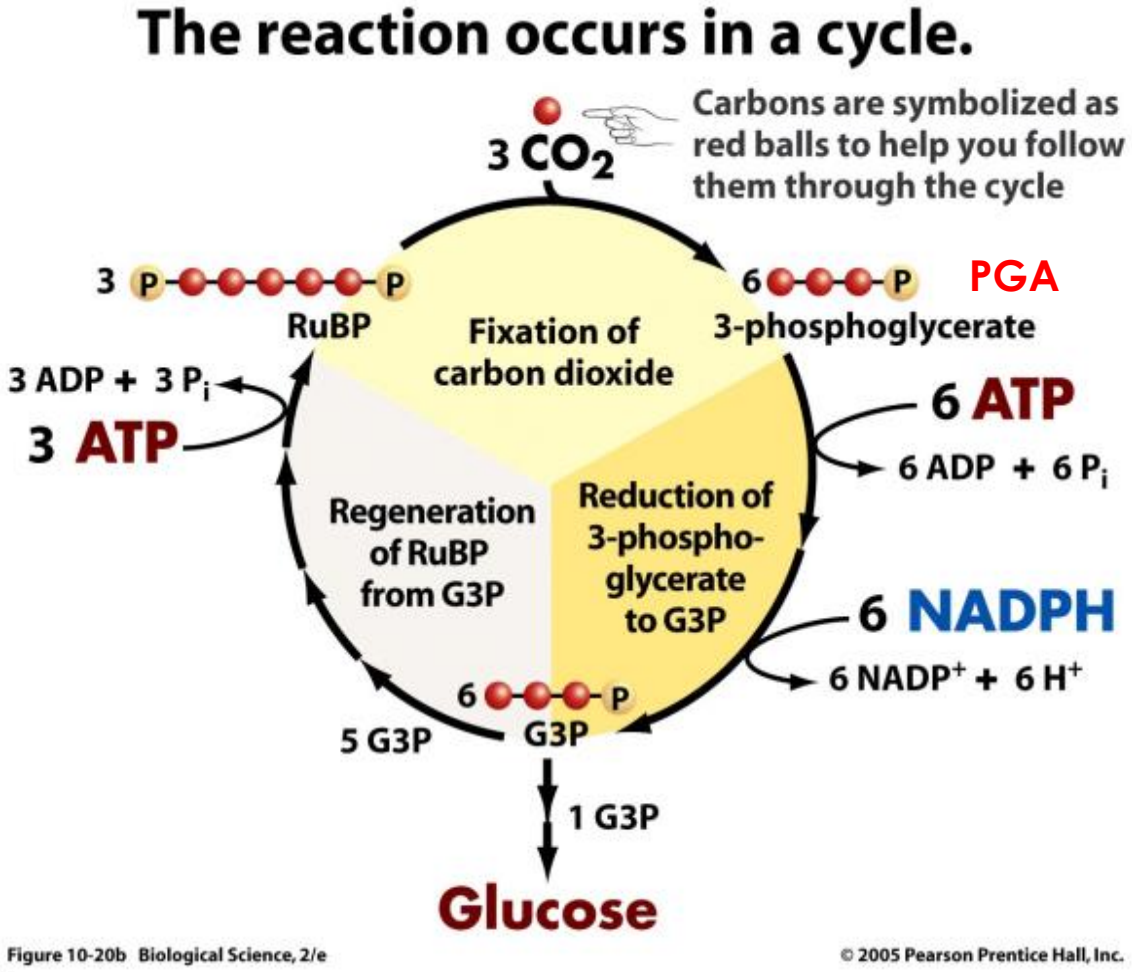
Players: Consumed 6 Carbon Dioxide (CO_2)
Regenerates 12 NADPH ➜ $NADP^+$
Regenerates 18 ATP ➜ ADP
Uses RuBP, PGA/PGAL, G3P

When: Anytime Fuel (ATP and NADPH) is Available; Sunlight Not Required

Where: Stroma

What: Chemical energy is stored as glucose (carbon fixation)

Produces: 1 molecule of Glucose ($C_6H_{12}O_6$)



C3 Carbon Fixation

Step 1 - Carbon dioxide combines with RuBP (ribulose biphosphate) catalysed by the enzyme Rubisco.
Rubisco = ribulose biphosphate carboxylase
Rubisco fixes carbon from the air and is the most abundant protein/enzyme on Earth.

Step 2 - Each 6-carbon molecule is highly unstable & breaks down into 2 - 3 carbon molecules called 3-phosphoglycerate = PGA

G3P Reduction

Step 3 - Each 3-carbon PGA molecule receives a phosphate from ATP & 2 electrons from NADPH to form 3-carbon sugars (G3P = Glyceraldehyde 3 Phosphate)

Step 4 - One of these sugars leaves the Calvin Cycle to start building a glucose molecule.

RuBP Regeneration

Step 5 - The remaining 5 molecules of G3P receive energy from ATP to be converted back into carbon dioxide accepting RuBP so the cycle can start over again.

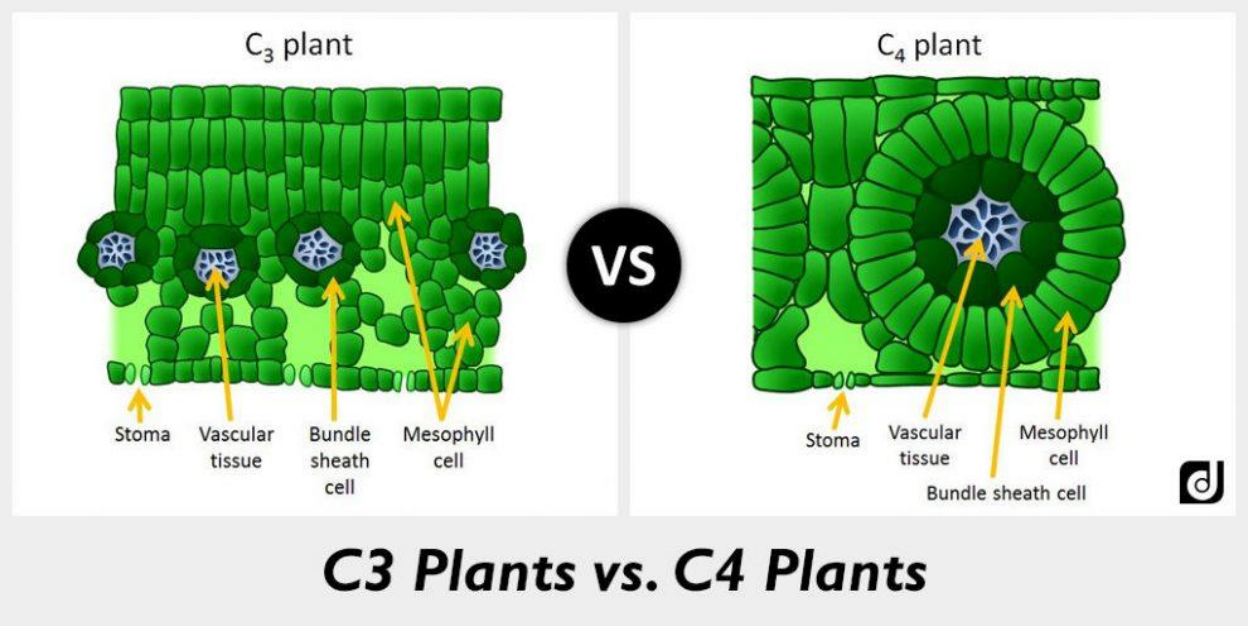
Accounting:

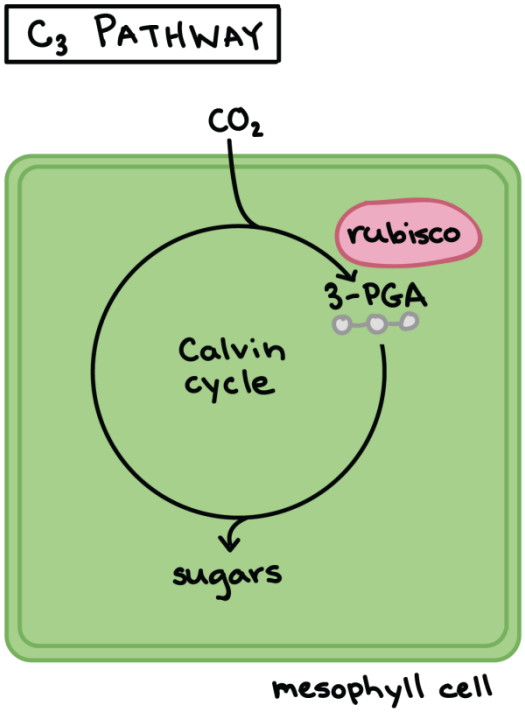
For every 6 molecules of carbon dioxide that enter the Calvin Cycle, 12 molecules of 3-carbon sugar (G3P) are formed. Ten (10) of these carbon sugar molecules are regenerated to the original 5-carbon molecule (RuBP) so that the cycle can continue.

The remaining 2 molecules of 3-carbon sugar forms a molecule of glucose and leaves the Calvin Cycle.

C4 & CAM Plants Photosynthesis: Dark Reactions/Calvin Cyle

Storing Converted Chemical Energy





C3 pathway plants are less efficient in carrying out photosynthesis than C4 pathway plants. Mesophyll cells perform complete photosynthesis in C3 plants but only initial fixation in C4 plants.

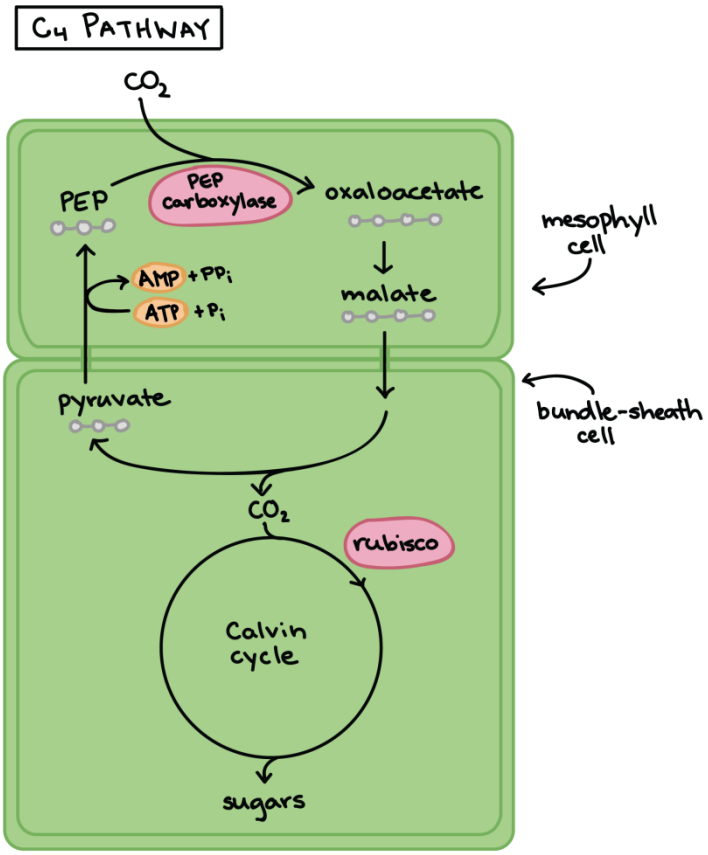
C3 pathway plants perform photosynthesis when stomata are open which results in water loss and make up **95% of all plants**.

C4 pathway plants perform photosynthesis even when the stomata is closed preventing water loss at high temperatures and make up **3% of all plants**. C4 plants do this by fixing CO_2 in mesophyll cells moving the Calvin Cycle into bundle sheath cells separating them by physical space.

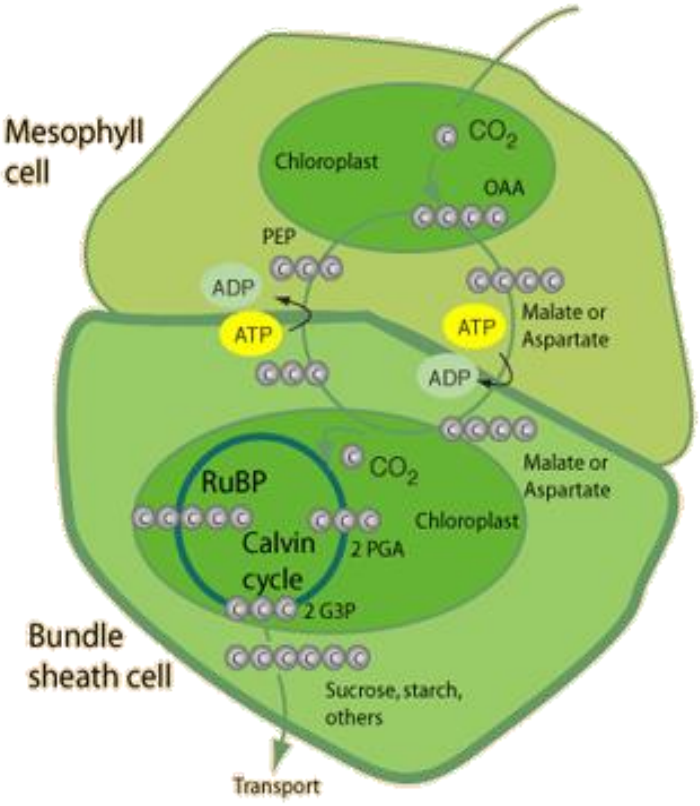
CAM plants (Crassulacean Acid Metabolism) make up **2% of all plants** and save water by separating these steps by time, between night and day.

C4 Plants

First, atmospheric **CO_2 is fixed** in the mesophyll cells to form a **4-carbon organic acid called oxaloacetate**. This step is carried out by a **non-rubisco enzyme, PEP carboxylase**. PEP has no tendency to bind O_2. Oxaloacetate is then converted to a similar molecule called **malate** that can be transported into the bundle-sheath cells. Inside the bundle sheath, **malate breaks down, releasing a molecule of CO_2.** The **CO_2 is then fixed by rubisco** and made into sugars via the Calvin cycle, **exactly as in C3 photosynthesis.**



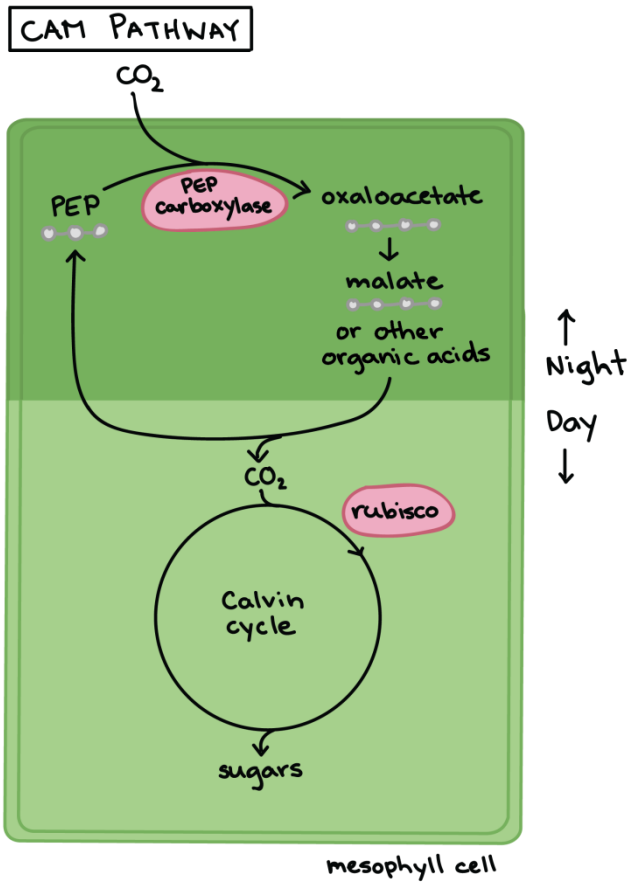
This process isn't without its energetic price: ATP must be expended to return the three-carbon "ferry" molecule from the bundle sheath cell and get it ready to pick up another molecule of atmospheric CO_2. However, because the mesophyll cells constantly pump CO_2 into neighboring bundle-sheath cells in the form of malate, there's always a high concentration of CO_2 relative to O_2, right around rubisco. This strategy minimizes photorespiration.



The C4 pathway is used in about 3% of all vascular plants; **examples are crabgrass, sugarcane and corn**. C4 plants are **common in habitats that are hot**, but are less abundant in areas that are cooler. In hot conditions, the benefits of reduced photorespiration likely exceed the ATP cost of moving CO_2 from the mesophyll cell to the bundle-sheath cell.

CAM Plants

CAM plants are typically dominant in very hot, dry areas, like deserts. CAM plant examples, such as **cacti and pineapples**, use the **crassulacean acid metabolism** (**CAM**) pathway to minimize photorespiration. This name comes from the family of plants, the Crassulaceae, in which scientists first discovered the pathway.



Instead of separating the light-dependent reactions and the use of CO_2 in the Calvin cycle in space, CAM plants separate these processes in time. **CAM plants only open their stomata at night allowing CO_2 to diffuse into the leaves** when humidity tends to be higher and temperatures are cooler - making them very water efficient. This **CO_2 is fixed into oxaloacetate by PEP** carboxylase (the same step used by C4 plants), **then converted to malate or another type of organic acid.**

The organic acid is stored inside vacuoles until the next day. **In the daylight, the CAM plants do not open their stomata**, **but they can still photosynthesis.** That's because the **organic acids are transported out of the vacuole** and broken down to **release CO_2 which enters the Calvin cycle**. This controlled release maintains a high concentration of CO_2 around rubisco.

Comparison of C3, C4 & CAM Plants

Type	Separation of Initial CO_2 Fixation and Calvin Cycle	Stomata Open	Best Adapted To
C3	No separation	Day	Cool, wet environments
C4	Between mesophyll and bundle-sheath cells (in space)	Day	Hot, sunny environments
CAM	Between night and day (in time)	Night	Very hot, dry environments

Photosynthesis: General Questions

1. What is its general purpose?

2. In what type of cell does it take place?
3. In what organelle does it take place?
4. What is the chemical equation for photosynthesis?

5. A) Where do the reactants come from?

   B) What are the products used for?

6. List the three (3) major events that happen before photosynthesis is complete?

7. These three (3) major events happen through a series of reactions. What are the two (2) distinct processes that they are grouped into?

The Light Reaction Questions

9. Where does it take place?
10. What is its purpose?

11. Does it require light energy?
12. Does it require CO_2? H_2O?
13. A) What substances are responsible for absorbing the light energy?

    B) Where are they located?

    Which of these is the most predominant?
14. A) Where is the light energy transferred once the chlorophyll b,c,d,e and other carotenoids have absorbed it?

    B) What happens when it gets there?

15. As the light energy is absorbed, water is split into H^+ ions and O_2.

    A) Where does the O_2 go?

    B) Where do the H^+ ions go?

16. A) The photosystems in the thylakoid membrane are connected by what?

    B) What purpose does it serve?

17. A) The electron transport chain results in the active transport of H^+ ions across the thylakoid membrane. This, along with the H^+ ions from the splitting of water, produces a concentration gradient inside the thylakoid. What happens to the H^+ ions?

    B) As a result, what is produced?

18. At what point has the light energy been converted to chemical energy?

19. A) What combines to form NADPH?
    B) What is its purpose?

20. Overall, how many ATP, NADPH, H_2O and O_2 are produced?

The Dark Reactions/Calvin Cycle Questions

21. Where does it take place?

22. What is its purpose?

23. Does it require light energy?

24. Does it require CO_2? H_2O?

25. A) Can this process occur during the night time?
    B) If not, why? If so, how?

26. What do these reactions use for fuel?

27. What two (2) substances combine to form the 6-carbon PGAL?

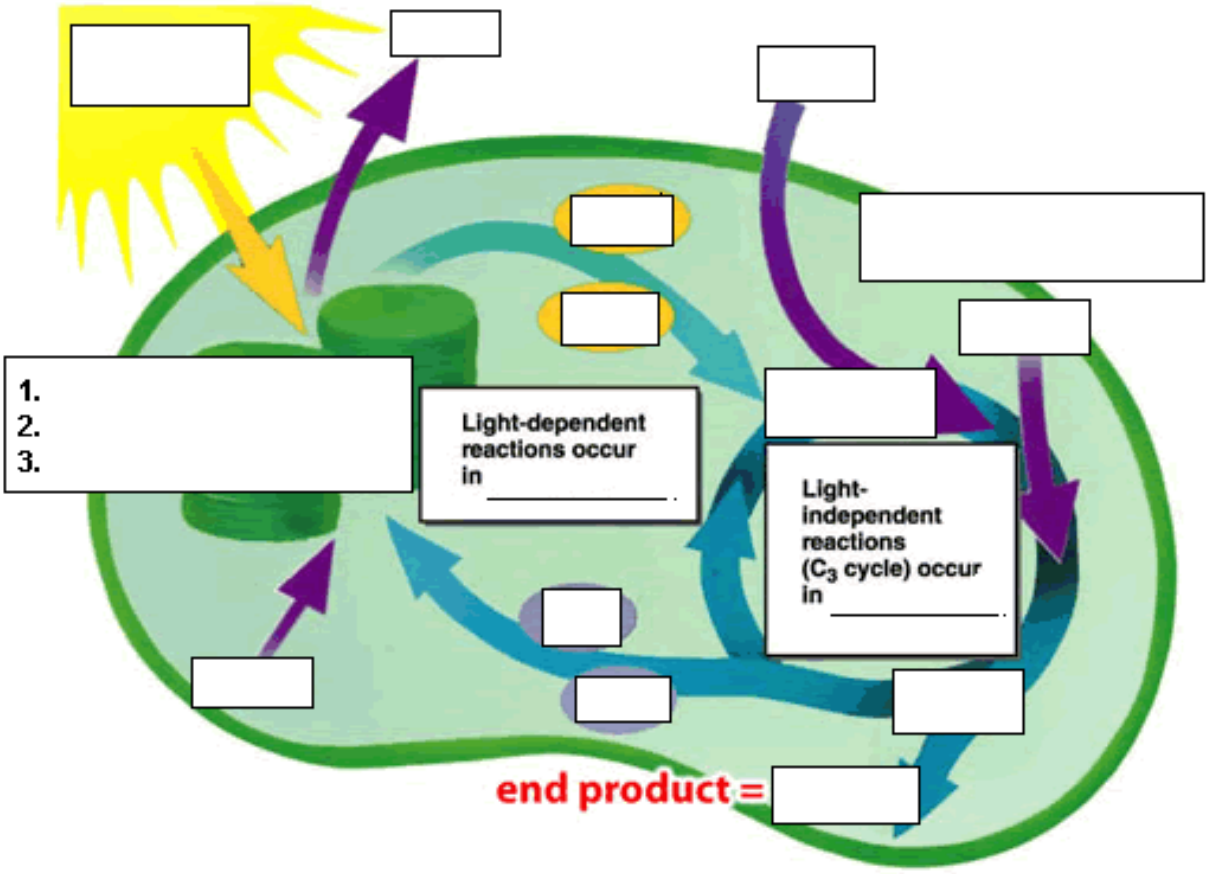
28. The RuBP & Carbon Dioxide combo splits into two 3-carbon acid molecules. What is required for these to be converted to carbon sugars?

29. A) How many molecules of 3-carbon sugars are formed for every 6 molecules of CO_2 that enter the cycle?

    B) How many of these leave the Calvin cycle and are used to produce 6-carbon glucose?

    C) How many of these are converted back to RuBP?

30. Why is it referred to as a "cycle"?



Miss Foley

Bio30: OL1 Cells Intro **Photosynthesis Review KEY**

Photosynthesis: General Questions

1. What is its general purpose?

   To convert light energy into stored energy (glucose)

2. In what type of cell does it take place? **Plant & Algae Cells**

3. In what organelle does it take place? **Chloroplast**

4. What is the chemical equation for photosynthesis?

   $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

5. A) Where do the reactants come from?

   Water – soil; Carbon dioxide – atmospheric air

   B) What are the products used for?

   Glucose – sugars for cellular respiration/storage; Oxygen - atmosphere

6. List the three (3) major events that happen before photosynthesis is complete?

   Light Absorption; Light energy converted to chemical energy; Chemical energy stored as glucose

7. These three (3) major events happen through a series of reactions. What are the two (2) distinct processes that they are grouped into?

   Light & Dark (Calvin Cycle) Reactions

The Light Reaction Questions

8. Where does it take place? **Thylakoids/Grana**

9. What is its purpose?
   To convert light energy into chemical energy

10. Does it require light energy? **Yes**

11. Does it require CO_2? **No** H_2O? **Yes**

12. A) What substances are responsible for absorbing the light energy? **Chlorophyll**

    B) Where are they located? **Chloroplasts**

    Which of these is the most predominant? **Chlorophyll A**

13. A) Where is the light energy transferred once the chlorophyll b,c,d,e and other carotenoids have absorbed it?

    To the Chlorophyll a rich Photosystems

    B) What happens when it gets there?

    It excites the electron to a higher energy level (from the splitting of water)

14. As the light energy is absorbed, water is split into H^+ ions and O_2.

    A) Where does the O_2 go? **Out the stomates on the bottom of the leaf**

    B) Where do the H^+ ions go? **The inside of the thylakoid**

15. A) The photosystems in the thylakoid membrane are connected by what?

Electron Transport System

B) What purpose does it serve?

To pull more H^+ into the thylakoid (across its membrane) before hitting Photosystem I

16. A) The electron transport chain results in the active transport of H^+ ions across the thylakoid membrane. This, along with the H^+ ions from the splitting of water, produces a concentration gradient inside the thylakoid. What happens to the H^+ ions?

They go down the concentration gradient producing ATP as they pass across the membrane through the ATP synthase (enzyme)

B) As a result, what is produced? **ATP**

17. At what point has the light energy been converted to chemical energy?

When the ATP and NADPH is formed

18. A) What combines to form NADPH? **H^+, 2 electrons and $NADP^+$**

B) What is its purpose?

To store energy and carry it to the Dark Reaction

19. Overall, how many ATP, NADPH, H_2O and O_2 are produced? **12; 12; 12; 6**

The Dark Reactions/Calvin Cycle Questions

20. Where does it take place? **Stroma**

21. What is its purpose? **To store chemical energy (fix the carbon as glucose)**

22. Does it require light energy? **No**

23. Does it require CO_2? **Yes** H_2O? **No**

24. A) Can this process occur during the night time? **Yes**

B) If not, why? If so, how?

As long as the ATP and NADPH fuel is available from the light reactions

25. What do these reactions use for fuel?

    ATP and NADPH

26. What two (2) substances combine to form the 6-carbon PGAL?

    RuBP and Carbon Dioxide

27. The RuBP & Carbon Dioxide combo splits into two 3-carbon acid molecules. What is required for these to be converted to carbon sugars?

    ATP and NADPH

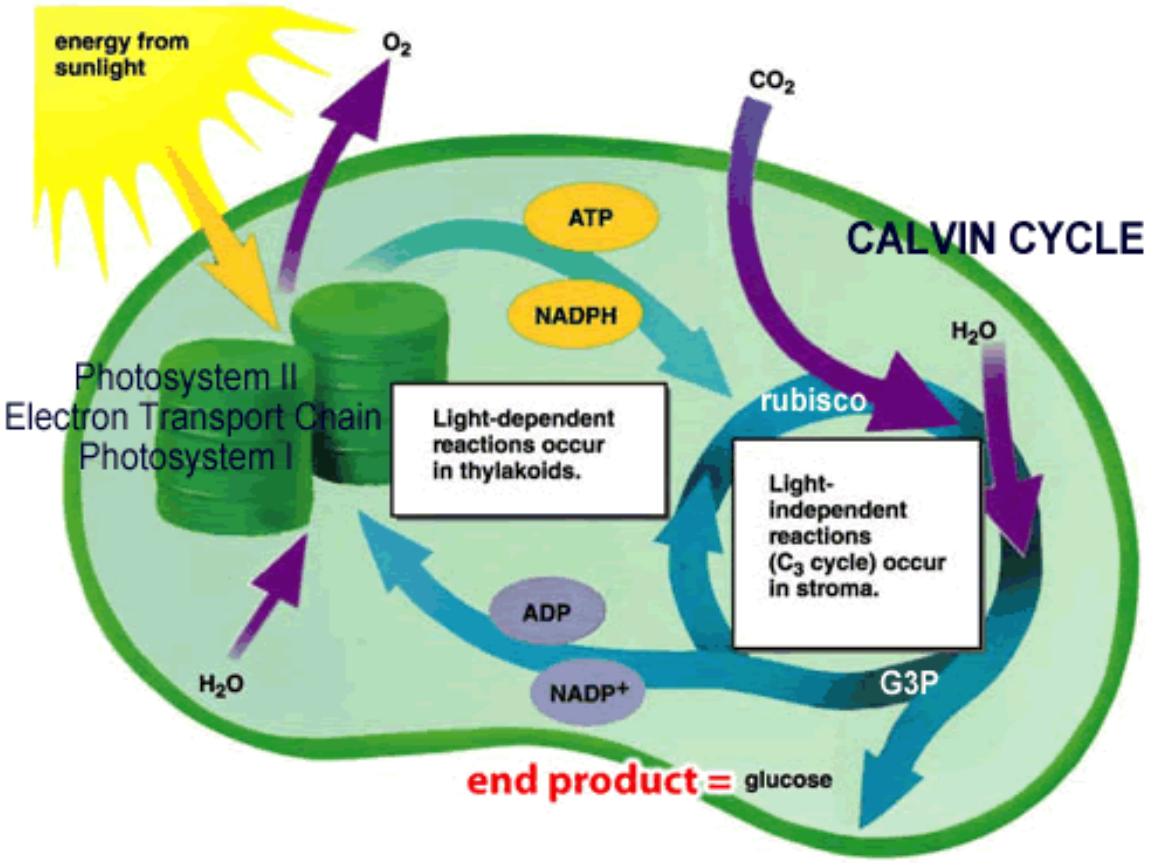
28. A) How many molecules of 3-carbon sugars are formed for every 6 molecules of CO_2 that enter the cycle? **12**

    B) How many of these leave the Calvin cycle and are used to produce 6-carbon glucose? **2**

    C) How many of these are converted back to RuBP? **10**

29. Why is it referred to as a "cycle"?

    The RuBP is reformed to combine with CO_2 again.



Hotel Room Tests Uncover High Levels Of Contamination

Posted: Dec 8, 2012

A CBC Marketplace investigation has uncovered potentially dangerous levels of filth and contamination in hotel rooms across the country. In the largest-ever survey of Canadian hotel cleanliness, Marketplace tested thousands of individual spots inside hotel rooms at a wide spectrum of chains in Montreal, Vancouver and Toronto. More than 800 "high-touch" spots were tested in 54 rooms at six hotel chains, including budget hotels EconoLodge and Super 8, mid-range hotels Best Western and Holiday Inn and the luxurious Fairmont and Sheraton.

Scientific analysis found high levels of contamination creating potentially hazardous conditions for guests. Guelph University microbiologist Keith Warriner conducted the tests for Marketplace and found alarming results. "I wasn't expecting [bacteria] to be so prolific," he said. "I was really surprised at the lack of sanitation. [Maids] make it look nice, but [they're] not making it sanitary, which is totally different."

Top 3 Hot Spots

Warriner tested common "hot spots" in hotel rooms using an adenosine triphosphate (ATP) measuring device that determines microbial contamination on surfaces. A scan of any surface gauges the level of contamination with a simple numerical value, employing a scale used in similar tests in schools and offices. An ATP level under 300 is considered a "pass," while anything between 300 and 999 is in considered to be in the "caution zone." An ATP level over 1,000 is deemed a fail.

Marketplace's test found that bed comforters, bathroom faucets and TV remotes were the top three dirtiest spots in hotel rooms. Comforters were the most consistently contaminated spot, rating a "fail" in 23 out of 51 tests, or nearly half of the tests. The highest contamination count for a comforter was found at a Super 8 hotel in Montreal with a 26,124 ATP level. Though doctors recommend proper hand washing to protect yourself from illness, faucets in hotel rooms were quite dirty themselves, with 16 fails out of 54, or a failure rate of 30 per cent. The Holiday Inn Toronto Downtown Centre had the highest contamination count for a faucet with an 11, 374 ATP level. Over 70 per cent of remote controls tested were rated a caution or fail. The highest contamination count for a remote came from the Fairmont Hotel Vancouver, with a 22,292 ATP level. Other major hot spots included bed throws, bathroom sinks, toilet bases and telephones.

Dangers of contamination

Bacteria is common in homes but hotels pose a greater threat because the germs come from thousands of strangers, said Warriner. "In a hotel, you've absolutely got no sort of notion of a history," he said. Warriner was shocked at the high levels of contamination revealed in the tests. "I was absolutely amazed to see how high those [ATP] counts were," he said. "They were beyond the sort of limits that you would accept even as a moderately sanitized surface. Those ATP counts, both in the comforters, and all around the hotel to be honest, were very alarming." He says comforters in particular

can pose a threat to guests. “When we step into a bed, we're exposing our bodies to it,” he said. “And we're there for a long time." “This poor comforter is getting exposed to all these different people, depositing their microbes down, and you're just acquiring theirs. So it's a significant transfer route.” Intimate exposure to highly contaminated areas like in a bed or on a toilet seat, is particularly dangerous, he warned, as it could lead in rare cases to myriad illnesses including urinary tract infections or sexually transmitted diseases.

'Looks are deceiving'

Warriner also used an ultraviolet light to search for stains otherwise invisible to the naked eye. Used in rooms that otherwise appeared clean, he discovered stains he said could be either from urine or beer, a coffeemaker covered in so much organic material that it appeared not to have been cleaned at all and a pillow with so much bacteria it has “its own life story.” “There's every chance that [guests] do get sick,” he said. “It's just that they don't realize it's the hotel bed they were sleeping on. “It just goes to illustrate that looks are deceiving,” he added.

Quality doesn’t count

Warriner was also surprised that high-end hotels were no cleaner than budget ones. Budget hotel Super 8 had among the cleanest bathrooms in the study, Warriner said. “The top-end hotels, they all really performed equally as bad," he said. A Montreal Best Western had among the overall best results, whereas some of the dirtiest bathroom surfaces were found in Fairmont rooms. “If you're going to pay the extra money for a top-end hotel, don't expect to have better sanitation,” he added.

Why so dirty?

Overburdened hotel staff is the main reason that many rooms are so filthy, says longtime hotel housekeeper Brigida Ruiz. Ruiz, who has worked at the Toronto Sheraton Centre for 21 years, says housekeepers have an extensive task list for cleaning each room, but rarely have enough time to complete it. Canada’s hotel union tries to enforce a cap 15 to 16 rooms cleaned per shift, giving staff approximately 30 minutes per room. Ruiz says that isn’t enough. At that rate, Ruiz says she can't complete her list of required tasks. “I wouldn't finish the 16 rooms perfectly because there's so many steps that you need to follow,” said Ruiz in reference to the required task list. “If they want it to be spotless, that will take so much time.” She said many housekeepers work unpaid overtime to reach their daily targets, but many still use time-saving “shortcuts” like not dusting or vacuuming. The way to ensure well-cleaned rooms is for management to relax its demands, she says. “My argument is that I say, ‘You have to give us less rooms,’ she said. “That's not going to happen.”

In response to the Marketplace tests, Fairmont Hotels replied with a statement saying the findings were "completely unacceptable to us and obviously inconsistent with our standards," and also pledged to pursue "retraining of all cleaning procedures and protocols." Starwood Hotels, which owns the Sheraton chain, said it is "taking [Marketplace's] findings very seriously" and made a similar pledge to revisit training and supervisory procedures. Holiday Inn parent company International Hotels Group also replied with an email saying, in part, "the health, safety and comfort of guests at all IHG hotels are important to us" and that it would investigate any reports of non-compliance.

W5 of Cellular Respiration

W5's	Glycolysis	Kreb Cycle	Electron Transport System
Who	Glucose, 3 carbon molecules ATP ↔ ADP, CO_2, O_2, NAD^+ ↔ NADH, Ethanol, Lactic Acid	Acetic Acid, CoA, CO_2 NAD^+ → NADH Oxaloacetic Acid Citric Acid ADP → ATP	NADH → NAD^+ H^+, e^-, O_2 ADP → ATP H_2O
What	Storing energy as ATP and NADH as glucose is converted to two 3 carbon molecules then Pyruvic Acid ***With O_2***: 44% efficient, goes into mitochondria making acetic acid and CO_2 ***Without O_2***: 3.2% efficient, produces lactic acid in animals, produces ethanol in plants	Acetic acid joins with CoA to form Acetyl CoA who then joins with Oxaloacetic Acid (releasing CoA) to form Citric Acid. Citric Acid is broken down to release CO_2 and storing energy (ATP and NADH) until Oxaloacetic Acid remains.	NADH drops off H^+ and $2e^-$ to form NAD^+. The e^- bounce across the inner membrane pulling H^+ inside increasing the concentration. Some bond with O_2 to form H_2O while others go down the concentration gradient regenerating ATP from ADP.
Where	Cytosol/Cytoplasm	Matrix of Mitochondria	Cristae of Mitochondria
When	Glucose is available inside the cell	When Acetic Acid is available as fuel	When NADH is available as fuel and O_2 is available.
Why	To split glucose molecules in both the absence and presence of oxygen to store released energy in a usable form (ATP&NADH)	To completely break down the 6 carbon molecule releasing the energy, storing it in a useable form and releasing CO_2	To regenerate NAD^+ for glycolysis, form H_2O and regenerate ATP storing the released energy from glucose in a useable form.

W5 of Cellular Respiration

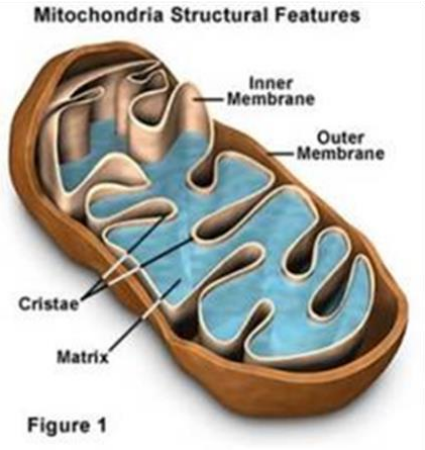
W5's	Glycolysis	Kreb Cycle	Electron Transport System
Who			
What			
Where			
When			
Why			

Cellular Respiration =

Breaking Down Glucose Releasing Energy

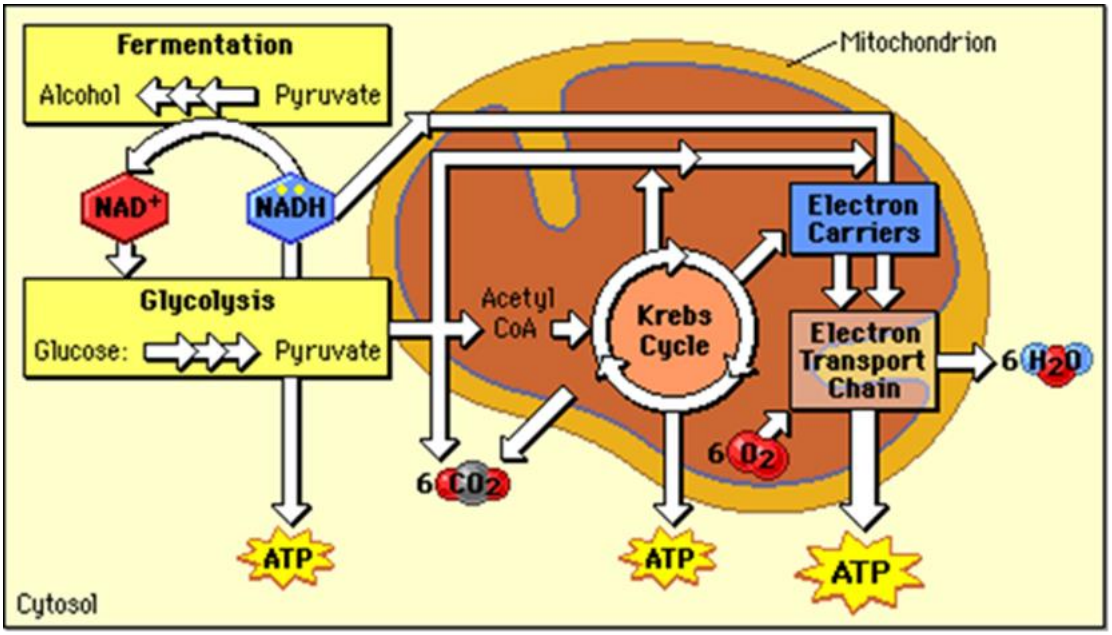
$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 36ATP$$

Cells require a continuous supply of energy. This energy comes from the food we eat. We **metabolize food releasing this stored energy** through digestion. Cells release energy from the building blocks of food (macromolecules) through a type of **controlled burning** called **cellular respiration**. Cellular respiration in humans is mainly an **aerobic** activity (requires oxygen). The oxygen and macromolecules move across the cell membranes via passive or active transport. The **primary macromolecule used in cellular respiration is glucose** ($C_6H_{12}O_6$). During respiration, the energy stored in the bonds of the glucose molecule is released slowly as the molecule is broken down.



Three Stages of Cellular Respiration:

1. **Glycolysis** – glucose is split into two 3-carbon molecules and converted into pyruvic acid with some of the released energy being stored as ATP. It can happen both in the presence of oxygen (**aerobically**) and without oxygen (**anaerobically**). Glycolysis takes place in the cytoplasm/cytosol.
2. **Kreb's Cycle** – each of the 3-carbon glucose fragments are ripped apart forming 6 carbon dioxide. Hydrogen atoms are also released. NADH energy carriers carry the hydrogen atoms to the next stage. The Kreb's Cycle takes place in the matrix (inner space) inside of the mitochondria.
3. **Electron Carrier System** – The large amount of energy released from the original glucose molecule is finally stored in several smaller amounts in ATP. Each hydrogen atom is separated into a hydrogen ion and electron before being transferred through many small steps to oxygen, eventually forming water. The Electron Carrier System takes place across the cristae (inner membrane) inside the mitochondria.

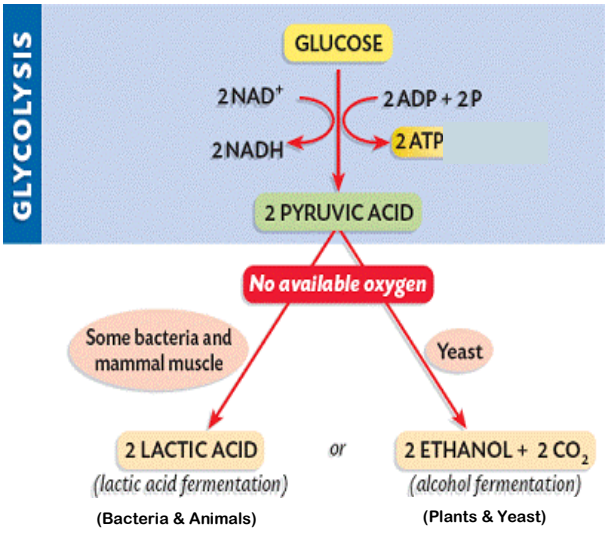


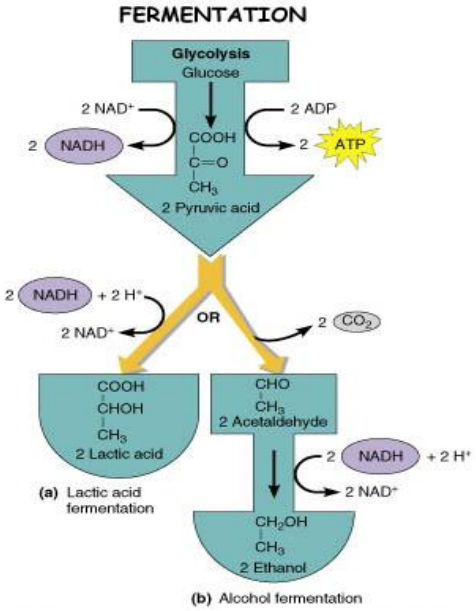
Cellular Respiration Overview:

Cellular Respiration Intro

Cellular Respiration: Glycolysis

"Splitting of Glucose in the Cytoplasm"





The Process:

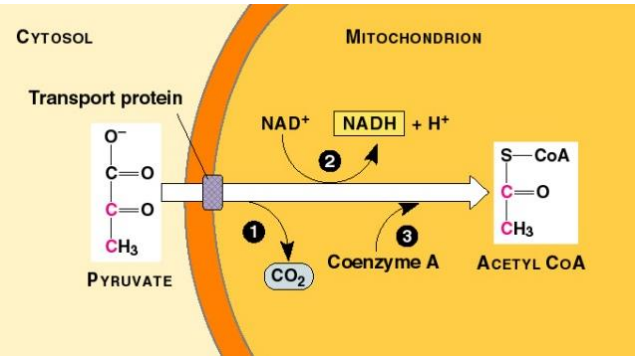
Energy is released as the glucose (6-carbon) molecule bonds are broken down into PGAL (3-carbon) molecules the PGAL molecules are converted into pyruvic acid (3-carbon), otherwise known as pyruvate. This glucose energy is released and captured in 2 ATP, 2 NADH, 2 CO_2, and pyruvate/pyruvic acid.

Option 1: Oxygen <u>IS NOT</u> Available = ANAEROBIC = FERMENTATION = Traps 3.2% Available Energy

The purpose of fermentation is to regenerate the supply of NAD+ that would have been done by the Electron Transport System if oxygen was available. In mammals, the pyruvic acid is turned into lactic acid through **Lactic Acid Fermentation**. This often occurs during strenuous effort exercise done for less than 2 minutes and/or when not enough oxygen is delivered to muscles to keep pace with the rapid rate of glycolysis required to fuel your moving body. The lactic acid acidifies your blood, which quickens your breathing to increase the amount of oxygen being carried to your muscles. This allows glycolysis to be carried out aerobically which is much more effective than fermentation. As lactic acid (a.k.a. lactate) accumulates in your muscle cells, it lowers the pH and contributes to muscle fatigue and DOMS (Delayed Onset Muscle Soreness). In plants, the pyruvic acid is turned into ethyl alcohol (ethanol) and carbon dioxide through **Alcoholic Fermentation**.

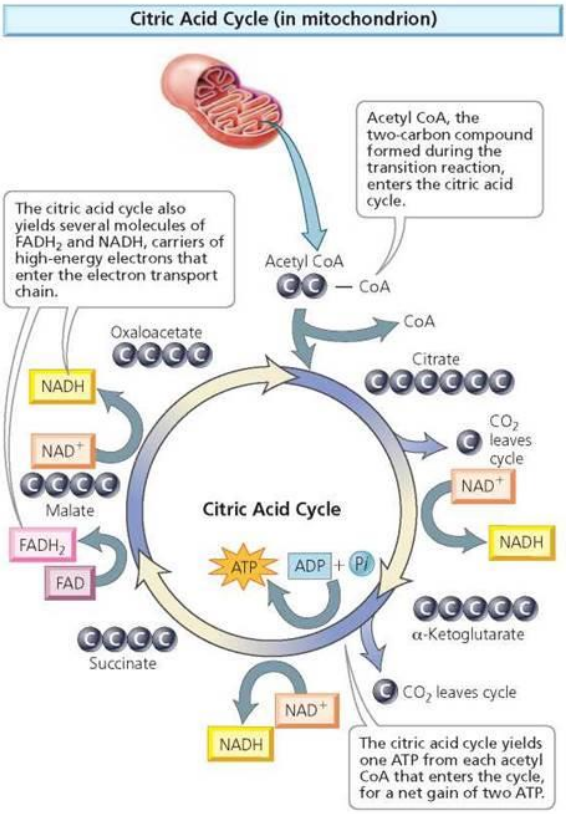
Option 2: Oxygen <u>IS</u> Available = AEROBIC = Traps 44% Available Energy

Pyruvic acid only crosses across the plasma/cell membrane of the mitochondria when **insulin** is present. Pyruvate is broken into acetic acid (2-carbon) producing CO_2. Acetic acid joins up with CoA (coenzyme A) to form the carrier molecule acetyl CoA, the main fuel for the Kreb's Cycle. The original glucose molecule is now broken down into 2 acetyl groups and 2 carbon dioxide.



Cellular Respiration: Kreb's/Citric Acid Cycle

"Completing Carbon Pathway of Destruction in the Matrix"



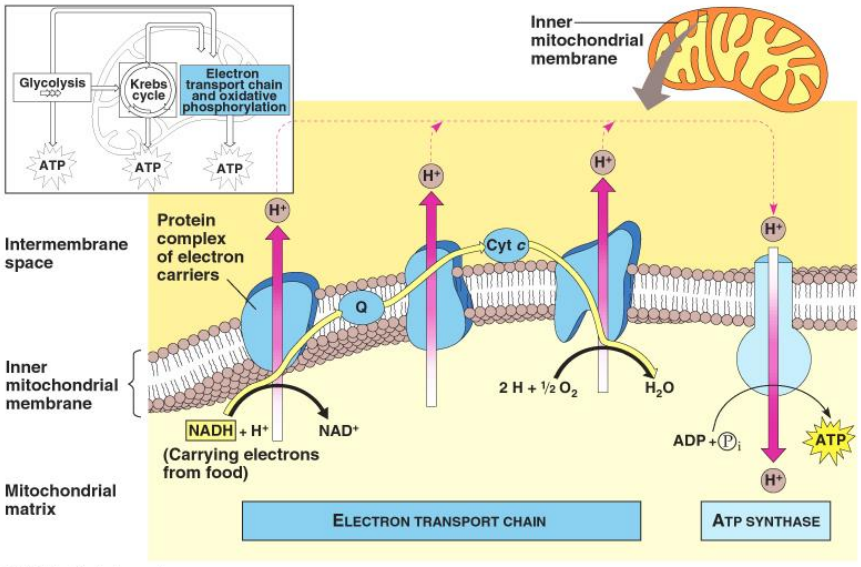
Glycolysis doesn't release ALL of the energy that glucose is capable of releasing. The acetyl CoA is further broken down in the Kreb's Cycle until the entire carbon chain has been broken down. Glycolysis and the Kreb's Cycle are often referred to as the **carbon pathway** for this reason. The Kreb's Cycle produces 4 carbon dioxide, 4 NADH, 2 $FADH_2$ and 2ATP.

Acetyl CoA enters the matrix of the mitochondria. An enzyme combines the **acetic acid** from the acetyl group (2-carbon) with **oxaloacetic acid** (4-carbon), CoA (coenzyme) is then released. Through a series of reaction, hydrogen, electrons, and 2 carbon atoms are stripped from the citric acid molecule. Oxaloacetic acid remains, ready to start the cycle all over again.

Cellular Respiration: Electron Transport System

"Packaging Energy As ATP In The Inner Membrane"

The Electron Transport System produces NAD+, 6 H_2O and 34 ATP. Enzymes in the inner membrane **transfer electrons and H^+ from NADH** across the membrane as they pump H^+ into the inter-membrane space. A **concentration gradient** forms as the H^+ build up along the outer part of the membrane allowing them to diffuse through the **ATP Synthase complex** forming ATP. The remaining electrons, hydrogen ions, and oxygen then **combine to form water**.



©1999 Addison Wesley Longman, Inc.

Miss Foley

Bio30: OL1 Cells Intro **Cellular Respiration Review**

Cellular Respiration: General Questions

1. What is its purpose?
2. Describe the general process (include the equation)?

3. How many ATP does it produce, overall?
4. List the three (3) stages of cellular respiration.

5. Why are ATP & NADH referred to as "energy carriers"?

6. Where does the NADH carry its 2 electrons and hydrogen?

Glycolysis Questions **(*Glycolysis ending with Pyruvic Acid/Pyruvate)**

7. Where does it take place?
8. What is its purpose?

9. How many ATP, NADH and CO_2 are produced?
10. Does it require O_2?
11. a) When O_2 isn't available, how does glycolysis proceed in plants?
    b) In animals?
12. a) How much of the available energy in glucose is converted to ATP when O_2 is available?
    b) When O_2 isn't available?
13. a) Why does the pyruvic acid have to be converted to Acetyl CoA?

    b) Where does this take place?

The Krebs (Citric Acid) Cycle

14. Where does it take place?
15. What is its purpose?
16. How many ATP, NADH and CO_2 are produced?
17. Does it require O_2?

18. Why is CoA referred to as a "carrier molecule"?

19. Why is it referred to as a "cycle"?

20. a) What is formed when acetyl CoA is combined with oxaloacetic acid?

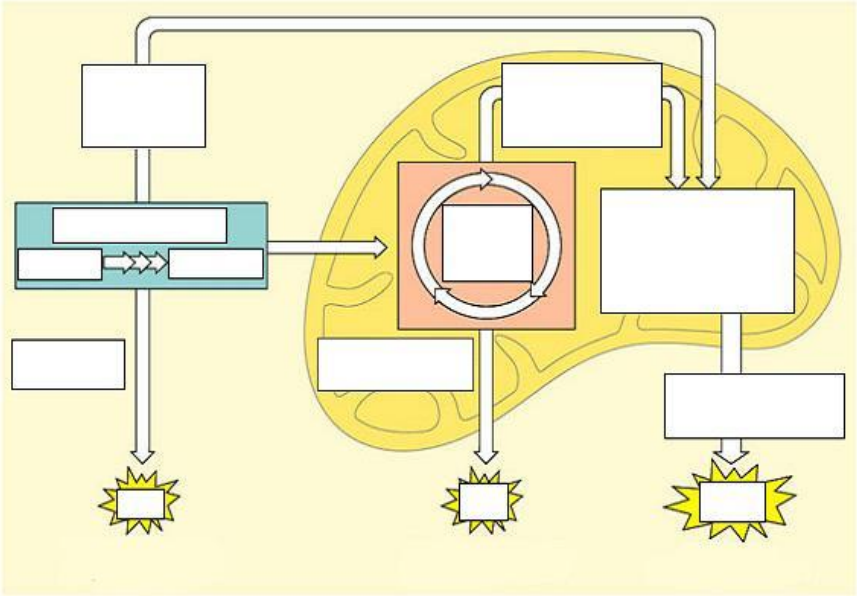
    b) What is released?

The Electron Transport System

21. Where does it take place?
22. What is its purpose?
23. How many ATP, NADH, CO_2 and H_2O are produced?
24. Does it require O_2?
25. The electron carriers in the inner membrane are made up of what type of matter?
26. Why is there a buildup of H^+ and protons in the inter-membrane space?

27. What happens as a result of this high concentration of H^+ and protons in the inter-membrane space?

28. How are the 34 ATP generated?



29. What is formed as the electrons are carried across the inner membrane and energy is released?

Miss Foley

Bio30: OL1 Cells Intro **Cellular Respiration Review KEY**

Cellular Respiration: General Questions

30. What is its purpose? **To break down glucose to release energy**
31. Describe the general process (include the equation)?

    $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 36ATP$
32. How many ATP does it produce, overall? **36**
33. List the three (3) stages of cellular respiration.

    Glycolysis, Kreb Cycle, Electron Transport System
34. Why are ATP & NADH referred to as "energy carriers"?

    Because they "carry" electrons that have been used/stored for energy
35. Where does the NADH carry its 2 electrons and hydrogen?

    Electron Transport System

Glycolysis Questions (*Glycolysis ending with Pyruvic Acid/Pyruvate)

36. Where does it take place? **Cytoplasm**
37. What is its purpose?

    Break glucose down into pyruvic acid (without O_2) or acetic acid (with O_2)
38. How many ATP, NADH and CO_2 are produced? **4, 2, 0**
39. Does it require O_2? **No**
40. a) When O_2 isn't available, how does glycolysis proceed in plants? **Ethanol**

    b) In animals? **lactic acid**
41. a) How much of the available energy in glucose is converted to ATP when O_2 is available? **44%**

    c) When O_2 isn't available? **3.2%**
42. a) Why does the pyruvic acid have to be converted to Acetyl CoA?

    Because it's the main fuel for the Kreb's Cycle

    c) Where does this take place? **Matrix of the mitochondria**

The Krebs (Citric Acid) Cycle

43. Where does it take place? **Matrix of the mitochondria**
44. What is its purpose? **Release energy by fully breaking down carbon chain**
45. How many ATP, NADH and CO_2 are produced? **4, 6, 4**
46. Does it require O_2? **No**

47. Why is CoA referred to as a "carrier molecule"?

It is used and reused as it combines with the acetic acid to form acetyl CoA; the carbon chain is broken down leaving the CoA to start over

48. Why is it referred to as a "cycle"? **Oxaloacetic acid is used and reused**

49. a) What is formed when acetyl CoA is combined with oxaloacetic acid?

Citric acid

c) What is released? **CoA**

The Electron Transport System

50. Where does it take place? **Cristae (inner-membrane space)**

51. What is its purpose? **ADP→ATP, water and NAD+→NADH production**

52. How many ATP, NADH, CO_2 and H_2O are produced? **34, 0, 0, 6**

53. Does it require O_2? **Yes**

54. The electron carriers in the inner membrane are made up of what type of matter? **Enzyme Complex**

55. Why is there a buildup of H^+ and protons in the inter-membrane space?

NADH drops off H+ and electrons; electrons go to the electron transport system and the H+ build up

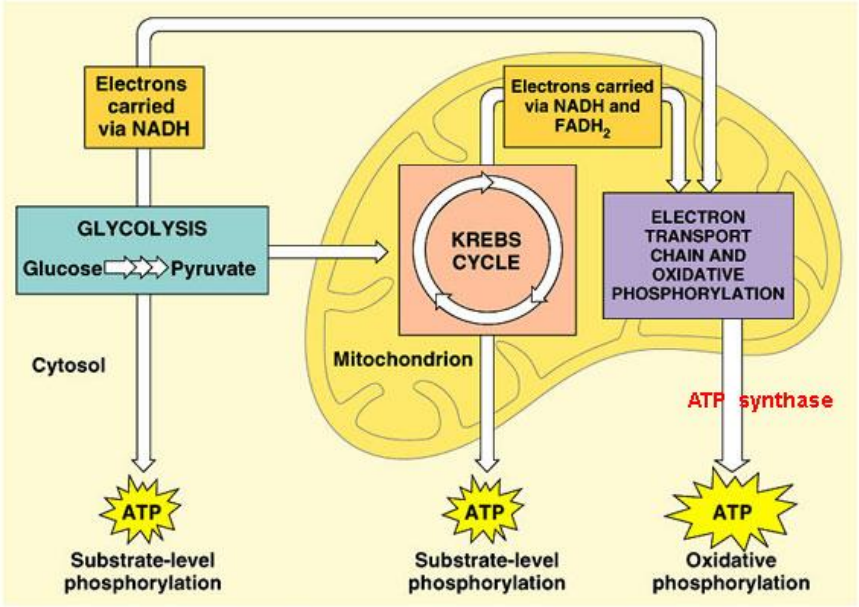
56. What happens as a result of this high concentration of H^+ and protons in the inter-membrane space?

Concentration gradient forms and H+ cross the membrane to regenerate ATP and form water

57. How are the 34 ATP generated?

H+ pass down the concentration gradient pulling phosphate closer & providing enough energy to attach the phosphate to ADP→ATP

58. What is formed as the electrons are carried across the inner membrane and energy is released? **Water**



Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.

Name: _____ Date: _____

Bio30: OL1 Cells Intro **Archaeans**

Structural & Biochemical Adaptations

Define each of the **archaeans** (a domain and kingdom of single-celled prokaryote microorganisms) before researching their adaptations.

http://www.microbeworld.org/types-of-microbes/archaea
http://learn.genetics.utah.edu/content/astrobiology/environments/
http://eol.org/info/457

Halophiles –

https://www.quora.com/What-are-the-biochemical-adaptations-that-halophiles-salt-loving-microbes-make-to-protect-their-proteins-lipids-DNA

Structural Adaptations:

Biochemical Adaptations:

Thermoacidophiles -

http://bitesizebio.com/2169/the-secrets-of-thermophile-survival-part-i/
http://bitesizebio.com/2462/how-thermophile-dna-survives/

Structural Adaptations:

Biochemical Adaptations:

Methanogens -

https://academic.oup.com/femsre/article/38/3/449/533519
https://www.sciencedaily.com/releases/2014/05/140519114248.htm
http://www.vet.ed.ac.uk/clive/cal/rumencal/Info/infMeth.html
https://methanogen.weebly.com/methanogens.html

Structural Adaptations:

Biochemical Adaptations:

Microbiology: Tools & Techniques

Research how the tools and techniques have enabled scientists to develop deeper understandings of cell structure & processes.

Light Microscopes –

Transmission Electron Microscopes –

Scanning Electron Microscopes –

Culturing Cells –

Cell Fractionation -

How Unicellular Organisms Move

Unicellular = single celled

Pseudopods =
cytoplasm-filled projections used for movement and feeding
pseudo = "false"; pods = "feet"

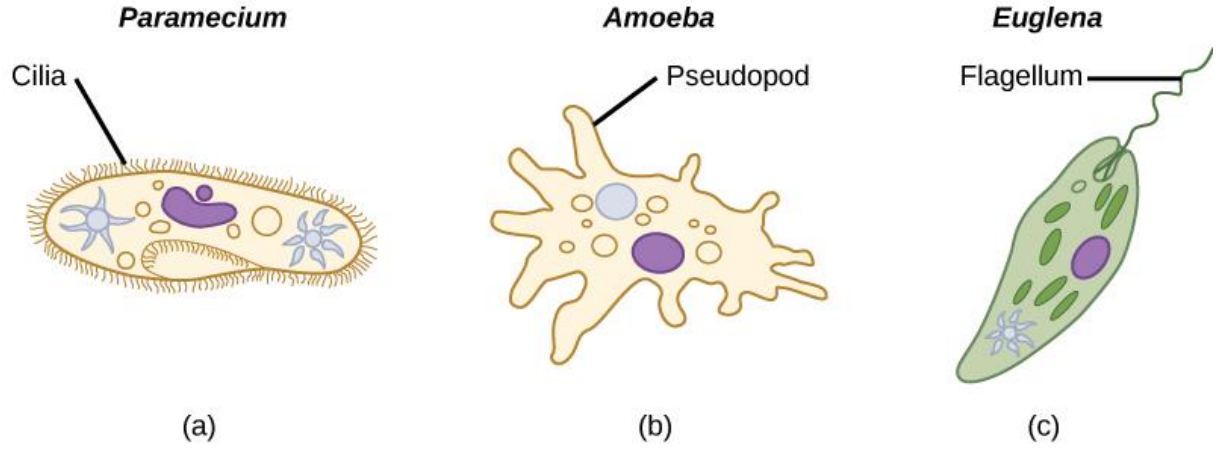
Pseudopods are actually extensions of the **cytoplasm**. Example organisms include **amoeba** and **human white blood cells.** The organism can change the shape of the pseudopod, making it move, appear, and disappear. The pseudopods are used in movement and as a tool to capture prey. In order to move using pseudopods, the organism pushes cytoplasm towards one end of the cell, which makes a projection, or pseudopod, off the cell. This projection holds the organism in place, and the rest of the cell can follow, thus moving it forward. For feeding, organisms extend their pseudopods, engulf their prey and then digest them using enzymes.

Cilia =
hair-like appendages used for movement and feeding

Cilia are little hair-like appendages that stick out from eukaryotic cells. They whip back and forth and help cells move around in cellular fluids. They also help particles move past the cell. Cilia are really tiny—only about 0.1 millimeters long. There are two categories of cilia. First, there are **motile cilia**, which help the cell move around in cellular fluids and help move fluids past the cell. The second type is **non-motile cilia**, and these are responsible for sensing the surrounding environment. Example organisms include **paramecium**.

Flagella =
single whip-like appendage used for movement

Flagella are found in all three domains of the living world: bacteria, archaea, and eukaryota, also known as protists, plants, animals, and fungi. While all three types of flagella are used for locomotion, they are structurally very different. It is similar to cilia in structure, though cilia generally move in a back and forth motion, as opposed to the corkscrew movement of a flagellum. Example organisms include **euglena**.



Name: _____ Date: _____

Bio30: OL3 Classification **Classification Intro**

Classification Systems

1. How do classification systems meet our human needs?

2. How do First Nations, Metis, and Inuit people represent their understandings of relationships among living things?

3. Taxonomy is the science of classifying and naming living things. What is the structure of our current classification system in biology?

4. Who are some scientists that contributed to developing the accepted scientific conventions for naming organisms currently known as binomial nomenclature?

5. Specifically, what was the contribution of Carl Linnaeus?

Name: _____ Date: _____

Bio30: OL3 Classification **Classification Intro KEY**

Classification Systems

1. How do classification systems meet our human needs?

   Brings order to chaos; comfort in predictability; common ground for clarity of communication; meets curiosity need to know;

2. How do First Nations, Metis, and Inuit people represent their understandings of relationships among living things?

   Mother Earth gives birth to, nurtures and sustains all life. Indigenous peoples are caretakers of Mother Earth and realize and respect her gifts of water, air and fire. This relationship is based on a profound spiritual connection to Mother Earth that guided indigenous peoples to practice reverence, humility and reciprocity. Everything is taken and used with the understanding that we take only what we need, and we must use great care and be aware of how we take and how much of it so that future generations (next seven generations) will not be put in peril.

   The intense and deep interconnected relationships with all living things are called the Sacred Circle of Life. First Nations teachings guide us to show respect for all within this Sacred Circle. This includes a connection to Mother Earth and all that the Universe contains, including other people (personal relationships, family, neighborhoods, communities, nations), all of the plant beings and four legged brothers and sisters, the finned and flying beings, and ultimately the Great Spirit that animates all.

   Classifications within the Sacred Circle are represented by a pyramid with two-legged people being the base of the pyramid moving up each level with four-legged people, swimming/winged people, creepy crawling people, standing people, rock/fire/air/water, sun/moon/earth/stars, finishing with Creator at the top of the pyramid.

3. Taxonomy is the science of classifying and naming living things. What is the structure of our current classification system in biology?

   Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species

4. Who are some scientists that contributed to developing the accepted scientific conventions for naming organisms currently known as binomial nomenclature?

   Prior to binomial nomenclature, a scientific name consisted of a generic name combined with a specific name that was from one to several words long. Andrea Cesalpino (Italy, 1519–1603), often referred to as "the first taxonomist", described over 1500 plant species. Caspar Bauhin (1560–1624), took some important steps towards the binomial system, by pruning the Latin descriptions, in many cases to two words. Then John Ray (England, 1627–1705) published details of over 18,000 plant species. Joseph Pitton de Tournefort (France, 1656–1708) published his work which included over 9000 species in 698 genera, directly influencing Linnaeus, as it was the text he used as a young student.

5. Specifically, what was the contribution of Carl Linnaeus?

   Carolus Linnaeus devised the formal two-part naming system we use to classify all life forms called binomial nomenclature (2 word naming system). Linnaeus classified living things by looking for similarities now known as homologous structures. As a result, taxonomy started with 2 kingdoms, the plant kingdom and animal kingdom. Linnaeus was one of the founders of the science of ecology. Linnaeus also invented index cards. He did this in response to his ever growing lists of species which required a cataloging method that was easily expandable and easy to reorganize.

Carolus (Carl) Linnaeus: The Swedish Botanist & Father of Taxonomy

Despite the importance of genetics and the theory of evolution, modern taxonomy owes a great deal to an 18th century scientist who knew little of either. This scientist was Carolus Linnaeus, the great Swedish botanist. Linnaeus set up a classification system still used today.

The key to Linnaeus' system was **structural similarity**. He divided living organisms into two major groups, or **kingdoms**. He recognized only the plant kingdom and the animal kingdom. Each kingdom contained a number of smaller groups, and these in turn were divided into successively smaller groupings. The smaller the grouping, the more alike the members of the group were. **Linnaeus' system of classification recognized similarities and differences, which became the basis for his groupings of organisms.**

Common Names vs Scientific Names

Common names vary from place to place and person to person. **Scientific names** are the same everywhere.

Another practice of Linnaeus was his use of scientific names made of Latin words. Latin words are still used in classification systems today. There were good reasons for him to use Latin. Latin was the language that scientists used in the 18th century. It was understood by all scientists of all countries.

The scientific names given by Linnaeus usually described some trait of the organism. Each name was made of two or more parts. This system, still used today, is called **binomial nomenclature**, which means **two-word naming**. The first word names a larger group, the **genus**, to which the organism belongs while the second word names a smaller group, the **species**. For example, both lions and tigers belong to the genus Panthera. Therefore, the scientific name of both begin with *Panthera*. Lions are *Panthera leo* and tigers are *Panthera tigris*.

Binomial Nomenclature Rules

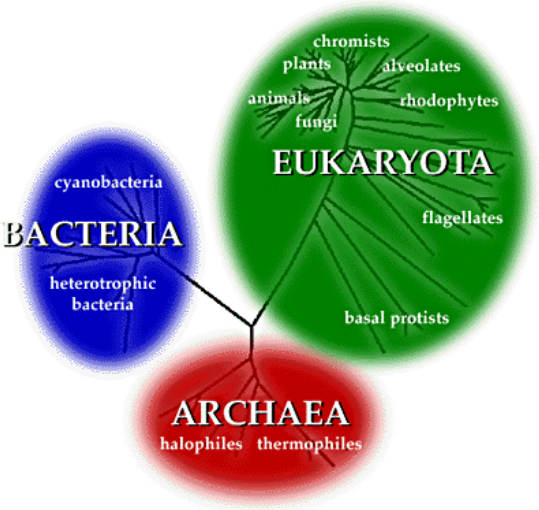
- written in *italics* or <u>underlined</u> (if handwritten)
- Genus (first word) is always CAPITALIZED
- Species (second word) is always lowercase
- The species name will tell you what type of organism is it. The genus name will be the adjective that describes the organism.

Miss Foley

Bio30: OL3 Classification **Classic Taxonomy**

Taxonomy =
the science of naming & classifying living things

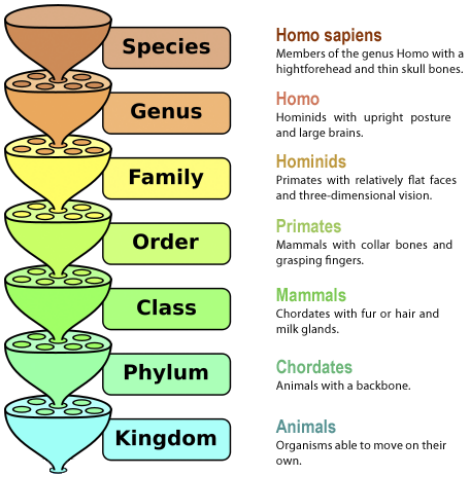
Categories within taxonomic classification are arranged in increasing specificity with the size of the groupings getting progressively smaller. **At each classification category, organisms become more similar because they are more closely related**.

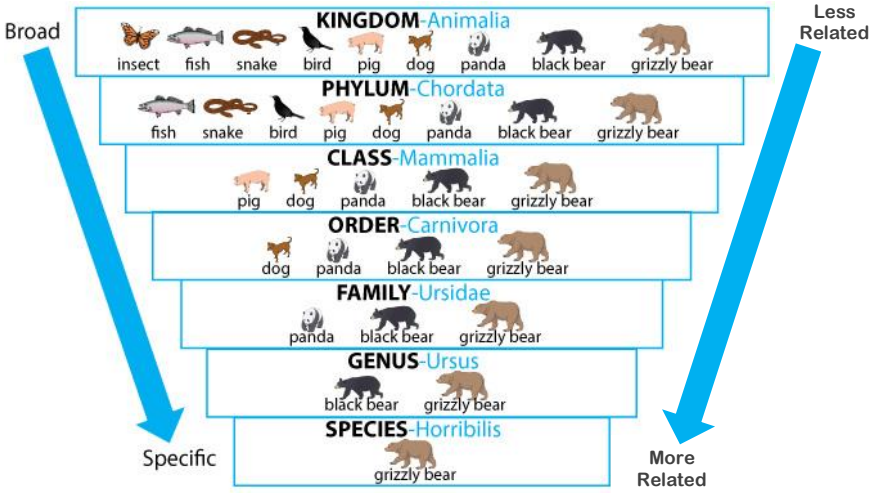


The most general category in classic taxonomic classification is **domain**, which is the point of origin for all species; all species belong to one of these domains: Bacteria, Archaea, and Eukarya.

Within each of the three domains, we find **kingdoms**, the second category within taxonomic classification, followed by subsequent categories that include **phylum, class, order, family, genus, and species**.

Do **K**ings **P**lay **C**ards **O**n **F**ridays, **G**enerally **S**peaking?





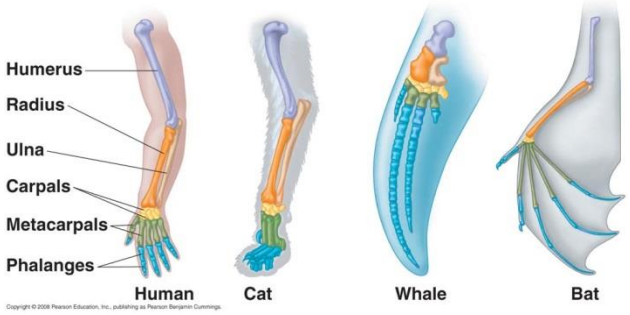
Evolution of Classic Taxonomy

The discovery of **microscopes** moved the classification system from 2 kingdoms to 3 kingdoms after the discovery of the "little cavorting beasties" now known as protists. The discovery of **types of cells and cell theory** brought the next shift to 2 empires, prokaryotes and eukaryotes. Modern **technology & technique advancements** have seen a recent addition of the 3 domains & a 6th kingdom.

Linnaeus 1735[33]	Haeckel 1866[34]	Chatton 1925[35]	Copeland 1938[36]	Whittaker 1969[37]	Woese et al. 1990[38]	Cavalier-Smith 1998[31]
2 kingdoms	3 kingdoms	2 empires	4 kingdoms	5 kingdoms	3 domains	6 kingdoms
(not treated)	Protista	Prokaryota	Monera	Monera	Bacteria	Bacteria
					Archaea	
		Eukaryota	Protoctista	Protista	Eucarya	Protozoa
						Chromista
Vegetabilia	Plantae		Plantae	Plantae		Plantae
				Fungi		Fungi
Animalia	Animalia		Animalia	Animalia		Animalia

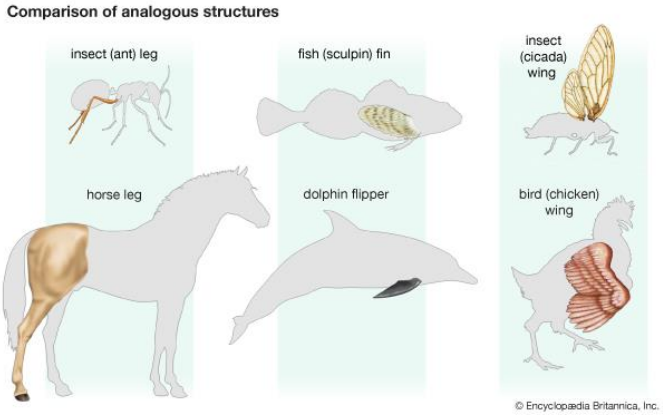
Relatedness: Basis for Classification

Related organisms are believed to have the same or common ancestors in biology. However, we must go beyond only looking at outward surface appearances when classifying.



1. **Homologous Structures** - similar structures in different organisms that have developed in the same way. Taxonomists place organisms with homologous structure in the <u>same category</u>.

   Example: arm of a human and the wing of a bat have similar bones that develop in the same way.

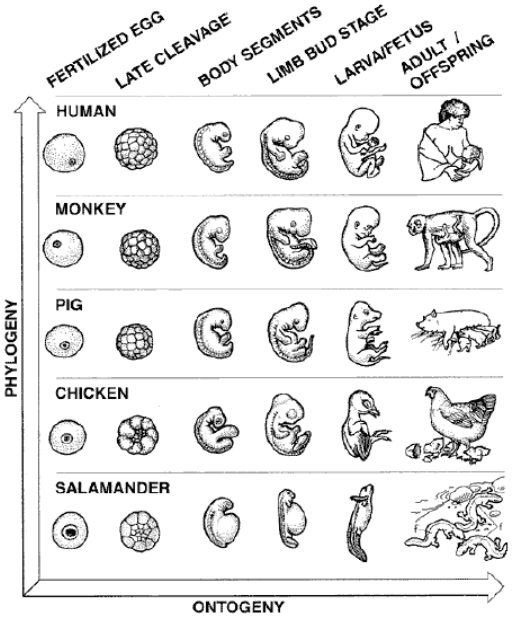


2. **Analogous Structures** – structures in organisms that have similar functions but have developed in different ways. Taxonomists place organisms with analogous structures in <u>different categories</u>.

   Example: wing of bird and wing of an insect

3. **Chemical Tests** – blood analysis one of the many chemical tests. Taxonomists put organisms with the <u>same test results</u> in the <u>same category</u>.

   Example: blood in whales is more closely related to human than to fish.



4. **Life History of Organisms (Embryology)** – the study of how organisms develop and reproduce. Taxonomists put organisms with the <u>same development</u> in the <u>same category</u>.

   Example: The embryos of humans and pigs are more alike than humans and salamanders.

5. **Breeding Studies (Biogenesis)** – if two organisms breed and produce offspring that also produce the same kind of offspring, they belong to the <u>same species</u> which puts them in the <u>same category</u>.

   Example: If a dog comes from a dog, comes from a dog, then it must be a dog.

Kingdom Characteristics

FINISH!!!!!!!!!!!!!!!!!!!!

Dichotomous Key =
tool used to identify the scientific name of organisms

Dichotomous keys consist of **a series of "either/or" choices** that lead the user to the **scientific name of a given item**. Dichotomous means "divided into two parts". Therefore, dichotomous keys always give two contrasting either/or choices at each step.

Using A Dichotomous Key

Help! Scientists have discovered quite a few new creatures on planet Pamishan. They need your help to identify and classify them. Use the dichotomous key on the next page to identify these creatures.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

11. _____

12. _____

13. _____

14. _____

15. _____

16. _____

17. _____

18. _____

19. _____

20. _____

A Dichotomous Key to New Pamishan

1. a. The creature has a large wide head.....go to 2
   b. The creature has a small narrow head.....go to 11
2. a. It has 3 eyes .....go to 3
   b. It has 2 eyes .....go to 7
3. a. There is a star in the middle of its chest.....go to 4
   b. There is no star in the middle of its chest .....go to 6
4. a. The creature has hair spikes .....*Broadus hairus*
   b. The creature has no hair spikes.....go to 5
5. a. The bottom of the creature is arch-shaped .....*Broadus archus*
   b. The bottom of the creature is M-shaped .....*Broadus emmus*
6. a. The creature has an arch-shaped bottom .....*Broadus plainus*
   b. The creature has an M-shaped bottom.....*Broadus tritops*
7. a. The creature has hairy spikes .....go to 8
   b. The creature has no spikes.....go to 10
8. a. There is a star in the middle of its body .....*Broadus hairystarus*
   b. The is no star in the middle of its body .....go to 9
9. a. The creature has an arch shaped bottom .....*Broadus hairyemmus*
   b. The creature has an M shaped bottum .....*Broadus kiferus*
10. a. The body is symmetrical .....Broadus walter
    b. The body is not symmetrical.....*Broadus anderson*
11. a. The creature has no antennae .....go to 12
    b. The creature has antennae .....go to 14
12. a. There are spikes on the face .....*Narrowus wolfus*
    b. There are no spikes on the face .....go to 13
13. a. The creature has no spike anywhere .....*Narrowus blankus*
    b. There are spikes on the right leg .....*Narrowus starboardus*
14. a. The creature has 2 eyes.....go to 15
    b. The creature has 1 eye.....*Narrowus cyclops*
15. a. The creature has a mouth.....go to 16
    b. The creature has no mouth.....go to 17
16. a. There are spikes on the left leg .....*Narrowus portus*
    b. There are no spikes at all .....*Narrowus plainus*
17. a. The creature has spikes .....go to 18
    b. The creature has no spikes .....*Narrowus georginia*
18. a. There are spikes on the head .....go to 19
    b. There are spikes on the right leg.....*Narrowus montanian*
19. a. There are spikes covering the face .....*Narrowus beardus*
    b. There are spikes only on the outside edge of head .....*Narrowus fuzzus*

Miss Foley

Bio30: OL3 Classification **Dichotomous Keys KEY**

Dichotomous Key =

tool used to identify the scientific name of organisms

Dichotomous keys consist of **a series of "either/or" choices** that lead the user to the **scientific name of a given item**. Dichotomous means "divided into two parts". Therefore, dichotomous keys always give two contrasting either/or choices at each step.

Using A Dichotomous Key

Help! Scientists have discovered quite a few new creatures on planet Pamishan. They need your help to identify and classify them. Use the dichotomous key on the next page to identify these creatures.

1. Narrowus portus

2. Broadus archus

3. Narrowus plainus

4. Broadus hairyemmus

5. Broadus hairus

6. Broadus anderson

7. Narrowus montanian

8. Narrowus georginia

9. Narrowus blankus

10. Broadus emmus

11. Narrowus cyclops

12. Broadus hairystarus

13. Narrowus beardus

14. Broadus walter

15. Broadus plainus

16. Broadus kiferus

17. Narrowus starboardus

18. Broadus tritops

19. Narrowus wolfus

20. Narrowus fuzzus

Name: _____ Date: _____

Bio30: OL3 Classification **Dichotomous Keys KEY**

Name: _____ Date: _____

Bio30: OL3 Classification **Dichotomous Keys**

Building A Dichotomous Key

1. Use the most general traits that can be used to divide organisms up into two categories. These two categories will become 1a and 1b.
   Example: 1a…… Go to 2
   1b…… Go to 3
2. Scientifically name each organism using this general trait as the genus portion of the scientific name. **Be sure to follow binomial nomenclature rules.*
3. Identify <u>one</u> (1) characteristic that is <u>UNIQUE</u> to each individual organism.
4. The second step (2a and 2b) needs to consist of a pair of either-or statements using the UNIQUE characteristic identified for that organism (2a should always ID this organism). (<u>EITHER</u> 2a - Has this trait… <u>OR</u> 2b – Does not has this trait…)
5. Every statement after the second should allow for the identification of one or two organisms.
6. The last pair of statements (ex. 5a and 5b) should identify two organisms.
7. There should be one less step then the total number of organisms to be identified in your key (if you have 6 organisms, you should have 5 paired statements to identify them all).
8. The more similarities the group of organisms has, the more difficult it is to develop the key. Try to choose characteristics that are different to make classifying the organisms easier.

1. a. _____
   b. _____
2. a. _____
   b. _____
3. a. _____
   b. _____
4. a. _____
   b. _____
5. a. _____
   b. _____
6. a. _____
   b. _____
7. a. _____
   b. _____
8. a. _____
   b. _____
9. a. _____
   b. _____

Miss Foley

Bio30: OL3 Classification **Dichotomous Keys**

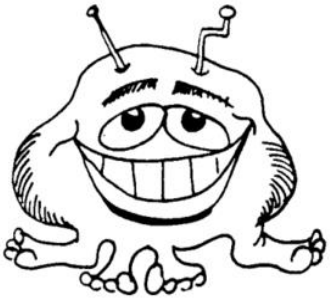
Name the Following Creatures!

1. _____

2. _____

3. _____

5. _____



4. _____

7. _____

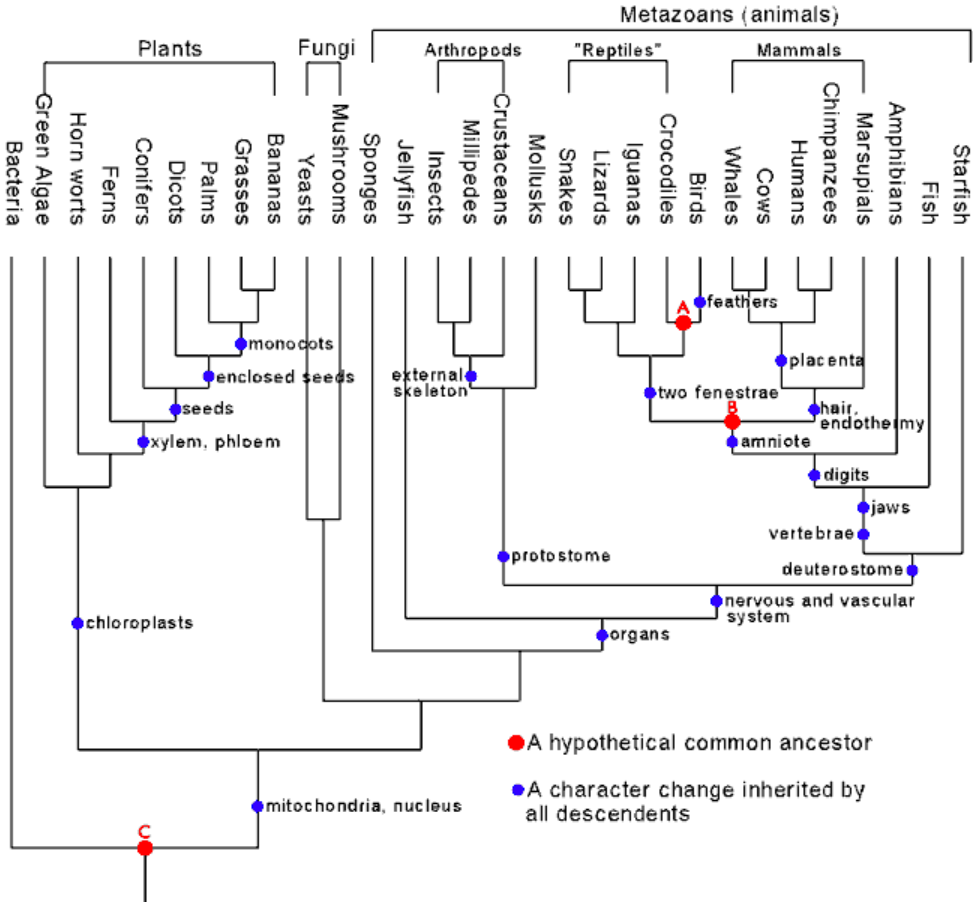
8. _____

6. _____

10. _____

9. _____

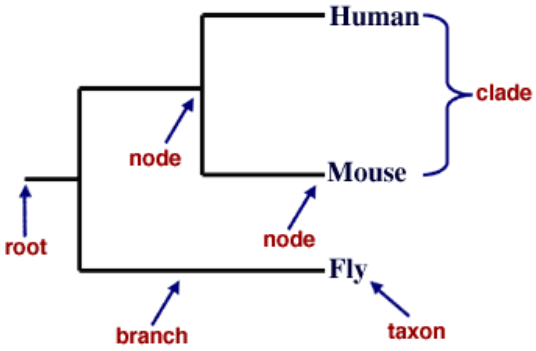
Phylogeny (a.k.a. Phylogenetics) = study of evolutionary relationships



Consensus Phylogenetic Tree of <u>ALL</u> Life

In the past, biologists grouped organisms based solely on their physical appearance. Today, with the advances in genetics and biochemistry, biologists look more closely at individuals to discover their pattern of evolution, and group them accordingly - this is called **evolutionary systematics**.

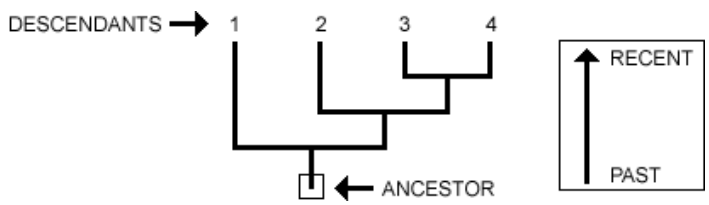
Evolutionary systematics makes an attempt to construct **phylogenetic trees** that **accurately show phyletic lineages** (proper branching on the family tree), along with a consideration of when and how new species arose and moved into new habitats and niches (established a 'new' way of life as opposed to some trivial character change).



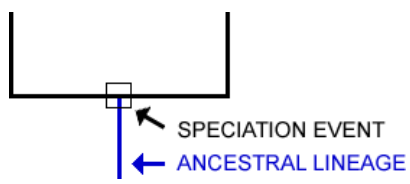
A phylogenetic tree has several parts. **Nodes** represent taxonomic units, such as an organism, a species, a population, a common

ancestor, or even an entire genus or other higher taxonomic group. **Branches** connect nodes uniquely and represent genetic relationships and timelines. The specific pattern of branching determines the tree's topology. Scaled trees have branch lengths that are proportional to some important biological property. Trees may also be rooted or unrooted. Rooted trees have a **special node, known as the root**, that represents a common ancestor of all taxa shown in the tree. Rooted trees are thus directional, since all taxa evolved from the root. Unrooted trees illustrate relationships only, without reference to common ancestors.

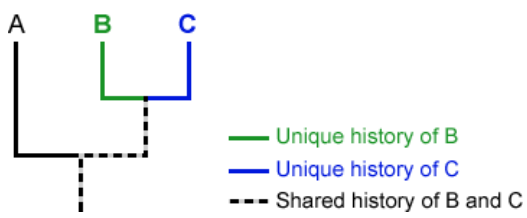
Understanding a phylogeny is a lot like reading a family tree. The root of the tree represents the ancestral lineage, and the tips of the branches represent the descendants of that ancestor. As you move from the root to the tips, you are moving forward in time.



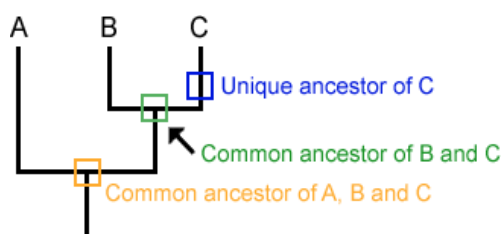
When a lineage splits (**speciation**), it is represented as branching on a phylogeny. When a speciation event occurs, a single ancestral lineage gives rise to two or more daughter lineages.



Phylogenies trace patterns of shared ancestry between lineages. Each lineage has a part of its history that is unique to it alone and parts that are shared with other lineages.

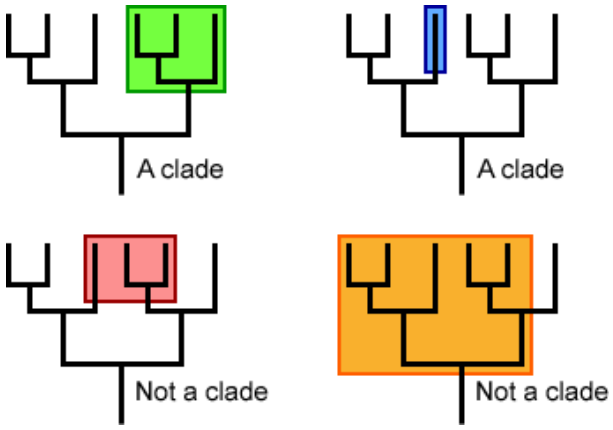


Similarly, each lineage has ancestors that are unique to that lineage and ancestors that are shared with other lineages — **common ancestors**.

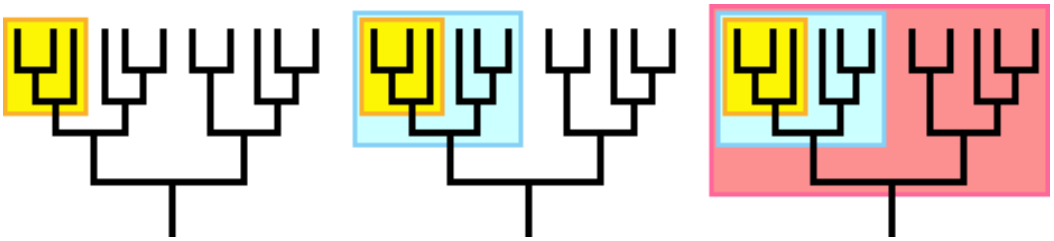


Cladistics is a form of analysis that looks at features of organisms that are considered "innovations", or newer characteristics that serve some kind of purpose and are called **derived characteristics**. These characteristics appear in later organisms but not earlier ones. Phylogenetic trees and cladograms attempt to visually demonstrate these evolutionary relationships. Both methods have their strengths and weaknesses. Cladistics, however, ignores when and where a branch occurs, tries to use purely objective criteria, and defines each branch point by a fundamental character of evolutionary significance. Cladistics gets its name from the branches on the family tree called clades. A **clade** is a grouping that includes a common ancestor and all the descendants (living and extinct) of that ancestor.

Using a phylogeny, it is easy to tell if a group of lineages forms a clade. Imagine clipping a single branch off the phylogeny — all of the organisms on that pruned branch make up a clade.



Clades are nested within one another — they form a nested hierarchy. A clade may include many thousands of species or just a few. Some examples of clades at different levels are marked on the phylogenies below. Notice how clades are nested within larger clades.

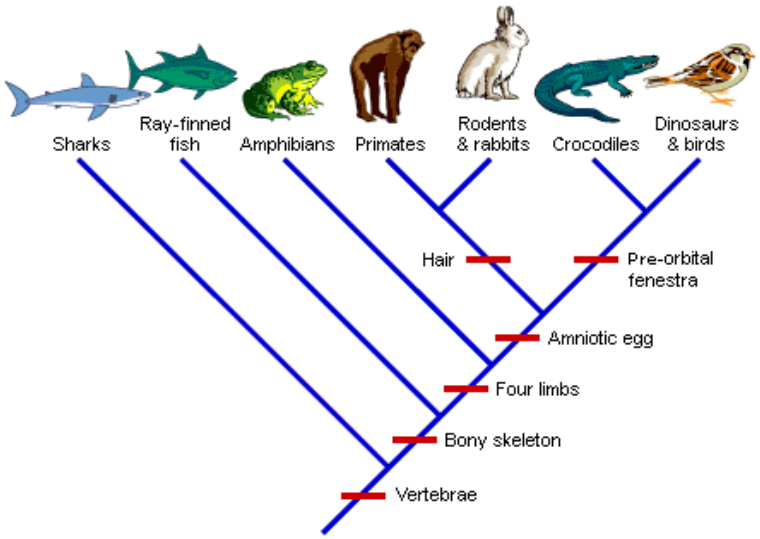


A **cladogram** is a stylized diagram that visually represents these clades and derived characteristics. At each branch, or "Y" junction, derived characters of evolutionary origin are used to separate off one group from the rest. At every branch, one of the organisms that does not share a common character with the rest of the group is "branched off" into its own clade. The order, or sequence, of these branches depends on how many characters are left within the larger group.

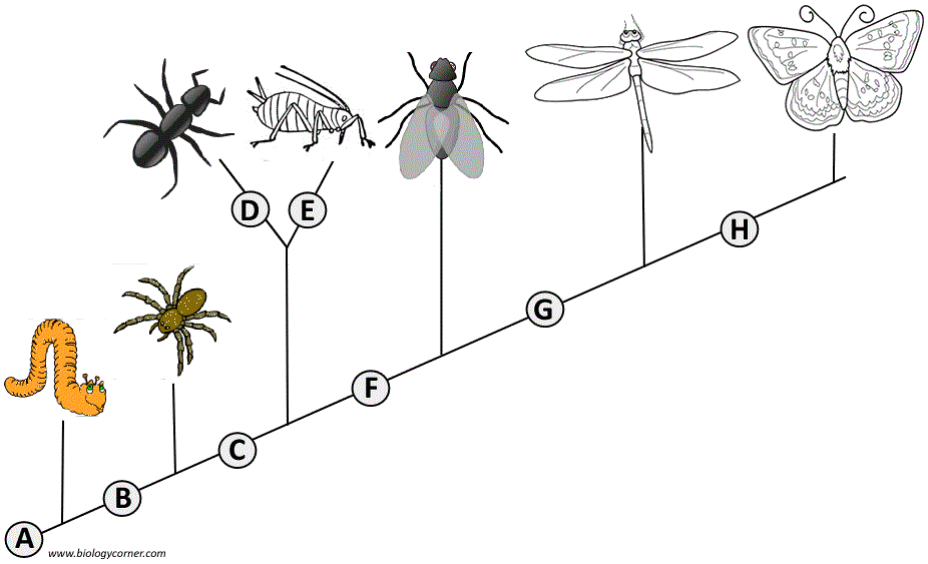
Miss Foley

Bio30: OL3 Classification **Modern Taxonomies**

Cladograms emphasize the sequence or order in which derived characters arise from a central phylogenetic tree. That is their main strength. However, nothing in a cladogram indicates how strong or profound the derived character is, and its evolutionary importance. Equal weight is given to all the characters used. This can sometimes lead to unusual groupings which may be technically correct, but questionable.



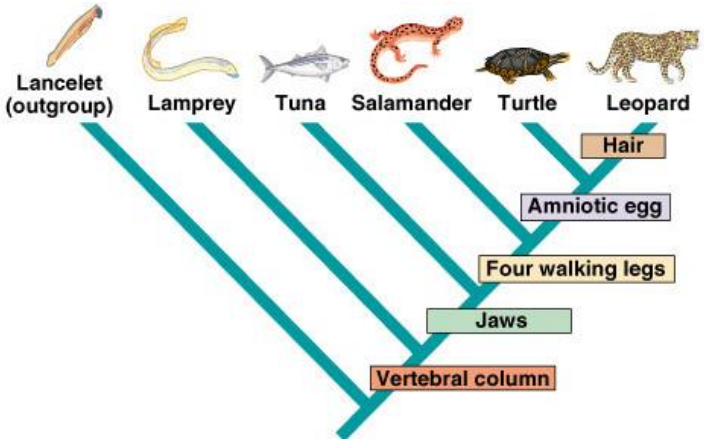
Examine the sample cladogram, each letter on the diagram points to a derived character, or something different (or newer) than what was seen in previous groups. Match the letter to its character. *Note: this cladogram was created for simplicity and understanding, it does not represent the established phylogeny for insects and their relatives.*



1. ____ Wings
2. ____ Six Legs
3. ____ Segmented Body
4. ____ Double set of wings
5. ____ Cerci (abdominal appendages)
6. ____ Crushing mouthparts
7. ____ Legs
8. ____ Curly Antennae

Name: _____ Date: _____

Bio30: OL3 Classification **Cladograms**

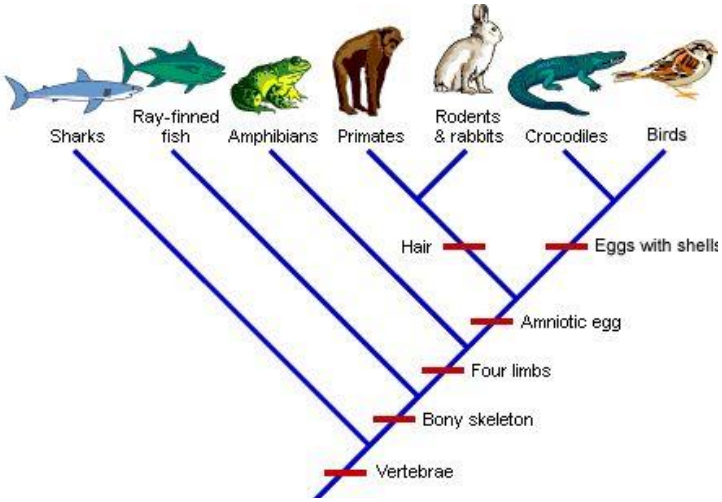


_____ =
27

1. What trait separates Lampreys from tuna on this cladogram? _____
2. What separates a salamander from a turtle? _____
3. Which organism is most related to the leopard? _____
4. What 4 traits do these two organisms share? _____

_____ _____ _____

5. Which organism will have DNA most similar to the turtle? _____
6. Which organism's DNA will differ the most from the leopard? _____



7. What trait separates amphibians from primates on this cladogram? _____
8. What separates rabbits & primates from crocodiles on this cladogram? _____
9. Which organism is most related to the bird on this cladogram? _____
10. What 5 traits do these two organisms share? _____

_____ _____

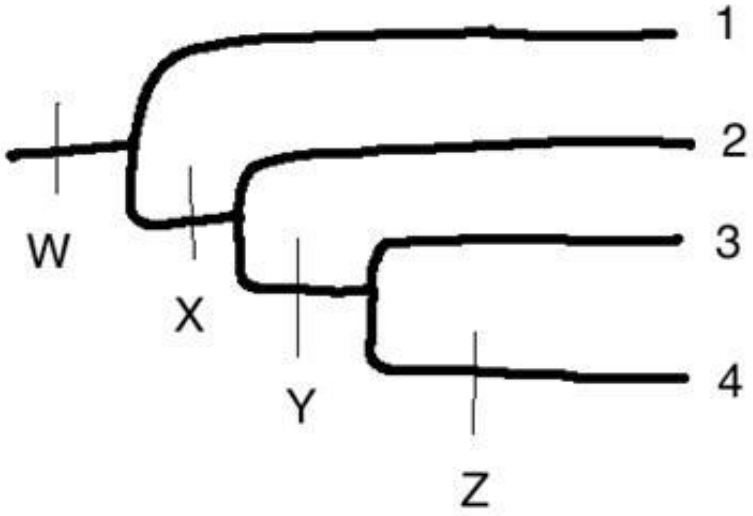
_____ _____

11. Which organism will have DNA most similar to the bird? _____
12. Which organism's DNA will differ the most from the bird? _____

Name: _____ Date: _____

Bio30: OL3 Classification **Phylogenetic Trees**

Trait	Snoozle	Bleeker	LooHoo	Floof
Green Skin	yes	yes	yes	yes
Giant eyes	yes	no	yes	yes
Fur	yes	no	yes	no
Suction cup feet	no	no	yes	no



Complete the following labels:

W – _____

X – _____

Y – _____

Z – _____

1- _____

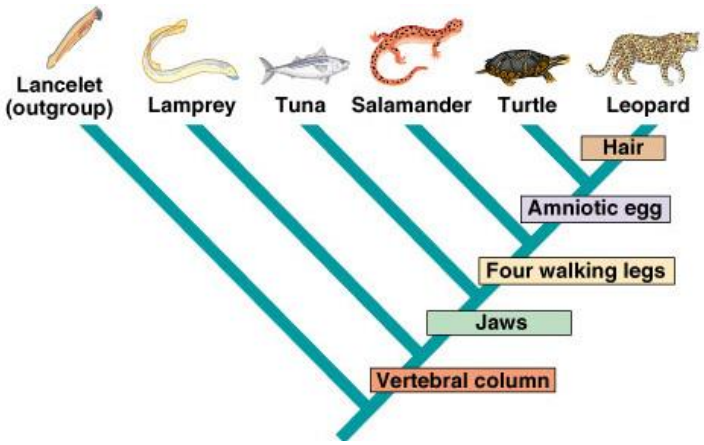
2 - _____

3 - _____

4 - _____

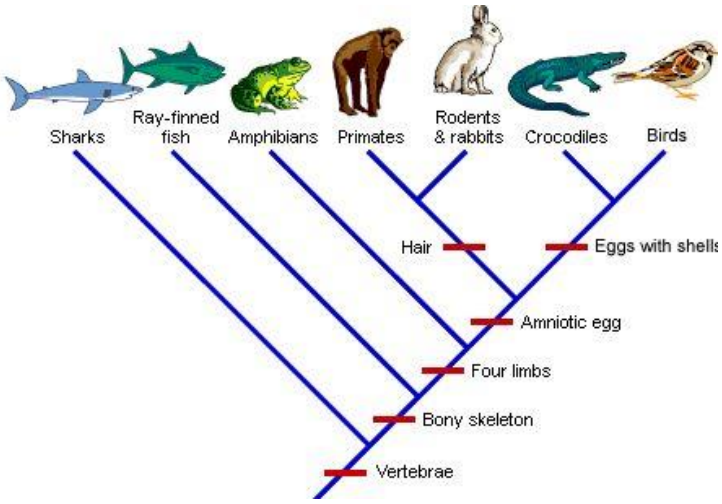
Name: _____ Date: _____

Bio30: OL3 Classification **Cladograms KEY**



_____ = 27

1. What trait separates Lampreys from tuna on this cladogram? _____**Jaws**_____
2. What separates a salamander from a turtle? _____ **Amniotic Egg**_____
3. Which organism is most related to the leopard? _____ **Turtle**_____
4. What 4 traits do these two organisms share? _____ **Amniotic Eggs**_____
_____ **Four Walking Legs**_____ ____**Jaws** _____ _____ **Vetebral Column**_____
5. Which organism will have DNA most similar to the turtle? _____ **Salamander**_____
6. Which organism's DNA will differ the most from the leopard? _____ **Lancelet**_____

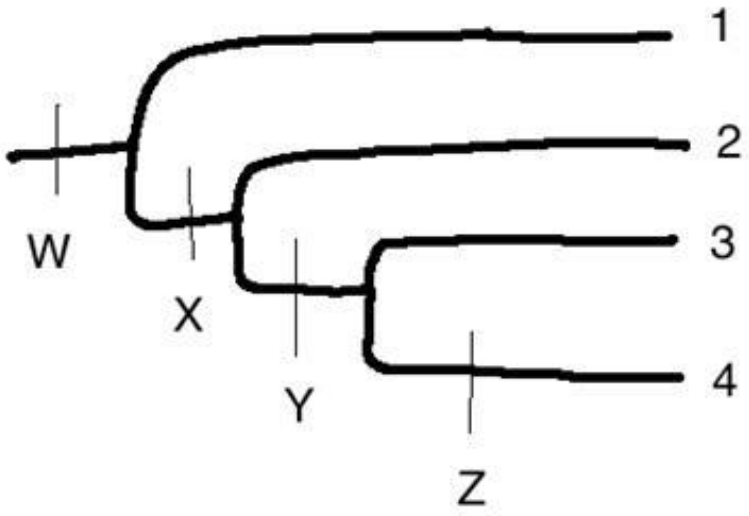


7. What trait separates amphibians from primates on this cladogram? __**Amniotic Egg**__
8. What separates rabbits & primates from crocodiles on this cladogram? **Eggs w/Shells**
9. Which organism is most related to the bird on this cladogram? ___**Crocodile**_____
10. What 5 traits do these two organisms share? _____**Vertebrae**_____
_____**Bony Skeleton**_____ _____**Four Limbs**_____
_____**Amniotic Eggs**_____ _____**Eggs With Shells**_____
11. Which organism will have DNA most similar to the bird? ____**Crocodiles**_____
12. Which organism's DNA will differ the most from the bird? _____**Sharks**_____

Name: _____ Date: _____

Bio30: OL3 Classification **Phylogenetic Trees KEY**

Trait	Snoozle	Bleeker	LooHoo	Floof
Green Skin	yes	yes	yes	yes
Giant eyes	yes	no	yes	yes
Fur	yes	no	yes	no
Suction cup feet	no	no	yes	no



Complete the following labels:

W – Green Skin

X – Giant Eyes

Y – Fur

Z – Suction Cup Feet

1- Bleeker

2- Floof

3- Snoozle

4- LooHoo

Modern Taxonomies Notes
Cladogram ANSWER KEY:

1. __F__ Wings
2. __C__ Six Legs
3. __A__ Segmented Body
4. __G__ Double set of wings
5. __E__ Cerci (abdomenal appendages)
6. __D__ Crushing mouthparts
7. __B__ Legs
8. __H__ Curly Antennae

Miss Foley

Bio30: OL3 Classification

Classic vs Modern

Critique the strengths and limitations of our historical and contemporary understanding of biological classification:

	Strengths	Limitations
Classic Taxonomy		
Modern Taxonomy		

Adaptations =

a change/process of change by which an organism or species becomes better suited to its environment

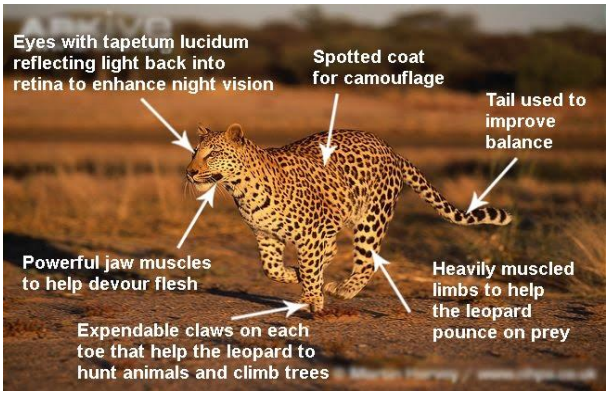
An adaptation in nature is acquired through evolution and conveys some type of advantage that helps a species to pass its genetic material along to another generation.

TYPES OF ADAPTATIONS

Type	Description	Example
Structural	Physical appearance	Large ears Thorns
Behavioral	Control how an organism acts	Hibernation Blooming only at night
Physiological	Based on body chemistry and metabolism; usually don't show	Toxins in plants Desert animals have efficient kidneys

Structural Adaptations

A structural adaptation is **a change involving a physical aspect of an organism**. An organism's environment shapes its appearance through structural adaptations. Some of the most obvious examples to us might be an aquatic animal developing fins to swim or a mammal growing thicker fur to survive freezing climates.



Cryptic - Cryptic animals are those which camouflage perfectly with their environment and are almost impossible to detect increasing their chance of survival. Certain reptiles and insects such as chameleons and stick insects may spring to mind as being particularly good at this type of animal adaptation.

Mimicry – Is a method used by animals to physically appear and behave like another animal to fool predators into thinking it is poisonous or dangerous.

Other Examples: The shape of an animal's teeth is related to its diet. Herbivores, such as deer, have many molars for chewing tough grass and plants. Carnivores, such as lions, have sharp canines to kill and tear meat. Desert foxes have large ears for heat radiation and Arctic foxes have small ears to retain body heat. Seals have flippers to navigate water and raccoons have separate, flexible digits to manipulate food. White polar bears blend into ice floes and spotted jaguars into the speckled jungle shade. Trees may have corky bark to protect from wildfires. Structural modifications affect organisms at different levels, from the way a knee is hinged to the presence of large flight muscles and sharp eyesight for predatory birds.

Physiological Adaptations

Based on **body chemistry and metabolism**, physiological adaptations aren't always seen in an organism's appearance. This type of adaptation may be driven by either a change to the environment or the behavior of another species. Laboratory studies that measure the contents of blood, urine and other body fluids, that trace metabolic path ways, or microscopic studies of an organism's tissues are often necessary to identify physiological adaptations. Sometimes detecting them is difficult if there isn't a common ancestor or a closely related species with which to compare findings.

These types of adaptations are related to changes in the metabolism of different organisms. Some organs in an animal body function differently when certain changes occur in the environment. The two most well-known physiological adaptations are **hibernation** and **estivation**. These are two different types of inactivity where the metabolic rate slows down so much that the animal can survive without eating or drinking anything.

In both cases, **temperature** is usually a factor. While we often think of bears hibernating for the winter, it is not only when the temperature is low that these processes occur. When the temperature is below 0 °C or is above 40 °C and there is a relatively low humidity, certain animals can lower their basal metabolic rate for serious amounts of time.

Other Examples: They consist of things like more efficient kidneys for desert animals like kangaroo rats, compounds that prevent blood coagulation in mosquito saliva, or the presence of toxins in plant leaves to repel herbivores. A species living in water that suddenly becomes more acidic might adapt by slowly shifting its own body chemistry. Other examples of physiological adaptations include developing greater intelligence and improving the senses.

Behavioral Adaptations

A behavioral adaptation is **a change affecting the way an organism naturally acts**. This type of adaption could be caused by a change in the surrounding environment or the actions of another species.

The two most characteristic forms of behavioral adaptations are probably migration and courtship. **Migration** allows the animals to find better resources or evade threat. **Courtship** is a set of behavioral patterns with the desired result of finding a mate and reproducing.

Often behavioral adaptations take careful field and laboratory studies to bring them fully to light, and often involve physiological mechanisms as well. Humans employ cultural adaptations as a subset of behavioral adaptations, where people who live in a given environment learn ways of raising the food they need and coping with the particular given climate.

Other Examples: Bears hibernate to escape cold; birds and whales migrate to warmer winter climates. Desert animals are active at night during hot summer weather. Lizards seek a sunny spot in the morning to warm up to operating temperatures more quickly. A nesting killdeer will pretend to be injured to lure a predator away from her young. Behavioral adaptations that involve mating procedures, such as that exhibited by the Australian bowerbird, can be amazingly complex. Predatory animals might start hunting in packs -- giving them an evolutionary advantage over solo hunters. In addition to changes in a predatory strategy, examples of behavioral adaptations include changes in social patterns, communication methods, feeding habits and reproductive strategy.

Structural Adaptations
Sharp quills for protection from predators
Protruding snout (for accessing termite mounds)
Sharp claws for digging / burrowing

Behavioural Adaptations
Curls into ball when threatened (exposes quills)
Digs burrows in which to nest and rest
May hibernate during winter in very cold regions

Physiological Adaptations
Ears sensitive to low frequencies (detect ant sounds)
Well developed olfactory system (used for detection)
Tongue can stiffen and penetrate soil due to blood flow

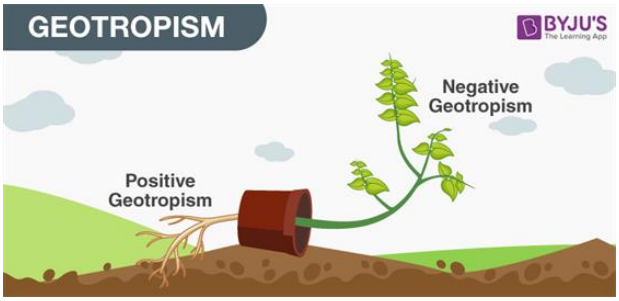
Plant Adaptations: Tropisms

External stimuli result in a response. When animals, including humans, respond to a stimulus (which is something that causes a response), we call it a reaction. For example, if someone touches your arm, you generally turn to react. Tropism comes from a Greek word Tropos meaning 'to turn'. In plants, the response of either **turning towards or away from a stimulus** is known as a **tropism**. Plants respond positively to some stimuli by moving toward them, and negatively to other stimuli by moving away from them.

Positive (+) Tropism = a turn TOWARDS a stimulus
Negative (-) Tropism = a turn AWAY from a stimulus

Gravitropism = plant response to gravity

Gravitropism and geotropism (response to the earth) are often used interchangeably. Roots, showing positive gravitropism, grow toward gravity while shoots, showing negative gravitropism, grow away from gravity.



If a normal, vertical plant is laid on its side, the plant will bend upward and the plant's root will grow downward. The roots grow downward due to higher concentrations of auxin hormone in cells on the underside of the root. Auxin inhibits root cell elongation. Therefore, cells underneath the root will grow more slowly than cells on the upper side of the root, so the root bends and grows in a downward direction.

In the stem, auxin has the opposite effect – that is, higher concentrations stimulate cell elongation. As in the root, auxin accumulates on the side of the stem toward the pull of gravity, but in the stem this causes cells underneath the stem to grow faster than cells above the stem, so the stem bends and grows in an upward direction.

Phototropism = plant response to light

This response is usually to unidirectional light from one source, such as a lamp or beam of sunlight. Light-sensitive proteins called phototropins absorb light and initiate phototropic responses mediated by auxins. Auxins act on the dark side of the plant, changing pH to relax cell walls and initiate cell elongation and growth. Because the growth rate is faster on the dark side of the stem than on the light, the stem bends toward the light.

Heliotropism = plant response to the sun's position in the sky

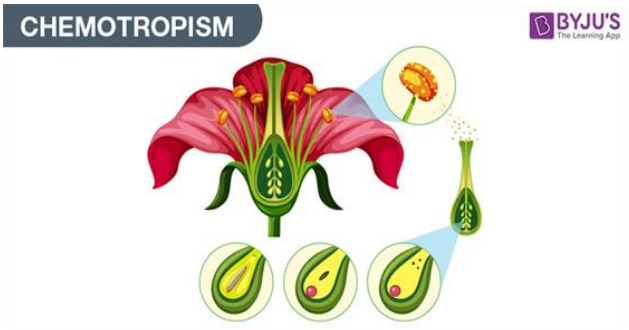
This is the response of an entire plant organ, such as a flower or leaf, to the sun's position in the sky. Plants orient leaves at different angles in relation to the sun to regulate temperature and rate of photosynthesis in leaves. Common example is the movement of sunflower heads throughout the day – facing east in the morning and west by the end of the day.

Thigmotropism =
plant response to touch

The most common example is the curling response of vines when in contact with an object. The response is controlled by specialized epidermal cells that produce auxin before transferring it to other cells. Auxin causes the untouched cells to elongate and grow faster than the touched cells, causing the tendril or stem to coil around the touched object. Ethylene may contribute to the success of this maneuver by causing the stem to grow horizontally for a period. While tendrils demonstrate positive thigmotropism, roots can exhibit negative thigmotropism at times, often growing away from objects.

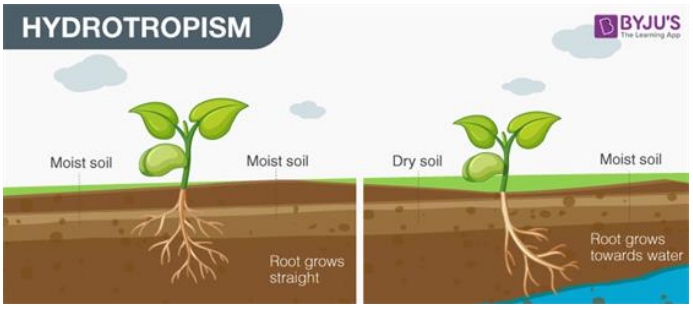
Chemotropism =
plant response to a chemical stimulus

Paired synergid cells, which flank the egg cell at the entrance to the ovule, release chemicals which guide pollen tubes in their growth through the pistil toward the micropyle and egg. Growth of the pollen tube toward the ovule is thus a positive chemotropism.



Plant roots also grow towards nutrients needed for growth, such as phosphorous, nitrogen, calcium, magnesium, potassium, etc.

Hydrotropism =
plant response to a moisture gradient



Plant roots grow towards sources of water. If you have witnessed roots growing into water or sewer pipes, one may think that positive hydrotropism is a strong response in tree roots. However, this is a myth. Roots cannot sense water through an unbroken pipe. However, should the pipe be broken, the roots will have a positive hydrotropic response and grow towards the available water.

Name: _____ Date: _____

Bio30: OL2 Organisms Compared **Plant Language**

PBS: What Plants Talk About (2013) Video Notes (52:57)

1. What is one way that plants "behave"?
2. What is one way that all plants hunt for food?
3. How much of a plant's mass is typically found underground?
4. How do plants "forage" for food? How is this "animal-like" characteristic of plants "foraging" similar to the way bears forage?

5. What did the scientists do to test whether or not the Dodder vine was actively *choosing* which plant to attach to?

6. What did the scientists do to test whether or not the Dodder vine was using *smell* to find its host?

7. Why do scientists believe that fresh grass gives off a smell?

8. What are scientists learning about plant behavior from the native tobacco plant?

9. What is the name of the *toxin* that native tobacco plants use to poison predators?

10. What are three (3) things the tobacco plant does to defend from caterpillars?

Name: _____ Date: _____

Bio30: OL2 Organisms Compared **Plant Language**

11. Why do the flowers on tobacco plants change in appearance?

12. How does spotted knapweed affect cattle ranchers in Montana?

13. How does wild lupine fight back against the spotted knapweed?

14. What do animals use kin recognition for?

15. How do seas rocket roots show kin recognition? How did plant root growth differ between "sibling" and unrelated plants? Why?

16. What *benefit* do fungi get from growing on Douglas fir trees? What *benefit* do Douglas fir trees get from allowing fungi to grow on them?

17. How are carbon resources "shuttled" between Douglas fir trees from larger to smaller trees in their surrounding area?

18. What question is still left unanswered by scientists?

19. What was your favorite thing that you learned about in this video?

Name: _____ Date: _____

Bio30: OL2 Organisms Compared **Plant Language KEY**

PBS: What Plants Talk About (2013) Video Notes (52:57)

1. What is one way that plants "behave"? **Through growth**
2. What is one way that all plants hunt for food? **Root growth**
3. How much of a plant's mass is typically found underground?

   80% found in root system

4. How do plants "forage" for food? How is this "animal-like" characteristic of plants "foraging" similar to the way bears forage?

   Roots grow to find nutrient patches, slow down while using the food source, and then grow again searching for the next nutrient patch to eat it's fill.

5. What did the scientists do to test whether or not the Dodder vine was actively *choosing* which plant to attach to?

   Dodder vines need to find a host plant within 72 hours before dying. They attach themselves to their host like vampires for food supply. Scientist used time lapse cameras to prove Dodder "chooses" tender tomato plants 9/10 times over tougher wheat plants.

6. What did the scientists do to test whether or not the Dodder vine was using *smell* to find its host?

   The tomato green leaf volatiles where captured and tested against a tomato plant under a glass beaker. The Dodder "chose" the volatiles plant 10/10 times.

7. Why do scientists believe that fresh grass gives off a smell?

   They believe it is their chemical SOS cry for help when under damage stress.

8. What are scientists learning about plant behavior from the native tobacco plant?

   Active self-defense mechanisms exist.

9. What is the name of the *toxin* that native tobacco plants use to poison predators?

   Nicotine.

10. What are three (3) things the tobacco plant does to defend from caterpillars?
    1. **Nicotine poisons any organisms that move via muscle.**
    2. **Plant releases chemical SOS which attracts caterpillar enemies (insect mercenaries such as the big eye bug) which eat eggs, larvae and bite adult caterpillars.**
    3. **Caterpillar's saliva chemically identify them. Plants produce tricone nectar (the evil lollipop) that causes caterpillar body odor which attracts ground predators to eat caterpillars.**

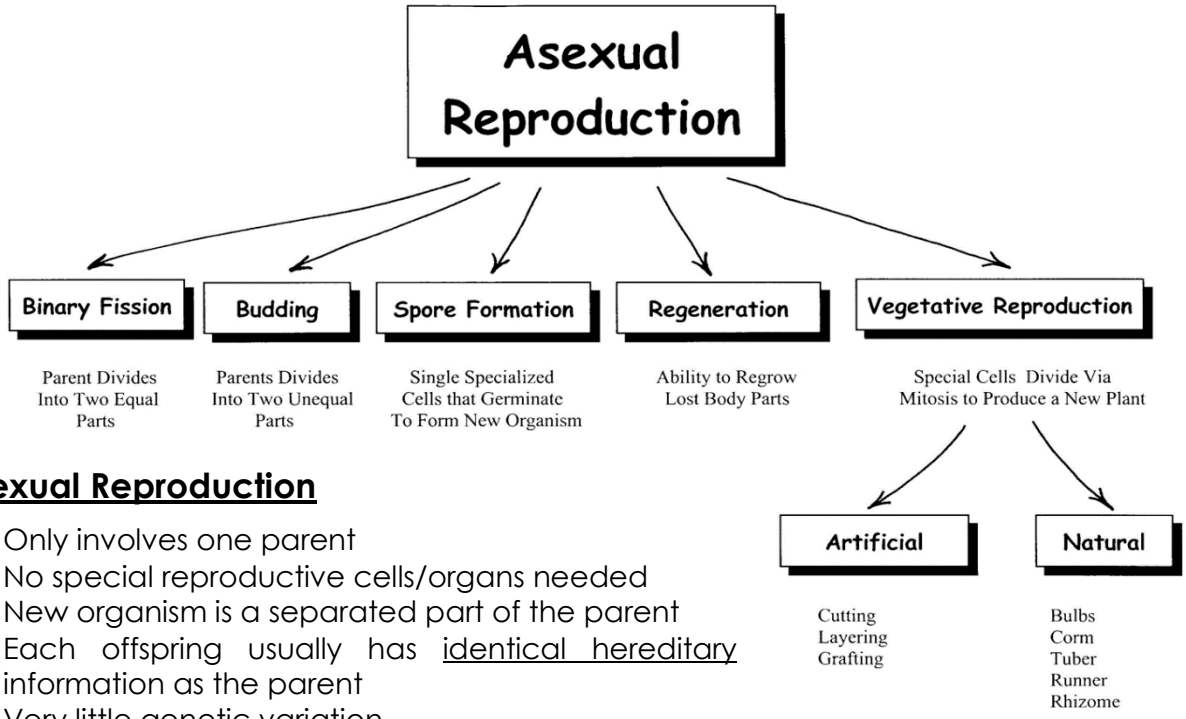
Name: _____ Date: _____

Bio30: OL2 Organisms Compared **Plant Language KEY**

11. Why do the flowers on tobacco plants change in appearance? **Normally bloom at dusk to attract hawk moths as nocturnal pollinators. However, hawk moths lay up to 200 eggs which eventually turn into tobacco plant caterpillar predators. Within 8 days, they change their nectar smell, change their flower shape and start blooming at dawn to attract hummingbirds as daytime pollinators. This results in no caterpillar predators. Surrounding plants chemically eavesdrop on chemical messages speeding up the process.**
12. How does spotted knapweed affect cattle ranchers in Montana? **After disturbances, spotted knapweed root chemicals kills off native grasses - 4.5 million acres – causing a huge decrease in biodiversity of native plants and decreasing rangeland food supply. Sheep are used as biological weapons to mow it down as they seem to be the only animal to use it as a consistent food supply. Even when root systems are infested, it doesn't seem to be affected by insects.**
13. How does wild lupine fight back against the spotted knapweed? **Lupine roots send chemical counterattack by releasing oxalic acid which shields roots against the spotted knapweed chemical toxins. The lupine chemical also protects the roots of surrounding plants.**
14. What do animals use kin recognition for? **Increase social interaction with relatives and to avoid mating with relatives**
15. How do seas rocket roots show kin recognition? How did plant root growth differ between "sibling" and unrelated plants? Why? **Reproduce with 2 seed pods with one staying attached to mother plant resulting in growing in kin groups. They show less chemical messages resulting in decreased root growth with kin; showing increased chemical messages growing more roots competing with stranger plants.**
16. What *benefit* do fungi get from growing on Douglas fir trees? What *benefit* do Douglas fir trees get from allowing fungi to grow on them? **Massive roots of Douglas fir are colonized by underground fungus mycelium. Fungus gets carbon-based sugar food supply tapping into the roots while providing trees with nutrients as it decomposes nutrients in the soil. Fungus needs carbon from the tree and can get into smaller spaces that roots can't. It costs the tree less to feed the fungus than to grow more roots.**
17. How are carbon resources "shuttled" between Douglas fir trees from larger to smaller trees in their surrounding area? **Fungus transfers carbon between root systems. Radioactive carbon 14 is injected into mother tree and then tracked with Geiger counter to see how far and where it has travelled. The youngest and most vulnerable trees benefit most with feeding system.**
18. What question is still left unanswered by scientists?

    How plants integrate all of this information without having a brain.
19. What was your favorite thing that you learned about in this video?

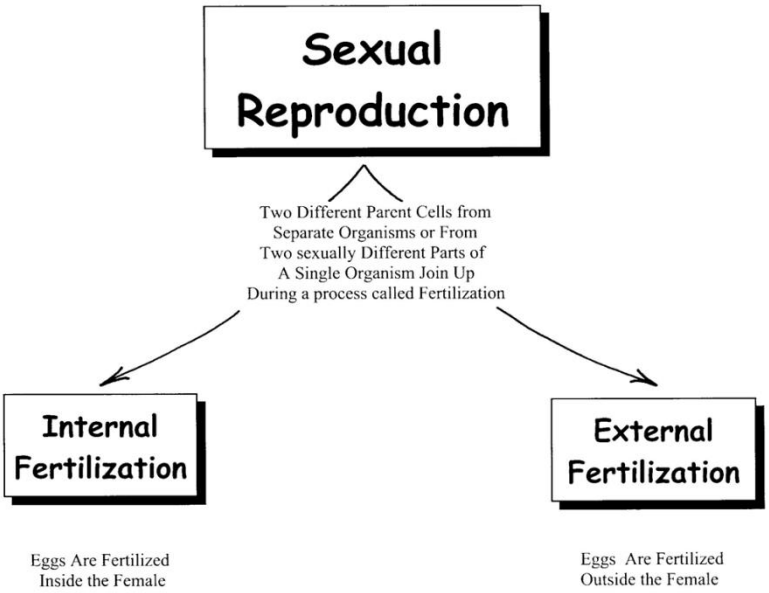
Types of Reproduction: Sexual vs Asexual



Asexual Reproduction

- Only involves one parent
- No special reproductive cells/organs needed
- New organism is a separated part of the parent
- Each offspring usually has identical hereditary information as the parent
- Very little genetic variation

Sexual Reproduction

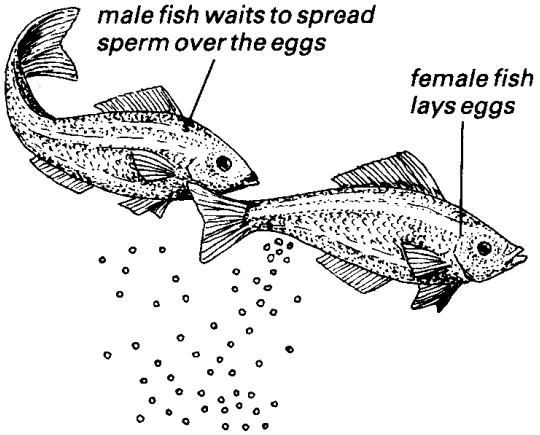


- Involves two parent cells
- Produces offspring that are genetically different from the parents; increases genetic variation
- called gametes come from each of the parents
- Special haploid sex cells called **gametes**, both male & female sex cells, are **formed by meiosis** (a type of cell division that results in gametes with half the # of chromosomes as the parent cells)
- Male gametes are called **sperm**. Sperm are motile, large in number and have a small food supply and needs a fluid medium to swim to the egg
- Female gametes are called **ova** (egg). Ovum (eggs) are larger, smaller in number, sessile and have a large food supply
- Sperm & eggs must be released together because they only live for a short period of time
- **Fertilization** happens when the nuclei of male & female gametes fuse
- The single cell formed by this fusion is known as a **zygote**

Miss Foley

Bio30: OL2 Organisms Compared **Reproduction**

External Fertilization

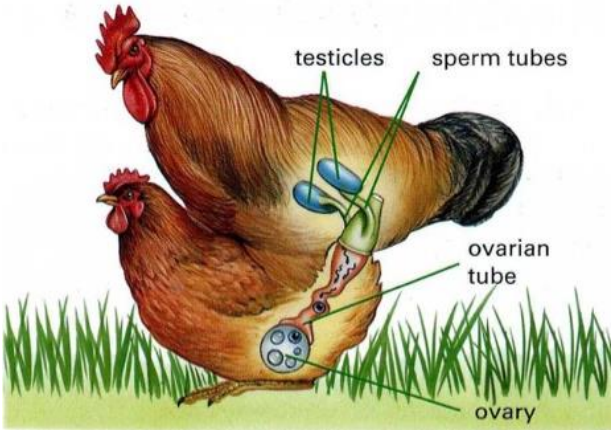


- Takes place in animals that breed in water (almost all aquatic invertebrates, most fish (excluding sharks), and many amphibians
- The only sex organs needed, besides the gonads, are ducts to carry the gametes from the gonads to the water
- Fertilization takes place directly in the water as the sperm swim to the eggs

Problems: Sperm & egg may not meet
Eggs/offspring may be eaten by predators
Death from temp./oxygen changes

Solutions: Large #'s of sperm & eggs are released

Internal Fertilization



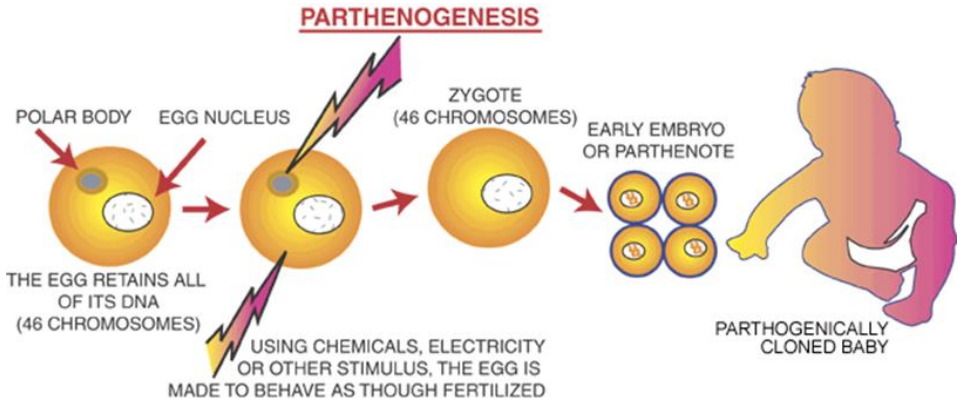
- Found most often in animals that reproduce on land (with the exceptions of sharks & lobsters)
- Requires a specialized sex organ to carry the sperm from the body of the male into the body of the female
- Using the moist tissues of the female & semen, sperm travels to fertilize the egg producing a single celled zygote
- Once fertilized, the zygote is either enclosed in a protective shell & released OR it remains and develops within a special part of the female's body
- Sperm have a short life span & short food supply. As well, eggs can only be penetrated for a brief time
- Human eggs can only be fertilized for about 24 hours

Advantages: No scattering of gametes
Less influence from environment
Fewer eggs needed because they are well protected
Chances of fertilization increase greatly

Advantages of Sexual Reproduction = Increased Variation

- Sexual reproduction increases the rate of genetic variation which increases the possibility that some individuals are better able to survive both short & long term changes in the environment
- Therefore, sexual reproduction helps ensure the survival of a species by making the population more varied

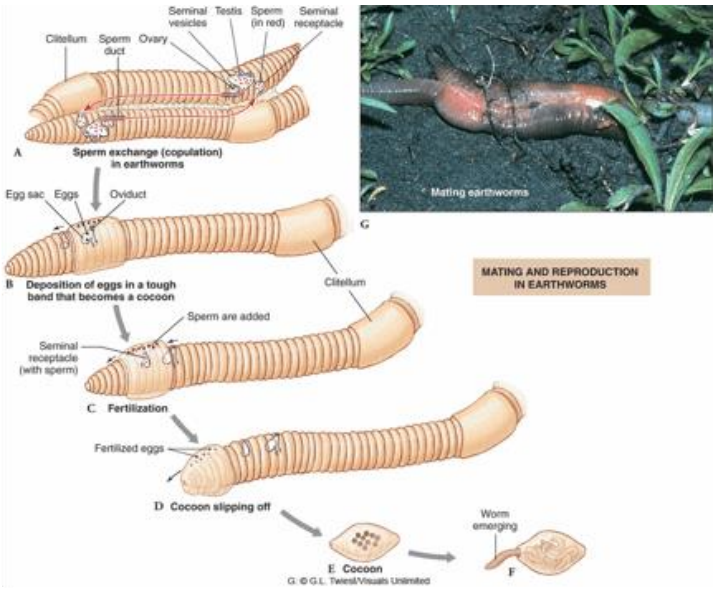
Parthenogenesis = "The Virgin Birth"



Females produce **eggs that develop into young without being fertilized**. Parthenogenesis occurs in some fishes, several kinds of insects, and a few species of frogs and lizards.

Examples:

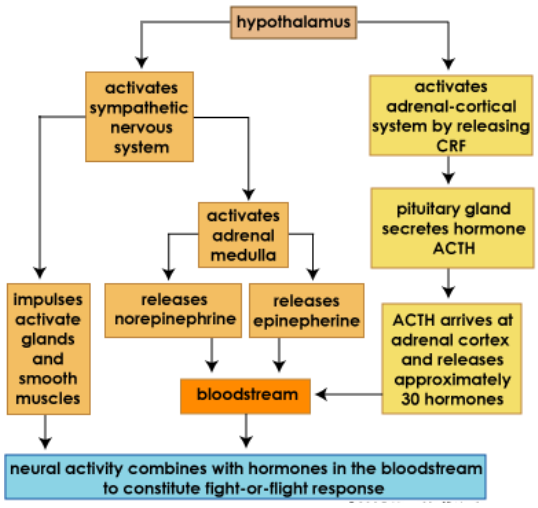
1. Aphids use parthenogenesis in the spring when they find themselves with ample food. In this species, reproduction by parthenogenesis is more rapid than sexual reproduction, and the use of this mode of asexual reproduction permits the animals to quickly exploit the available resources.
2. Female Komodo dragons can produce offspring by parthenogenesis when no male is available for sexual reproduction.
3. Parthenogenesis is forced on some species of wasps when they become infected with bacteria (in the genus Wolbachia). Wolbachia can pass to a new generation through eggs, but not through sperm, so it is advantageous to the bacterium for females to be made rather than males. In these wasps, fertilized eggs (diploid) become females; unfertilized (haploid) eggs become males.

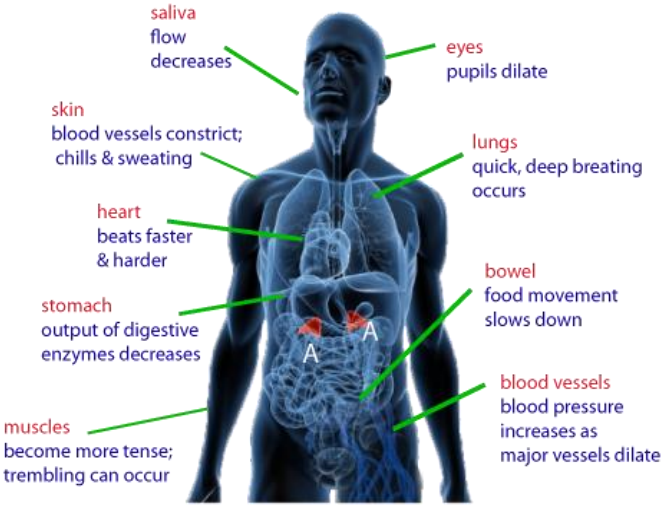


Hermaphrodites

Hermaphrodites are organisms which do not have separate sexes. Instead, each individual has both testes & ovaries. Usually found among animals that move slowly or are attached to surfaces such as earthworms, snails & hydras. Self-fertilization is rare. As a result, sperm is usually transferred for fertilization.

Fight-or-Flight Response





To produce the fight-or-flight response, the hypothalamus activates two systems: the sympathetic nervous system and the adrenal-cortical system. The **sympathetic nervous system uses nerve pathways** to initiate reactions in the body, and the **adrenal-cortical system uses the bloodstream**. The combined effects of these two systems are the fight-or-flight response.

When the hypothalamus tells the sympathetic nervous system to kick into gear, the overall effect is that the body speeds up, tenses up and becomes generally very alert. The sympathetic nervous system sends out impulses to glands and smooth muscles and tells the adrenal medulla to release **epinephrine (adrenaline)** and **norepinephrine (noradrenaline)** into the bloodstream. These "stress hormones" cause several changes in the body, including an increase in heart rate and blood pressure. At the same time, the hypothalamus releases **corticotropin-releasing factor** (CRF) into the pituitary gland, activating the adrenal-cortical system. The **pituitary gland** (a major endocrine gland) secretes the hormone **ACTH (adrenocorticotropic hormone**). ACTH moves through the bloodstream and ultimately arrives at the adrenal cortex, where it activates the release of approximately 30 different hormones that get the body prepared to deal with a threat.

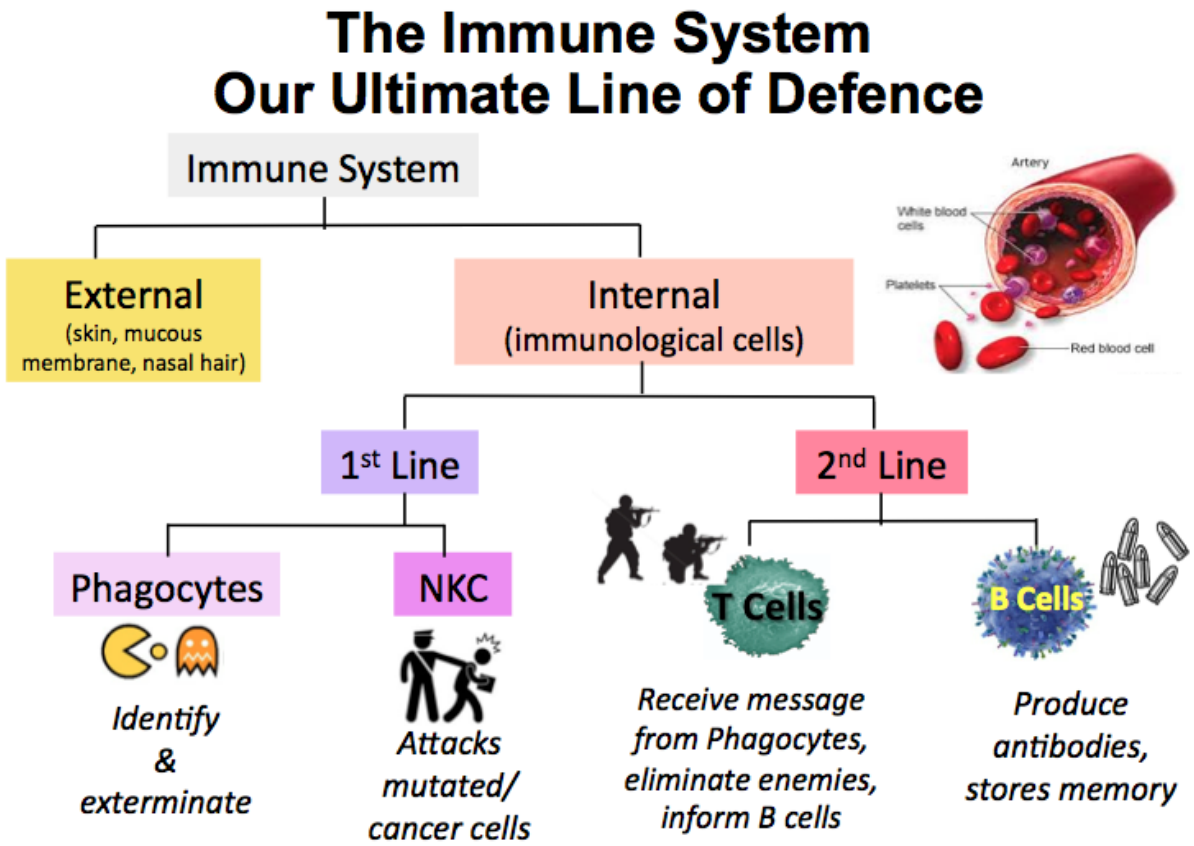
The sudden flood of epinephrine, norepinephrine and dozens of other hormones causes changes in the body that include:

- heart rate and blood pressure increase
- pupils dilate to take in as much light as possible
- veins in skin constrict to send more blood to major muscle groups (responsible for the "chill" sometimes associated with fear -- less blood in the skin to keep it warm)
- blood-glucose level increases
- muscles tense up, energized by adrenaline and glucose (responsible for goose bumps -- when tiny muscles attached to each hair on surface of skin tense up, the hairs are forced upright, pulling skin with them)
- smooth muscle relaxes in order to allow more oxygen into the lungs
- nonessential systems (like digestion and immune system) shut down to allow more energy for emergency functions
- trouble focusing on small tasks (brain is directed to focus only on big picture in order to determine where threat is coming from)

All of these physical responses are intended to help you survive a dangerous situation by preparing you to **either run for your life or fight for your life**, thus the term "fight or flight".

Miss Foley

Bio30: OL2 Organisms Compared **Defense Mechanisms**



We are exposed to thousands of **germs** (bacteria and viruses) floating in the air. Your immune system deals with most of them without a problem. Occasionally, a germ gets past the immune system and you get sick. Sickness is the visible sign that your immune system failed to stop the germ. Getting over sickness is a visible sign that the immune system was able to eliminate the **pathogen** (disease-causing organism).

We also eat hundreds of germs daily with most of them dying in the saliva or stomach acid. Those that get through usually cause food poisoning with very visible signs of this immune system breach: vomiting and diarrhea being two of the most common symptoms. The body uses the "liquify everything" strategy to eliminate pathogens quickly.

Immune systems protect in different ways:

1. **Physical & Chemical Barriers** - Humans have therefore evolved several physical and chemical barrier mechanisms to prevent the invasion of infective organisms:
    - *Intrinsic epithelial barriers* exist between the body and the outside world. Epithelial cell walls have very tight junctions between them, and are therefore hard to penetrate. Examples include the linings of the mouth, nasal passages, upper airways, lungs and GI tract.
    - *Continuous longitudinal flow of air or fluid* through most body systems helps create a flushing action which prevents situations in which bacteria could adhere to structures, proliferate and invade.

- *Movement of mucus by cilia in the lungs* also helps prevent the stagnation of secretions and the adherence of inhaled droplets and particles. Mucus is moved upwards towards the pharynx, where it is then swallowed or coughed up.
- *Shedding of skin* prevents adherence of microorganisms.
- *Natural acids* persist in many parts of the body, for example fatty acids on the skin, lysozymes in saliva and hydrochloric acid in the stomach.
- *Natural antibacterial peptides* on the skin and the surface linings of the lungs and gut.
- *Normal bacterial flora colonize various parts of the body* compete with infective microorganisms, and some also produce antimicrobial substances. For example, vaginal lactobacilli produce lactate, which creates an acidic environment and destroys many potentially infectious organisms.

2. **If a pathogen enters the body**, the immune response detects and eliminates *before* it can make itself at home and replicate (viruses) or reproduce (bacteria). If the pathogen is able to reproduce/replicate and starts causing problems, the immune system is then in charge of eliminating it.

Leukocytes = "Identifiers & Fighter Cells"

Leukocytes (white blood cells) are produced or stored in many locations in the body, including the thymus, spleen, and bone marrow. For this reason, they're called the lymphoid organs. There are also clumps of lymphoid tissue throughout the body, primarily as **lymph nodes**, that house the leukocytes.

The leukocytes circulate through the body between the organs and nodes via lymphatic vessels and blood vessels. In this way, the immune system works in a coordinated manner to monitor the body for germs or substances that might cause problems.

The two basic types of leukocytes are:

1. **phagocytes**, cells that chew up invading organisms
2. **lymphocytes**, cells that allow the body to remember and recognize previous invaders and help the body destroy them

A number of different cells are considered phagocytes. The most common type is the neutrophil, which primarily fights bacteria. If doctors are worried about a bacterial infection, they might order a blood test to see if a patient has an increased number of neutrophils triggered by the infection. Other types of phagocytes have their own jobs to make sure that the body responds appropriately to a specific type of invader.

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

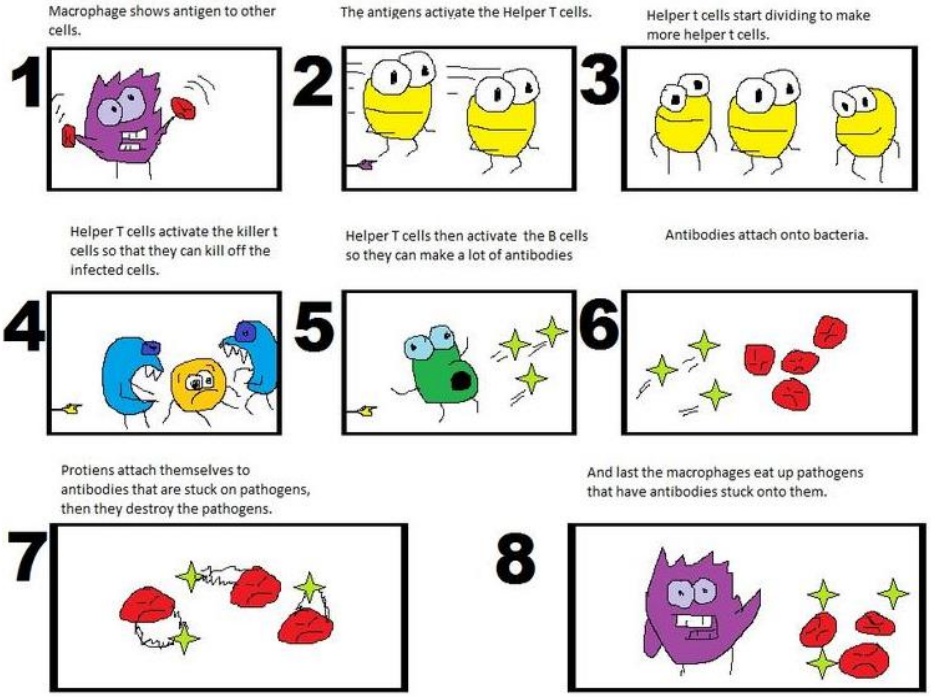
Miss Foley

Bio30: OL2 Organisms Compared **Defense Mechanisms**

How The Immune Response Works:

When **antigens** (foreign substances that invade the body) are detected, several types of cells work together to recognize them and respond. These cells trigger the B lymphocytes to produce antibodies, which are specialized proteins that lock onto specific antigens.

Once produced, these antibodies stay in a person's body, so that if his or her immune system encounters that antigen again, the antibodies are already there to do their job. So if someone gets sick with a certain disease, like chickenpox, that person usually won't get sick from it again.



This is also how immunizations prevent certain diseases. An immunization introduces the body to an antigen in a way that doesn't make someone sick, but does allow the body to produce antibodies that will then protect the person from future attack by the germ or substance that produces that particular disease.

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

Antibodies also can neutralize toxins (poisonous or damaging substances) produced by different organisms.

Once pathogens are eliminated, the immune response keeps a memory of how to fight them next time.

All of these specialized cells and parts of the immune system offer the body protection against disease. This protection is called immunity.

Homeostasis =

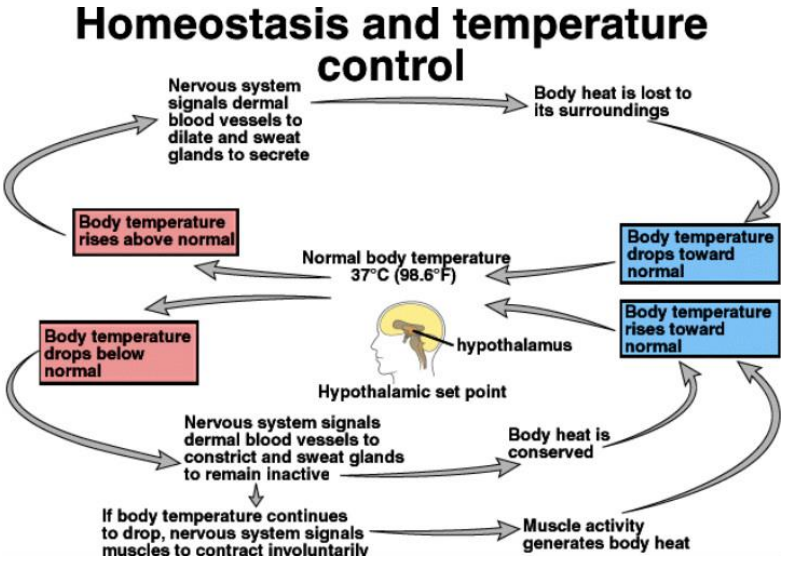
(Greek words meaning "same" and "steady")

any process that living things use to maintain stable conditions necessary for survival

The term was coined in 1930 by the physician Walter Cannon. His book, *The Wisdom of the Body*, describes how the human body **maintains steady levels** of temperature and other vital conditions such as the water, salt, sugar, protein, fat, calcium and oxygen contents of the blood.

Thermoregulation: Skin, Blood Vessels & Metabolism

Sensors in your central nervous system (CNS) send messages to your hypothalamus when internal body temperature changes. In response, it sends signals to various organs and systems in your body. They respond with a variety of mechanisms.



If your body needs to <u>COOL DOWN</u>, these mechanisms include:

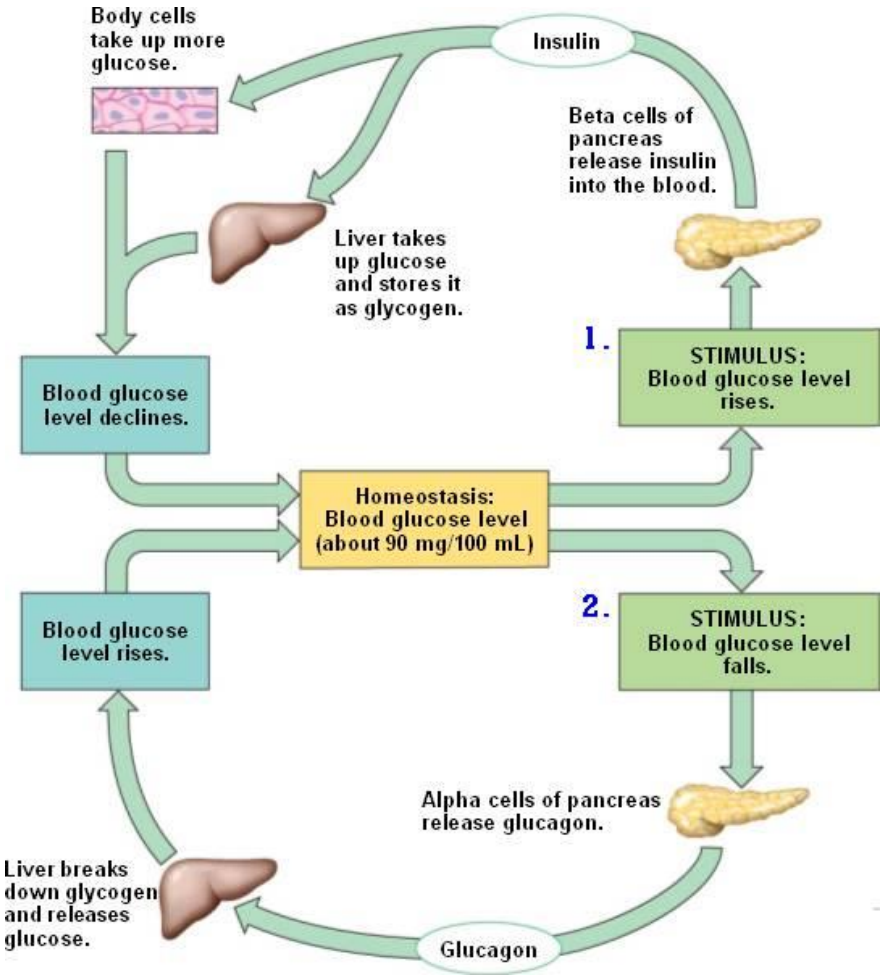
- **Sweating**: Your sweat glands release sweat, which cools your skin as it evaporates. This helps lower your internal temperature.
- **Vasodilatation:** The blood vessels under your skin get wider. This increases blood flow to your skin where it is cooler — away from your warm inner body. This lets your body release heat through heat radiation.

If your body needs to <u>WARM UP</u>, these mechanisms include:

- **Vasoconstriction:** The blood vessels under your skin become narrower. This decreases blood flow to your skin, retaining heat near the warm inner body.
- **Thermogenesis:** Your body's muscles, organs, and brain produce heat in a variety of ways. For example, muscles can produce heat by shivering.
- **Hormonal Thermogenesis:** Your thyroid gland releases hormones to increase your metabolism. This increases the energy your body creates and the amount of heat it produces.

Blood Sugar Regulation: The Pancreas

In a healthy person, blood glucose levels are restored to normal levels primarily through the actions of two pancreatic hormones, namely insulin and glucagon.



Insulin = decrease in blood glucose levels back to normal levels.

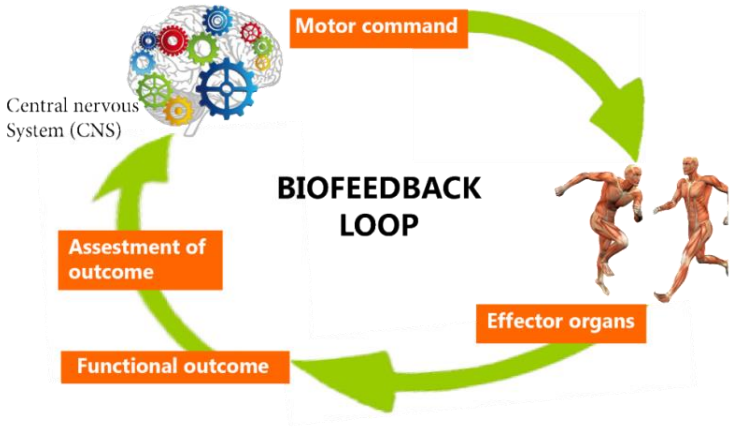
1. it stimulates most body cells to increase their rate of glucose uptake (transport) from the blood
2. it increases the cellular rate of glucose utilization as an energy source
3. it accelerates the formation of glycogen from glucose in liver and skeletal muscle cells
4. it stimulates fat synthesis (from glucose) in liver cells and adipose (fat) tissue.

Glucagon = increase in blood glucose levels back to normal levels.

1. it accelerates the breakdown of glycogen to glucose in liver and skeletal muscle cells
2. it increases the breakdown of fats to fatty acids and glycerol in adipose tissue and, consequently, the release of these substances into the blood (which cells can thus use for energy)
3. it stimulates liver cells to increase glucose synthesis (from glycerol absorbed from the blood) and glucose release into the blood.

In addition to insulin and glucagon, there are several other hormones that can influence blood glucose levels. The most important ones are epinephrine, cortisol, and growth hormone, all of which can increase blood glucose levels.

Biofeedback: Skin, Circulatory, Nervous, & Muscular Systems



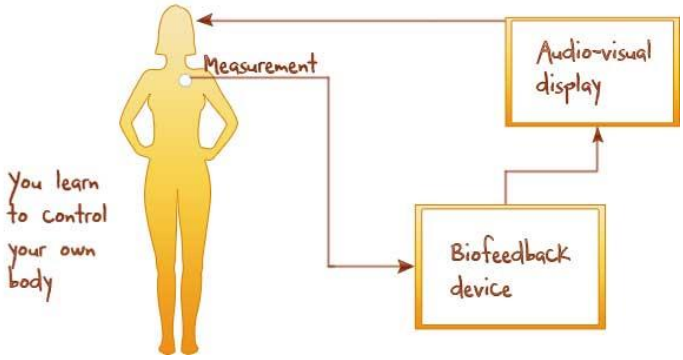
Biofeedback is a technique that trains people to improve their health by controlling certain bodily processes that normally happen involuntarily, such as heart rate, blood pressure, muscle tension, and skin temperature.

This feedback helps you focus on making subtle changes in your body, such as relaxing certain muscles, to achieve the results you want, such as reducing pain. In essence, biofeedback gives you the power to use your thoughts to control your body, often to improve a health condition or physical performance.

Types of Biofeedback

Your therapist might use several different biofeedback methods. Determining the method that's right for you depends on your health problems and goals. Biofeedback methods include:

- **Brainwave.** This type of method uses scalp sensors to monitor your brain waves using an electroencephalograph (EEG).
- **Breathing.** During respiratory biofeedback, bands are placed around your abdomen and chest to monitor your breathing pattern and respiration rate.
- **Heart rate.** This type of biofeedback uses finger or earlobe sensors with a device called a photoplethysmograph or sensors placed on your chest, lower torso or wrists using an electrocardiograph (ECG) to measure your heart rate and heart rate variability.
- **Muscle.** This method of biofeedback involves placing sensors over your skeletal muscles with an electromyography (EMG) to monitor the electrical activity that causes muscle contraction.
- **Sweat glands.** Sensors attached around your fingers or on your palm or wrist with an electrodermograph (EDG) measure the activity of your sweat glands and the amount of perspiration on your skin, alerting you to anxiety.



- **Temperature.** Sensors attached to your fingers or feet measure your blood flow to your skin. Because your temperature often drops when you're under stress, a low reading can prompt you to begin relaxation techniques.

Fluid Regulation: Kidneys

The kidneys' role in homeostasis falls into four areas of regulation:

1. osmotic pressure of body fluid
2. concentration of various ions in the body fluid
3. acidity of body fluids
4. volume of body fluids.

Osmotic Pressure of Body Fluid
The osmotic pressure of body fluid is most affected by the concentration of Na^+ ions present, since Na^+ ions account for 90 percent of all the cations (positive ions) in the body. Note that the key word here is "concentration." The Na^+ concentration can be regulated by the amount of water retained or excreted.

Three mechanisms regulate the amount of dilution. One is the use of ***antidiuretic hormone*** (ADH). ADH is released by the posterior pituitary gland when osmoreceptors sense a high osmolarity in the blood and tissue fluids. It acts by increasing the permeability of the distal tubules and the collecting ducts to water so that more water is reabsorbed into the blood. The effect of this is that a smaller volume of concentrated urine is produced. A person who has the disease diabetes insipidus produces no ADH and may excrete 20 liters of urine daily.

Another mechanism that is extremely important is the countercurrent mechanism. This very efficient method of maintaining constant osmotic concentrations in the body is explained in the section on the ***Regulation of Urine Concentration and Volume*** in your text and illustrated by Figure 25.16 "Medullary Osmotic Gradient" (Figure 25.16 text alternative). (Click on the graphic to enlarge; review before proceeding to the rest of the content.) This homeostatic mechanism allows the osmotic concentration of the blood plasma and other body fluids to be maintained around 300 milliosmol (mOsm). (The osmolality of solutions is measured in milliosmols in the body and is related to its osmotic activity.) For a refresher on osmosis, you can refer to the section on "Types of Transport" in lesson 2 as well as the discussion of osmosis in your textbook .

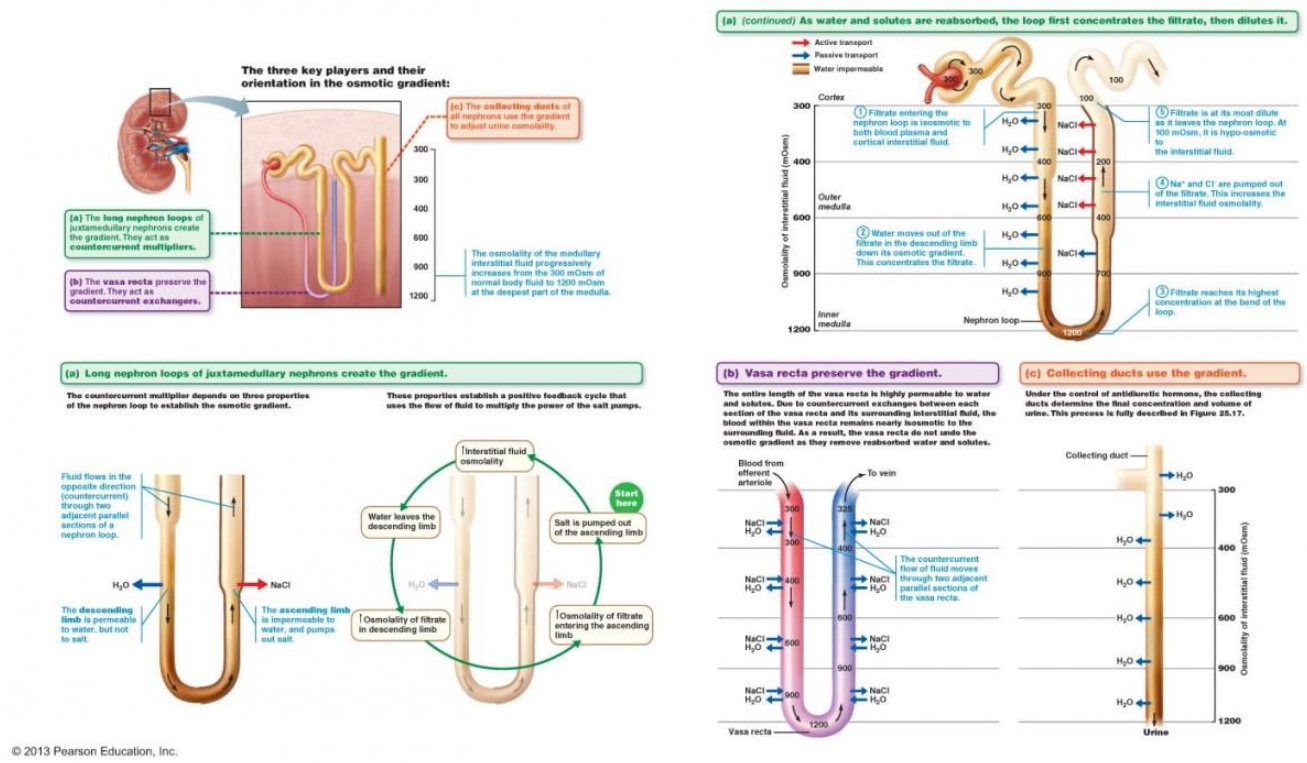
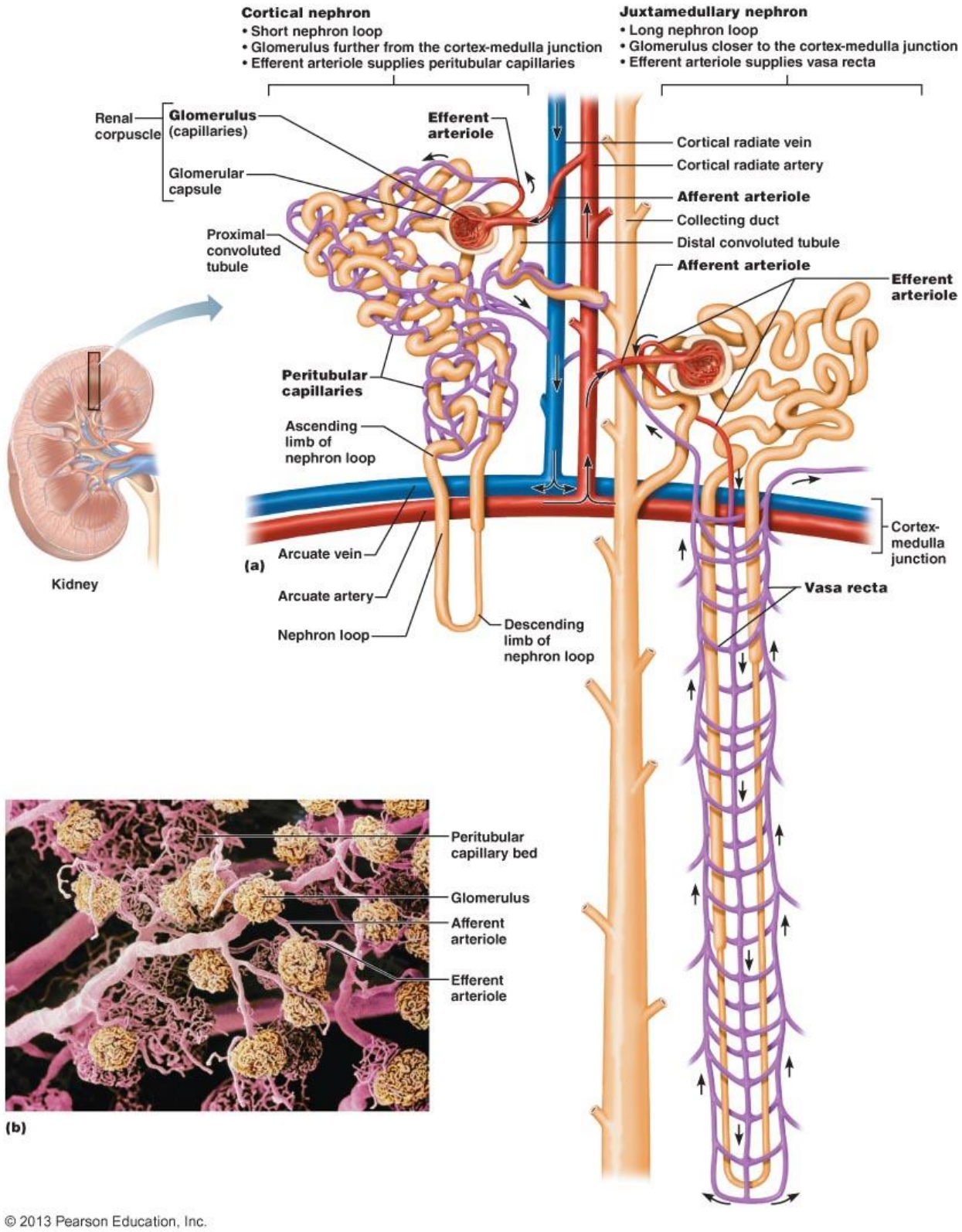


Figure 25.16 Medullary Osmotic Gradient
(Click on the figure to enlarge; review the figure thoroughly before proceeding to the rest of the content.)

The juxtamedullary nephrons (see Figure 25.7 "Juxtamedullary Nephrons" (Figure 25.7 text alternative)) whose loops of Henle extend deep into the kidney medulla, are involved in this mechanism. Make sure to click on the graphic to enlarge and review the figure, before proceeding to the rest of the content.



© 2013 Pearson Education, Inc.

Figure 25.7 Juxtamedullary Nephrons
(Click on the figure to enlarge; review the figure thoroughly before proceeding to the rest of the content.)
The kidney filtrate passes into the descending limb of the loop of Henle and then moves into the ascending limb of the loop. The ascending limb is impermeable to water and also responsible for actively transporting NaCl out of the nephron setting up a hypertonic conditions in the interstitial fluid surrounding the loop of Henle and the collecting duct. (Urea also moves into the interstitial fluid of the medulla and contributes to the hypertonic concentration as well.) Since the descending portion of the loop of Henle is

not impermeable to water, water can move out of the descending limb of the loop of Henle in response to the osmotic gradient established by the presence of NaCl and urea in the interstitial fluid. If ADH is present, it increases water permeability in the collecting ducts. When ADH is present, water leaves the collecting duct as well resulting in the production of a concentrated filtrate within the nephron and a concentrated urine.
The third mechanism for controlling osmotic concentration is the ***thirst response***. Neurons in the thirst center, located in the hypothalamus, are stimulated when the osmotic concentration of the body fluids is too high. This causes a person to feel thirsty and to drink; this increases the amount of water in the body, thus decreasing the osmotic concentration. The thirst mechanism is described in Chapter 26 "Fluid, Electrolyte and Acid-Base Balance" in the section "Water Balance and ECF Osmolality." You can consult your textbook for more information.
The table "Reabsorption Capabilities of Different Segments of the Renal Tubules and Collecting Ducts" (Table 25.1) details the selective reabsorption of water, salts and other substances in the different parts of the nephron

Regulation of Specific Ions

Regulation of concentration of specific ions such as Ca^{++} and PO_4 is discussed in the textbook in the section on Regulation of Calcium and Phosphate Balance (text p 1003).The primary control for this is parathyroid hormone, secreted by the parathyroid glands. To review you can consult the text (pp 1003, 610-611) since parathyroid hormone and its antagonist calcitonin were discussed in Lesson 7 "The Endocrine System". Parathyroid hormone acts in three ways: (1) it causes increased release of Ca^{++} and HPO_4^{2-} from the bone because it stimulates osteoclast cells to digest the bone, (2) in the small intestine, it causes increased reabsorption of Ca^{++} (Intestinal reabsorption of Ca^{++}occurs because parathyroid hormone stimulates the kidneys to activate vitamin D, which is necessary for Ca^{++} reabsorption in the intestine and (3) in the nephrons, it induces increased reabsorption of Ca^{++} while it inhibits reabsorption of PO_4 Thus calcium (Ca^{++}) ions are reabsorbed while phosphate (HPO_4^{2-}) ions are excreted by the kidneys. Parathyroid hormone secretion is controlled by a negative feedback mechanism. When the calcium concentration in the blood and tissues drops, parathyroid hormone is actively secreted; when calcium levels rise, the hormone ceases to be released. Figure 16.13 "Effect of parathyroid hormone on bone, the kidneys and the intestine" illustrates the actions of parathyroid hormone discussed above. Make sure to click open and review the figure, before proceeding to the rest of the content.

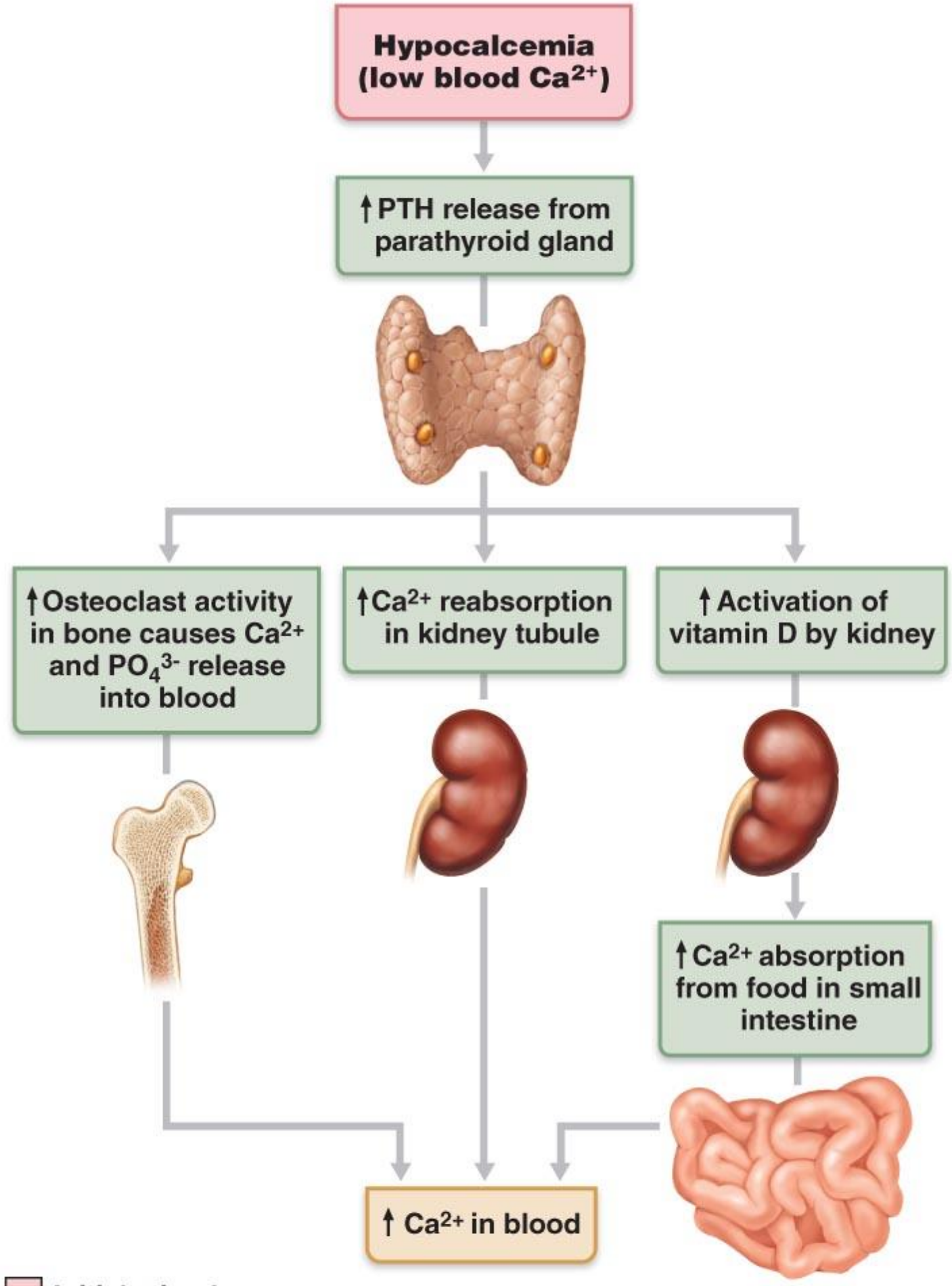

Hypocalcemia (low blood Ca^{2+})
↑ PTH release from parathyroid gland
↑ Osteoclast activity in bone causes Ca^{2+} and PO_4^{3-} release into blood
↑ Ca^{2+} reabsorption in kidney tubule
↑ Activation of vitamin D by kidney
↑ Ca^{2+} absorption from food in small intestine
↑ Ca^{2+} in blood
Initial stimulus
Physiological response

Figure 16.13 Effect of parathyroid hormone on bone, the kidneys and the intestine (Click on the figure to enlarge; review the figure thoroughly before proceeding to the rest of the content.)

As an antagonist to parathyroid hormone, calcitonin from the thyroid gland opposes the action of parathyroid hormone, working to remove Ca++ from the blood and deposit it in the bone. Calcitonin stimulates the bone-building osteoblasts which deposit Ca++ in bone while it also inhibits the bone-digesting osteoclasts. Calcitonin action is especially essential during bone growth in children and for women during pregnancy and lactation where it protects against excess loss of calcium.

Regulation of pH in the Body Fluids

Acidity of body fluids is of crucial importance. The level of pH in the blood must be maintained between 7.35 and 7.45. Interstitial fluid averages a pH of about 7.35, and a pH of about 7.0 is found inside most cells. (Of course, there are parts of the body that are exceptions: the gastric glands work to produce an extremely acid environment in the stomach, the contents of the small intestine are somewhat basic, and the vaginal secretions are acidic.) Acid is produced constantly in the cells as a byproduct of metabolism. If allowed to remain, the cells would cease to function in short order. Three basic systems mediate pH homeostasis: the circulatory system, the respiratory system, and the excretory (kidney) system. The circulatory system monitors pH by the presence of buffers in the blood. A buffer is a compound that, when added to a solution, prevents drastic changes in pH. It usually consists of a weak acid and the salt of that acid, or a weak base and the salt of that base. An example is the buffer pair H_2CO_3 (carbonic acid, a weak acid) and $NaHCO_3$ (sodium bicarbonate, the salt of carbonic acid). This buffer pair is capable of neutralizing either a strong acid or a strong base:

(Strong Base)NaOH + (Weak Acid)H_2CO_3 (Weak Base)$NaHCO_3$ + H_2O

(Strong Acid)HCl + (Weak Base)$NaHCO_3$ NaCl + (Weak Acid)H_2CO_3

In both instances, the strong acid or base was converted into a more neutral chemical. It is important that you understand the principle of buffering. Consult the section on ***Chemical Buffer Systems*** in your text (pp. 1004-1006) or any basic chemistry text if you are having difficulty in understanding buffers. (Remember that a strong acid will not be neutralized by another acid. A strong base will be neutralized by an acid.)

The respiratory system helps balance pH by causing a faster rate of breathing when a low pH is detected by the respiratory center in the medulla. This allows excess CO_2 to be exhaled. Since CO_2 lowers the pH by combining with water to form carbonic acid, eliminating CO_2 helps to increase the pH.

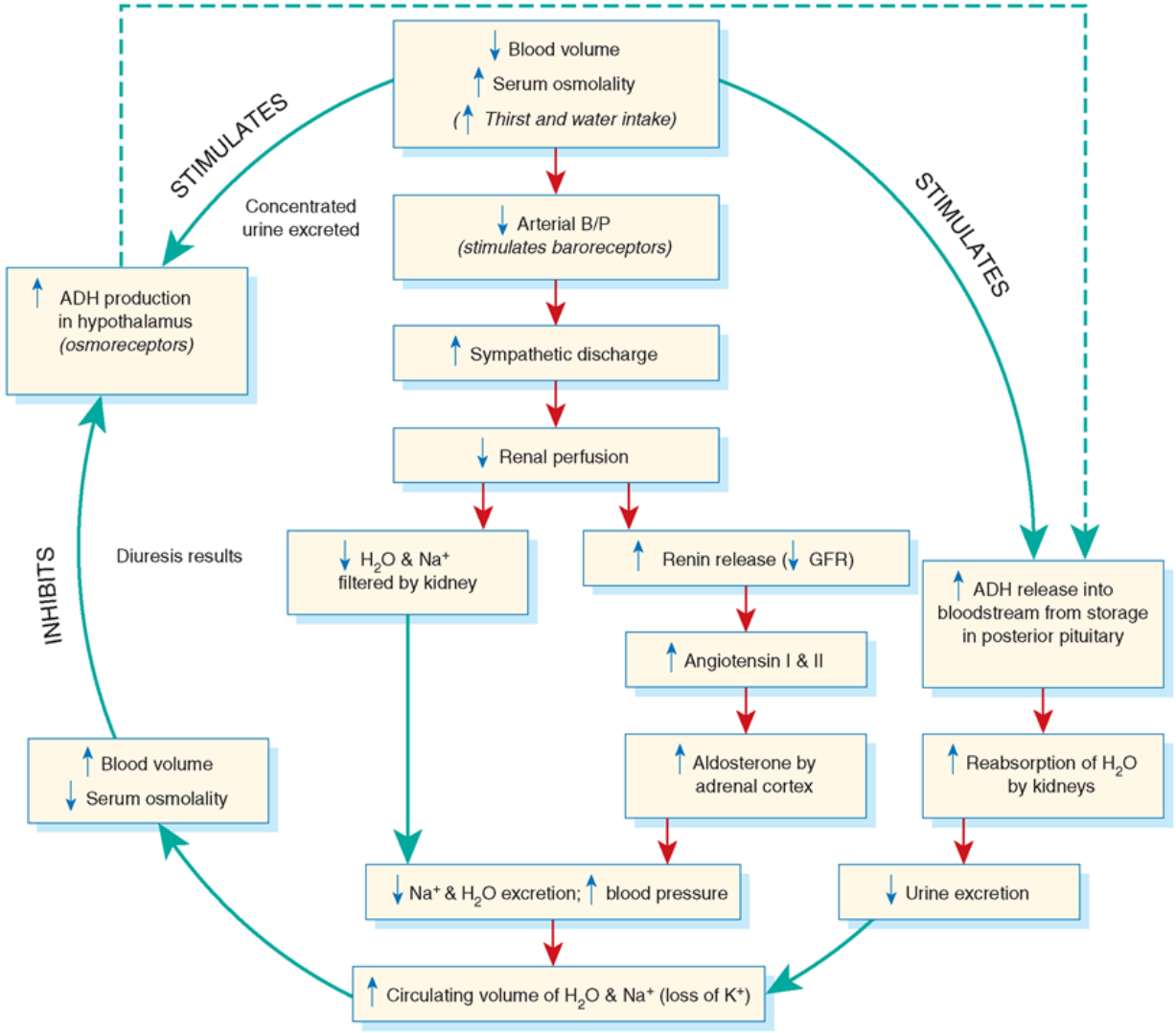
The excretory system assists with pH regulation by excreting H^+ and reabsorbing Na^+ when the pH is too low. The opposite occurs when the pH is elevated.

Abnormalities in acid-base balance constitute a very serious danger. A discussion of acid-base balance abnormalities is found in the section ***Abnormalities of Acid-Base Balance*** in chapter 26. The table on the ***Causes and Consequences of Acid-Base Imbalances*** (p. 1010) is extremely helpful in understanding how to diagnose a patient with acidosis or alkalosis (Table 26.3).

Fluid Volume

Volume of body fluids is regulated partially by the fact that increased fluid volume causes increased fluid pressure, which will cause more plasma to enter the Bowman's capsules and be filtered. The renin-angiotensin system also plays an important role. A decrease in blood volume or blood pressure stimulates the kidney to secrete the hormone, ***renin***. Renin catalyzes the conversion of the inactive plasma protein angiotensinogen, into the active protein ***angiotensin II***. Angiotensin II, then, helps to

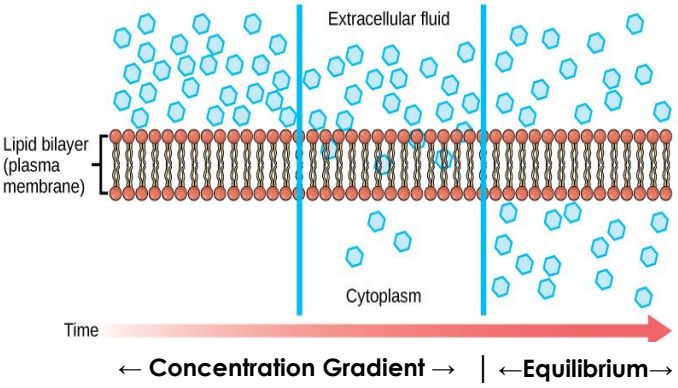
maintain fluid volume by (1) inducing the adrenal cortex to release the hormone ***aldosterone***, which increases Na^+reabsorption in the kidneys, (2) causing the posterior pituitary to release antidiuretic hormone and (3) stimulating the thirst center in the hypothalamus. Finally, angiotensin II is a strong vasoconstrictor affecting the smooth muscle of the arterioles.



Miss Foley

Bio30: OL2 Organisms Compared **INTRA(within)organism**

Mechanisms of Transport



Concentration Gradient (c.g.) = the process of particles moving from an area of **high** concentration **to** an area of **low** concentration, usually across a membrane.

Equilibrium = concentrations of solute and solvent are equal on both sides of the membrane

Passive Transport

(DO NOT require energy)

High → Low Concentration
a.k.a. Goes Down c.g.

Diffusion
(movement from high to low c.g.)

Osmosis
(movement of H_20 from high to low c.g.)

Active Transport

(Requires ATP Energy)

Low → High Concentration
a.k.a Goes Up c.g.

Exocytosis
(Exiting Cell)

Endocytosis
(Entering Cell)

Pinocytosis (Liquids entering)

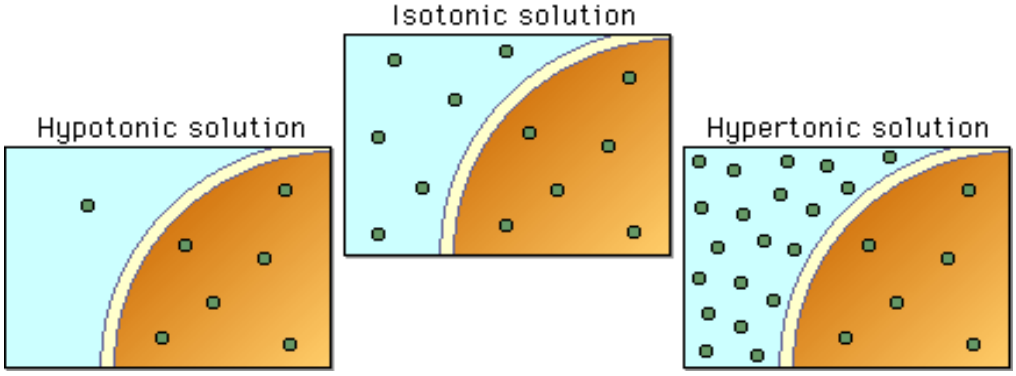
Phagocytosis (Solids Entering)

Types of Solutions

Hypotonic – concentration of solutes are higher inside than outside = water moves in & solutes move out = cell swells
Animal cells – burst Plant cells – increase turgor pressure

Isotonic – solute concentrations are equal inside & outside of cell = no movement of water or solutes

Hypertonic – Concentration of solutes lower inside than outside = water moving out & solutes moving in = cell shrinks Ex. Too Much Fertilizer



Legend

Green = solute
Brown = inside cell
Blue = outside cell
White = cell/plasma membrane

Symbiosis = "Living together"

A close, long-term interaction between two different species.

Interaction	Species A	Species B
Commensalism	Receives benefit	Not affected
Mutualism	Receives benefit	Receives benefit
Parasitism	Receives benefit	Harmed

There are three different types of symbiotic relationships: mutualism, commensalism, and parasitism:

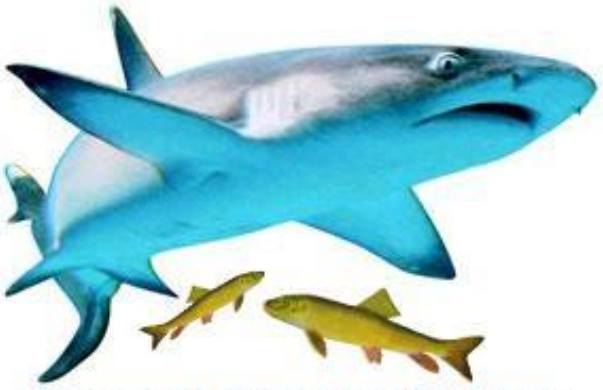
Mutualism - both partners benefit. An example of mutualism is the relationship between the Egyptian plover and the crocodile. In the tropical regions of Africa, the crocodile lies with its mouth open. The plover flies into its mouth and feeds on bits of decaying meat stuck in the crocodile's teeth. The crocodile does not eat the plover. Instead, he appreciates the dental work. The plover eats a meal and the crocodile gets his teeth cleaned. Coincidentally, the Egyptian plover is also known as the crocodile bird.

An astounding number of mutualistic relationships occur between multicellular organisms and microorganisms. Termites are only able to eat wood because they have mutualistic protozoans and bacteria in their gut that helps them digest cellulose. Inside our own bodies, there are hundreds of different types of bacteria that live just in our large intestine. Most of these are uncharacterized, but we do know a lot about E. coli, which is one of the normal bacteria found in all human large intestines. Humans provide E. coli with food and a place to live. In return, the E. coli produce vitamin K and make it harder for pathogenic bacteria to establish themselves in our large intestine. Whether or not most of the other species of bacteria found in our digestive tract aid in digestion, absorption, or vitamin production isn't completely known, but they all make it harder for invasive pathogens to establish a foothold inside us and cause disease.

Miss Foley

Bio30: OL2 Organisms Compared **INTERorganism**

Commensalism - only one species benefits while the other is neither helped nor harmed. For example, remora fish are very bony and have a dorsal fin (the fin on the back of fish) that acts like a suction cup. Remora fish use this fin to attach themselves to whales, sharks, or rays and eat the scraps their hosts leave behind. The remora fish gets a meal, while its host gets nothing. Selfish, sure, but neither gets hurt. The cattle egret follows cattle, water buffalo, and other large herbivores as they graze. The herbivores flush insects from the vegetation as they move, and the egrets catch and eat the insects when they leave the safety of the vegetation. In this relationship the egret benefits greatly, but there is no apparent effect on the herbivore.

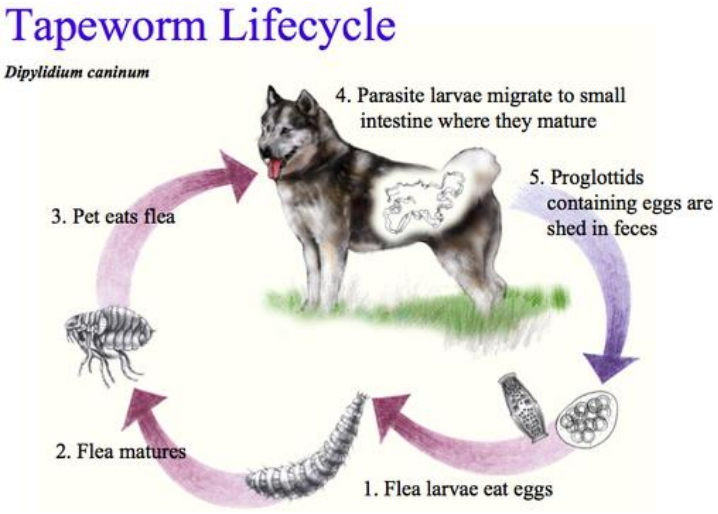


Commensalism between Sucker fish and Shark

Some biologists maintain that algae and barnacles growing on turtles and whales have a commensalistic relationship with their hosts. Others maintain that the presence of hitchhikers causes drag on the host as it moves through the water and therefore the host is being harmed, albeit slightly. In either case, it is unlikely that the fitness of the host is really affected by the hitchhikers, so commensalism is probably the best way to describe these relationships as well.

Parasitism - One organism (parasite) gains, while the other (host) suffers. The deer tick is a parasite. It attaches to a warm-blooded animal and feeds on its blood. Ticks need blood at every stage of their life cycle. They also carry Lyme disease, an illness that can cause joint damage, heart complications, and kidney problems. The tick benefits from eating the animal's blood. Unfortunately, the animal suffers from the loss of blood and nutrients and may get sick. Not all parasites have to cause disease. Lice, ticks, fleas, and leeches are all examples of parasites that don't usually cause disease directly, but they do suck blood from their host, and that is causing some harm, not to mention discomfort to their host.

Parasites can also act as organisms that transmit disease-causing pathogens to other species of animals. The bacteria that cause the bubonic plague are carried by rodents, such as rats. The plague bacteria then infect fleas that bite the rats. Infected fleas transmit the bacteria to other animals they bite, including humans. In this case, both the flea and the bacteria are parasites, and the flea is also a vector that transmits the disease-causing bacteria from the rat to the person.



Gregor Mendel = "Father of Genetics"

- "Father of Genetics" - Mendel discovered the basic principles of heredity by breeding garden peas in carefully planned experiments.
- Mendel defined different types of hybridization
  - P generation – parental; true breeding parents
  - F1 generation – 1st filial or generation of offspring
  - F2 generation – 2nd filial

Gregor Mendel (1822-1884)

Mendel discovered that:

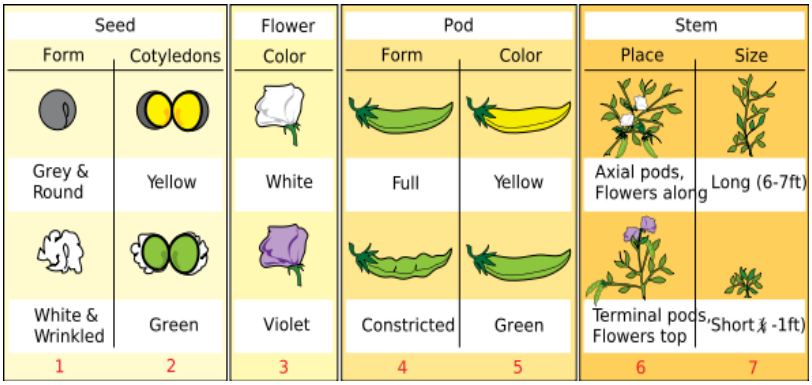
- If 2 genes differ, one is dominant and one is recessive. Dominant allele is capitalized.
- A dominant allele is fully expressed in an organism's appearance. A recessive allele has no noticeable effect.
- Alternative versions of genes (alleles) account for variations in inherited characteristics
- An organism inherits 2 genes, one from each parent, for every character.
- A sperm or egg only carries one allele for each inherited trait

Mendel's Law of Dominance:

One gene is dominant over another gene

Mendel's Law of Segregation:

The pair of alleles from each parent separate during gamete formation (meiosis) & only one allele passes from each parent to the offspring.



Mendel's Law of Independent Assortment:

Different pairs of alleles are passed to offspring independently of each other.

Miss Foley

Bio 30: GB1 Genetics Intro **Mendel Introduction**

Genetic Vocabulary

1. **Homozygous –** pair of identical alleles for a character
2. **Heterozygous –** having 2 different alleles for a character
3. **Phenotype –** an organism's outward appearance
4. **Genotype –** an organism's genetic makeup
5. **Gene –** a section of DNA that codes for a specific trait (protein) in offspring
6. **Allele –** one of a number of different forms of a gene

Ways to Determine Traits

1. Predicting Traits = Punnett Squares

Punnett Squares – a square used to show all of the possible combinations of gametes.

Ex. A blue-eyed mother mates with a homozygous, brown-eyed father. What ratio of brown-eyed to blue-eyed children will they have?

Brown eyes is the dominant trait, therefore… B – Brown b – blue

F1:

	B	**B**
b	**Bb**	**Bb**
b	**Bb**	**Bb**

Phenotypes: 100% Brown

*** F1 Generation Always 100% Dominant ***

F2:

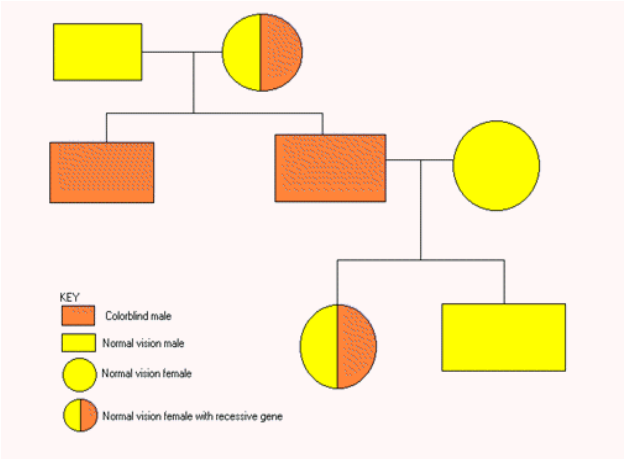
	B	**b**
B	**BB**	**Bb**
b	**Bb**	**bb**

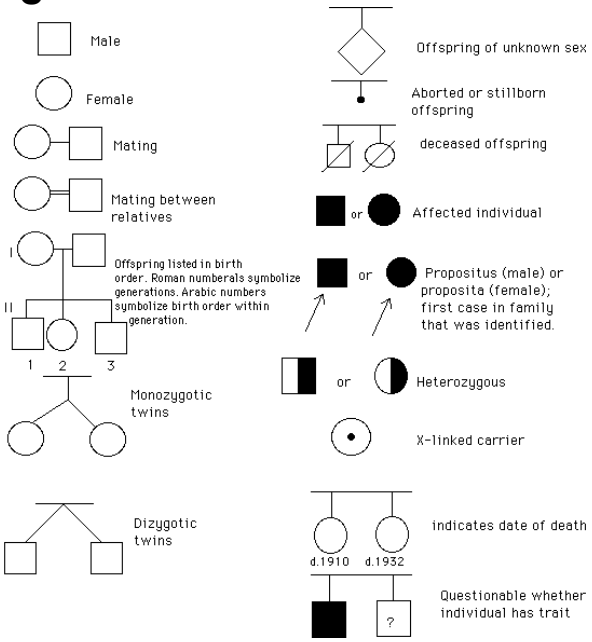
Phenotypes: 75% Brown 25% Blue

*** F2 Generation Always 3:1 ***

2. Determining Parental Genotypes = Pedigree Tests

Pedigree Test – Test where you look at the genetic makeup of the offspring to determine the genotypes of the parents.





Key Review Points:

- Gregor Mendel studied inheritance of traits in pea plants. He proposed a model where pairs of "heritable elements," or **genes**, specified traits.
- Genes come in different versions, or **alleles**. A dominant allele hides a recessive allele and determines the organism's appearance.
- When an organism makes **gametes**, each gamete **receives just one gene copy**, which is selected randomly. This is known as the law of segregation.
- A **Punnett square** can be used to **predict genotypes** (allele combinations) **and phenotypes** (observable traits) of offspring from genetic crosses.

Probabilities in Genetics

The two probability rules that are most relevant to Punnett squares are the Product Rule and the Sum Rule.

The **Product Rule** states that the probability of two (or more) independent events occurring together can be calculated by multiplying the individual probabilities of the events.

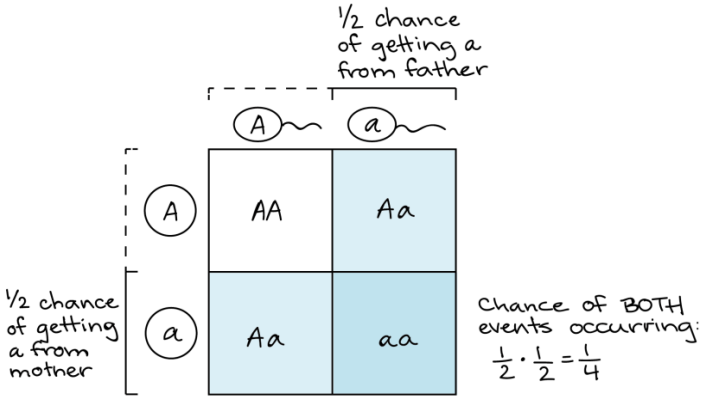


Illustration of how a Punnett square can represent the product rule.

In some genetics problems, you may need to calculate the probability that any one of several events will occur. In this case, you'll need to apply another rule of probability, the sum rule.

The **Sum Rule** states that the probability that any of several mutually exclusive events will occur is equal to the sum of the events' individual probabilities.

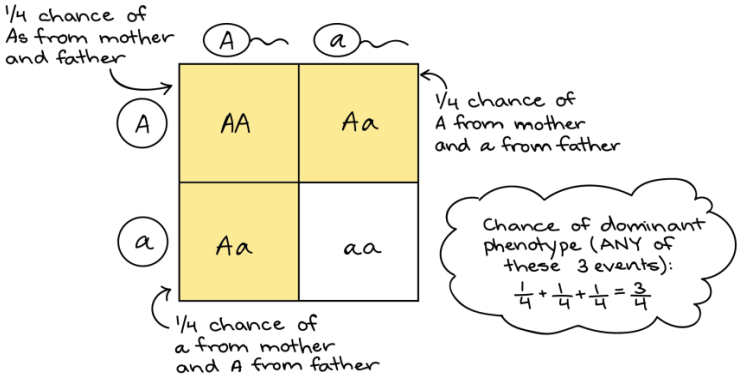
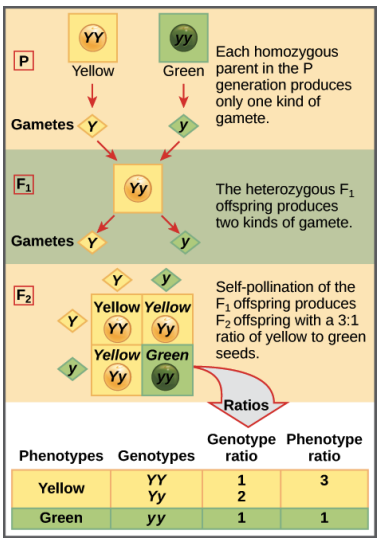


Illustration of how a Punnett square can represent the sum rule.

Miss Foley

Bio30: GB1 Genetics Intro **Hybrid Crosses**

Monohybrid Cross =
crossing a single gene trait at a time



Monohybrid Cross (Dominant & Recessive Alleles)

PROBLEM: Cross two heterozygous tall pea plants.
Give genotypic and phenotypic ratios.

STEP 1: Determine what kind of problem you are trying to solve.

- Does it involve simple dominant and recessive traits, Incomplete dominance, or Co-dominance?
- Is it a monohybrid or dihybrid?
- In this case there is only one trait…this is a monohybrid cross involving dominant and recessive traits.

STEP 2: Determine letters you will use to specify traits.

- In this case it is dominant and recessive, so you can use ***T*** and ***t.***

STEP 3: Determine parent's genotypes.

- In this case you were told the parents were heterozygous. You therefore know that the parents must be ***Tt*** and ***Tt***
- The Cross is: ***Tt X Tt***

STEP 4: Make your punnett square and list gametes.

- these go on the top and side of your punnett square
- ***Tt*** would make a ***T*** and a ***t***

STEP 5: Complete cross and determine possible offspring.

STEP 6: Determine genotypic and phenotypic ratios.

- **Genotypic ratio:** Make a list of all the different genotypes (the letter combinations) and determine how many of each you have.
  - In your problem this would be: ***TT = 1, Tt = 2,*** and ***tt - 1.***
    The genotypic ratio would therefore be ***1 : 2 :1***
- **Phenotypic ratio:** Make a list of all the different phenotypes (physical characteristics).
  - In you problem this would be: ***Tall = 3, and short = 1***. The phenotypic ratio would therefore be ***3 : 1***

Dominant and Recessive
(T = Tall & t = short
Cross: Tt x Tt

	T	t
T	TT	Tt
t	Tt	tt

Genotypic ratio: 1 : 2 : 1 (TT=25% Tt=50% tt=25%)

Phenotypic ratio: 3 : 1 (Tall=75% Short=25%)

Monohybrid (Incomplete Dominance)

PROBLEM: Cross two heterozygous plants. Give genotypic and phenotypic ratios. The tall gene is this plant is incompletely dominant over the short gene. TT=Tall, Tt=medium & tt=short.

STEP 1: Determine what kind of problem you are trying to solve.

- Does it involve simple dominant and recessive traits, Incomplete dominance, or Co- dominance?
- Is it a monohybrid or dihybrid?
- In this case there is only one trait.....this is a monohybrid cross involving incomplete dominant traits.

STEP 2: Determine letters you will use to specify traits.

- In this case it is a incomplete dominant problem. ***TT=tall, Tt=medium, and tt=short***

STEP 3: Determine parent's genotypes.

- In this case you were told the parents were heterozygous. You therefore know that the parents must be ***Tt*** and ***Tt***
- The Cross is: ***Tt X Tt***

STEP 4: Make your punnett square and make gametes (these go on the top and side of your punnett square).

- ***Tt*** would make a ***T*** and a ***t***

STEP 5: Complete cross and determine possible offspring.

STEP 6: Determine genotypic and phenotypic ratios.

- **Genotypic ratio:** Make a list of all the different genotypes (the letter combinations) and determine how many of each you have.
  - In your problem this would be: ***TT = 1, Tt = 2,*** and ***tt - 1.*** The genotypic ratio would therefore be ***1 : 2 : 1***
- **Phenotypic ratio:** Make a list of all the different phenotypes (physical characteristics.
  - In you problem this would be: ***Tall = 1, medium = 2, and short = 1***. The phenotypic ratio would therefore be ***1 : 2 : 1***

Incomplete Dominance
(TT = Tall & Tt = Medium & tt = short
Cross: Tt x Tt

	T	t
T	TT	Tt
t	Tt	tt

Genotypic ratio: 1 : 2 : 1 (TT=25% Tt=50% tt=25%)

Phenotypic ratio: 1 : 2 : 1 (Tall=25% Medium=50% Short=25%)

Genetics With A Smile

Part A: Smiley Face Traits

1. Obtain two coins from your teacher. Mark one coin with a "F" and the other with a "M" to represent each of the parents. The parents are heterozygous for all the Smiley Face traits.
2. Flip the coins for parent for each trait. If the coin lands with heads up, it represents a dominant allele. A coin that lands tails up indicates a recessive allele. Record the result for each person by circling the correct letter. Use the results and the Smiley Face Traits page to determine the genotype and phenotype for each trait.

Trait	Female		Male		Genotype	Phenotype
Face Shape	C	c	C	c		
Eye Shape	E	e	E	e		
Hair Style	S	s	S	s		
Smile	T	t	T	t		
Ear Style	V	v	V	v		
Nose Style	D	d	D	d		
Face Color	Y	y	Y	y		
Eye Color	B	b	B	b		
Hair Length	L	l	L	l		
Freckles	F	f	F	f		
Nose Color	R	Y	R	Y		
Ear Color	P	T	P	T		

Part B: Is it a boy or girl?

To determine the sex of your smiley face, flip the coin for the male parent. Heads would represent X, while tails would be Y.

	Female	Male		Genotype	Phenotype
Sex	X	X	Y		

Part C: Create Your Smiley Face!

Use the Smiley Face Traits chart and your results from Part A to create a sketch of your smiley face in the box. If doing the assignment electronically, use the drawing tools in Microsoft Word to create your smiley face!

Two things to remember...

- ❑ Do not add color on the computer! Print a black and white copy and then use crayons or colored pencils to finish it.
- ❑ Don't forget to give your smiley face a name! You will also need to include your name as parent and your class hour.

Baby's Name: _____

Smiley Face Traits

FINISH!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!111

Name: ____________________ Date: _________

Bio30: GB1 Genetics Intro **Build Your Baby**

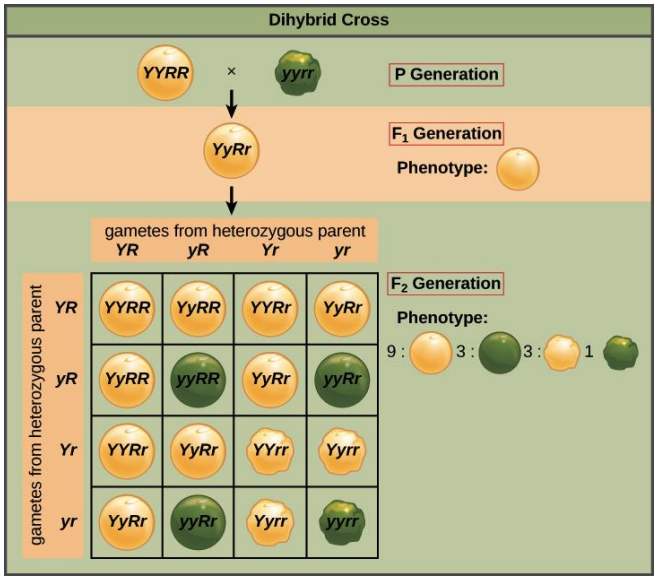
Genetics With A Smile: Wrapping Up

1.

FINISH!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

Name: _____ Date: _____

Bio30: GB1 Genetics Intro **Build Your Baby**



Dihybrid Cross = crossing two gene traits at a time

Transfer the **FOIL Method** from math to combine alleles from both traits for each of the parents:

First Alleles

Outside Alleles

Inside Alleles

Last Alleles

Dihybrid (Dominant and Recessive)

PROBLEM: Cross two heterozygous tall Black cows. Tall is dominant over short, and Black is dominant over white. Give genotypic and phenotypic ratios of offspring.

STEP 1: Determine what kind of problem you are trying to solve.

- Does it involve simple dominant and recessive traits, Incomplete dominance, or Co-dominance?
- Is it a monohybrid or dihybrid?
- In this case there are two traits.....this is a *dihybrid cross involving dominant and recessive traits.*

STEP 2: Determine letters you will use to specify traits.

- In this case there are two traits you will need letters for. Use ***T = Tall, and t = short* for one trait, and *B = Black, and b = white*** for the second trait. These are both dominant/recessive genes

STEP 3: Determine parent's genotypes.

- In this case you were told the parents were heterozygous for both traits. You therefore know that the parents must be **TtBb** and **TtBb**
- The Cross is: **TtBb X TtBb**

STEP 4: Make your punnet square and list gamete combinations (these go on top and side of your punnett square).

- Making gametes for a dihybrid cross requires you use *FOIL* (first-outside-inside-last)
- ***TtBb*** would make four different gametes = ***TB, Tb, tB, tb***

STEP 5: Complete cross and determine possible offspring.

STEP 6: Determine genotypic and phenotypic ratios.

- **Genotypic ratio:** Make a list of all the different genotypes (the letter combinations) and determine how many of each you have.
  - The genotypic ratio would therefore be **1:2:2:1:4:1:2:3:1**
- **Phenotypic ratio:** Make a list of all the different phenotypes (physical characteristics.
  - In you problem this would be: **Tall/Black = 9, and Tall/white = 3, short/Black = 3, and short/white = 1**.
  - The phenotypic ratio would therefore be **9:3:3:1**

Dihybrid Cross
Dominant and Recessive
T=Tall, t=short
B=Black, b=white
Cross: TtBb x TtBb

	TB	Tb	tB	tb
TB	TTBB	TTBb	TtBB	TtBb
Tb	TTBb	TTbb	TtBb	Ttbb
tB	TtBB	TtBb	ttBB	ttBb
tb	TtBb	Ttbb	ttBb	ttbb

Genotypic ratio: 1:2:2:1:4:1:2:2:1

Phenotypic ratio: 9:3:3:1

Miss Foley

Bio30: GB1 Genetics Intro **Hybrid Crosses**

Dihybrid (Dominant and Recessive and Sex-linked)

PROBLEM: Cross a homozygous tall female carrier for hemophilia with a short normal male. Give genotypic and phenotypic ratios of offspring.

STEP 1: Determine what kind of problem you are trying to solve.

- Does it involve simple dominant and recessive traits, Incomplete dominance, or Co-dominance, or sex-linked?
- Is it a monohybrid or dihybrid?
- In this case there are two traits.....this is a *dihybrid cross involving dominant and recessive traits and sex-linked trait for hemophilia*.

STEP 2: Determine letters you will use to specify traits.

- In this case there are two traits you will need letters for. Use *T = Tall, and t = short* for one trait, and *H =normal, and h = hemophilia* for the second sex-linked trait. These are both dominant/recessive genes

STEP 3: Determine parents genotypes.

- In this case you were told the parents were heterozygous for both traits. You therefore know that the parents must be **X^hXTT** and **XYtt**
- The Cross is: **X^hXTT** X **XYtt**

STEP 4: Make your punnet square and make gametes (these go on the top and side of your punnett square.

- Making gametes for a dihybrid cross requires you use *FOIL* (first-outside-inside-last)
- **X^hXTT** would make four different gametes = **X^hT, X^hT, XT,** and **XT**
- **XYtt** would make four different gametes **= Xt, Xt, Yt,** and **Yt**

STEP 5: Complete cross and determine possible offspring. When you have a sex-linked trait, make sure you put the females gametes on top of the punnett square and the male's on the side.

STEP 6: Determine genotypic and phenotypic ratios.

- **Genotypic ratio:** Make a list of all the different genotypes (the letter combinations) and determine how many of each you have.
  - The genotypic ratio would therefore be **4:4:4:4** or **1:1:1:1**
- **Phenotypic ratio:** Make a list of all the different phenotypes (physical characteristics.
  - In you problem this would be: **Tall/female carrier = 4, Tall/normal female = 4, Tall/male w/ hemophilia = 4, and Tall/normal male = 4**.
  - The phenotypic ratio would therefore be **4:4:4:4** *or* **1:1:1:1**

Dihybrid Cross
Dom.-Rec. / Sex-linked
T=Tall, t=short
H=Normal, h=hemophilia

Cross: homozygous Tall female carrier w/ short male

Cross: X^hXTT x XYtt

	X^hT	X^hT	XT	XT
Xt	X^hXTt	X^hXTt	XXTt	XXTt
Xt	X^hXTt	X^hXTt	XXTt	XXTt
Yt	X^hYTt	X^hYTt	XYTt	XYTt
Yt	X^hYTt	X^hYTt	XYTt	XYTt

Genotypic ratio: 4:4:4:4 or 1:1:1:1

Phenotypic ratio: 4:4:4:4 or 1:1:1:1

Name: _____ Date: _____

Bio30: GB1 Genetics Intro **Dihybrid Crosses**

Dihybrid Crosses _____ /70 = _____%

Suppose that we mate a pair of hamsters:

Black fur (B) is dominant over brown fur (b). Short fur (A) is dominant over long fur (a).

1. What will be there genotypes and phenotypes for each of the following cases?
2. What is the ratio of phenotypes in each generation?

Generation	**Case One**	
P	Genotype	BBAA x bbaa
	Phenotype	
F1	Punnett Square	
	Genotypes	
	Phenotypes	
	Phenotype Ratio	
F2	Punnett Square	
	Genotypes	
	Phenotypes	
	Phenotype Ratio	

Name: _____ Date: _____

Bio30: GB1 Genetics Intro **Dihybrid Crosses**

Dihybrid Crosses ANSWER KEY ____ /70 = ____%

Suppose that we mate a pair of hamsters:

Black fur (B) is dominant over brown fur (b). Short fur (A) is dominant over long fur (a).

1. What will be there genotypes and phenotypes for each of the following cases?
2. What is the ratio of phenotypes in each generation?

Generation	Case One	
P	Genotype	BBAA x bbaa
	Phenotype (2)	**Black Short Fur** **Brown Long Fur**
F1	Punnett Square (24)	

	BA	BA	BA	BA
ba	BbAa	BbAa	BbAa	BbAa
ba	BbAa	BbAa	BbAa	BbAa
ba	BbAa	BbAa	BbAa	BbAa
ba	BbAa	BbAa	BbAa	BbAa

Genotypes (1)	**BbAa**
Phenotypes (1)	**100% Black Short Fur**
Phenotype Ratio (1)	**1:0**
F2	Punnett Square (24)

	BA	Ba	bA	ba
BA	BBAA	BBAa	BbAA	BbAa
Ba	BBAa	BBaa	BbAa	Bbaa
bA	BbAA	BbAa	bbAA	bbAa
ba	BbAa	Bbaa	bbAa	bbaa

Genotypes (9)	**BBAA, BBAa, BbAA, BBaa, BbAa, Bbaa, bbAA, bbAa, bbaa**
Phenotypes (4)	**Black Short, Black Long, Brown Short, Brown Long**
Phenotype Ratio (4)	**9 : 3 : 3 : 1**

Name: _____ Date: _____

Bio30: GB1 Genetics Intro **Pedigree Chart**

Pedigree Chart Case Study _____ /10 = _____%

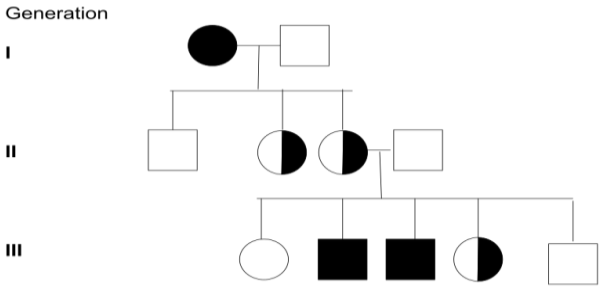
Objective: To construct and examine a pedigree chart for Duchenne's muscular dystrophy, a sex-linked condition in humans.

Background Information:

Duchenne's muscular dystrophy is a well-known lethal condition. Evidence supports its inclusion as a sex-linked condition, as it appears nearly always in males. It is usually carried by females. The disease causes the muscles of the body to slowly deteriorate (atrophy). Boys with this condition often need to use a wheelchair by five years of age, and death usually occurs in the early to mid-teens. Knowing how this disease is inherited through family members suspected of carrying the gene will be helpful in genetic counselling and decision making.

Procedure: ** Note: The symbol DMD will be used to represent Duchenne's muscular dystrophy.*

1. A pedigree chart attempts to trace a specific trait using a series of circles, squares, and straight lines to represent generations in a family. Circles represent females, squares represent males, and lines join individuals. Fully shaded circles and squares indicate individuals who show the condition being studied. Partially shaded circles and squares indicate individuals who carry the gene but do not show the condition being studied. Children of a union are listed in order from left to right and generations are listed chronologically from top to bottom.



2. Carefully read the following information concerning the four generations of a family:
   - Two people marry and have four children (F1 generation) in the following order: a daughter, a son, a daughter, and another daughter.
   - The **first daughter** (F1) marries and has three children: a son, a daughter, and a second daughter. Her son does not marry. Her first daughter does not marry. Her second daughter marries and produces a son, who develops DMD, and two daughters.

     *** This family history is designated as **Line A**.*
   - The **son** (F1) develops muscular dystrophy and dies.
   - The **second daughter** (F1) marries, but produces no children.
   - The third daughter (F1) marries and has two children: a son who develops DMD and dies, and a second son. Her second son marries. His wife produces two children: a daughter and then a son.

     *** This family history is designated as **Line B**.*

3. Construct a pedigree chart to represent the information provided above. The chart should occupy at least half a page. Keep line A and Line B on opposite sides of the page. Mark in the generations.

Check the accuracy of your pedigree chart with your teacher before proceeding with the questions below.

Name: _____ Date: _____

Bio30: GB1 Genetics Intro **Pedigree Chart**

Pedigree Chart:

Analysis Questions:

4. If the original parents did not exhibit the trait for DMD, how could it have appeared in one of their children?

5. Is there any indication from the pedigree chart that DMD is a sex-linked condition? Explain.

6. Which females in generation 2 are definitely carriers of the DMD condition? Explain.

7. In Line A, generation 3, could the husband of the married daughter have been responsible for passing the DMD gene on to his son? Explain.

Application Questions:

9. Is it possible for a sex-linked disease like DMD to pass from one generation to another without appearing in any offspring? Explain.

10. In Line B, generation 4, what is the probability of the son developing DMD? Explain.

11. In generation 2, concerned by the appearance of DMD in her brother, the second daughter and her husband decided to visit a genetic counsellor before having any children. Their decision was to adopt rather than have children of their own. Reconstruct the reasoning they probably used in arriving at this decision.

Name: _____ Date: _____

Bio30: GB1 Genetics Intro **KEY** **Pedigree Chart**

Pedigree Chart:

Analysis Questions:

8. If the original parents did not exhibit the trait for DMD, how could it have appeared in one of their children?
   Since DMD is a sex-linked condition, the father cannot have the condition and the mother must be the carrier.

9. Is there any indication from the pedigree chart that DMD is a sex-linked condition? Explain.
   DMD appears to be sex-linked due to its characteristic appearance in males only, often skipping a generation.

10. Which females in generation 2 are definitely carriers of the DMD condition? Explain.
    Daughters 1 and 3 are definite carriers of DMD. Daughter 3 has passed the gene to her son; daughter 1 has passed the gene to her grandson through her second daughter.

11. In Line A, generation 3, could the husband of the married daughter have been responsible for passing the DMD gene on to his son? Explain.
    The husband could not have passed the gene to his son since the males express only one gene of a sex-linked condition, and he does not have DMD. Also, DMD victims die before they are old enough to conceive children.

Application Questions:

12. Is it possible for a sex-linked disease like DMD to pass from one generation to another without appearing in any offspring? Explain.
    It is possible for a sex-linked disease to pass from one generation to another without appearing in any offspring. Students should show how a sex-linked recessive trait can pass from female to female (may use a Punnett square) without ever showing up.

13. In Line B, generation 4, what is the probability of the son developing DMD? Explain.
    The chance of the son developing DMD is very low, since the female is the carrier and his mother is not a member of this family. To determine if there is a chance of his son having DMD, a pedigree study of the mother's past generations is required to see if the gene has ever expressed itself.

14. In generation 2, concerned by the appearance of DMD in her brother, the second daughter and her husband decided to visit a genetic counsellor before having any children. Their decision was to adopt rather than have children of their own. Reconstruct the reasoning they probably used in arriving at this decision.
    There is a 50% probability of the daughter being a carrier. If she is a carrier, then there is a 50% chance that any male child she produces will have DMD. By not having children of her own she stops the gene from being passed on. A mathematical way of looking at it is as follows:

    daughter has gene (1/2) x daughter has son (1/2) x son has gene (1/2) = son has DMD (1/8)

    The same probability exists for any daughters she produces being carriers.

Miss Foley

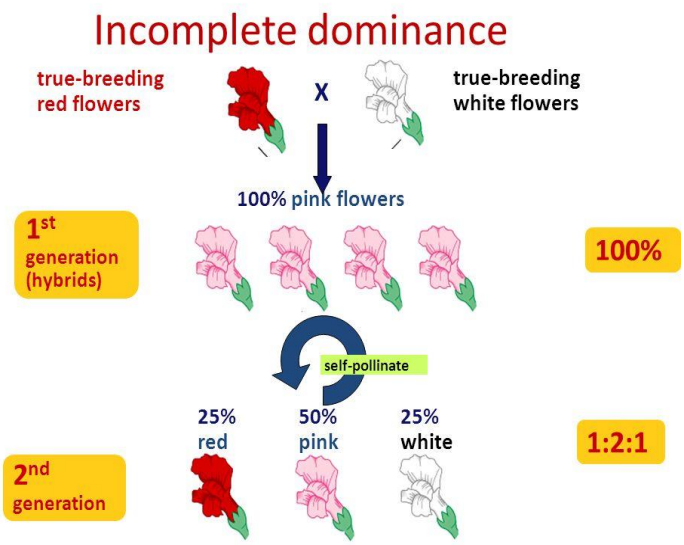
Bio30: GB1 Genetics Intro **Exceptions to Mendel**

While many genes follow the patterns outlined by Mendel's Laws, many do not. Such situations include incomplete dominance, co-dominance and multiple alleles.

Incomplete Dominance = PARTIAL Expression

Both alleles **PARTIALLY** contribute to the phenotype of a heterozygous individual producing a trait that is not exactly like either parent.

Example: Japanese four-o'clock plant does not follow the pattern of Mendel dominance. A cross between a plant with red flowers and one with white flowers produces offspring with pink flowers.



Genotypes for incomplete dominance are written using capital initial letter of each allele, since both alleles influence the phenotype. For our flower example, red is represented by R and white is represented by W.

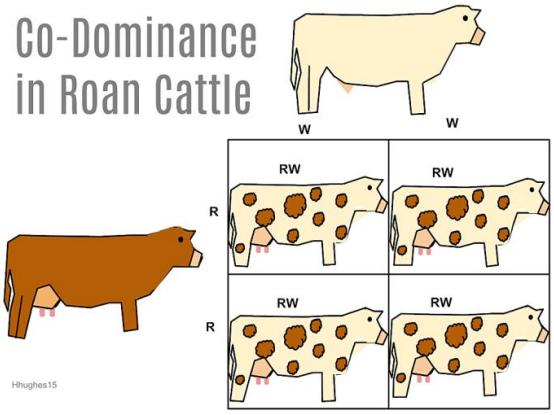
Individuals with red or white flowers are always homogenous (RR or WW).

Individuals with an intermediate color are pink and heterozygous (RW).

When two pink hybrid flowers (F1's) are crossed, a 1:2:1 ratio of red to pink to white is produced for the F2 generation.

Co-Dominance = FULL Expression

Both alleles **FULLY** contribute to the phenotype of a heterozygous individual combining both traits identical to the parents.



Incomplete Dominance

Co-dominance

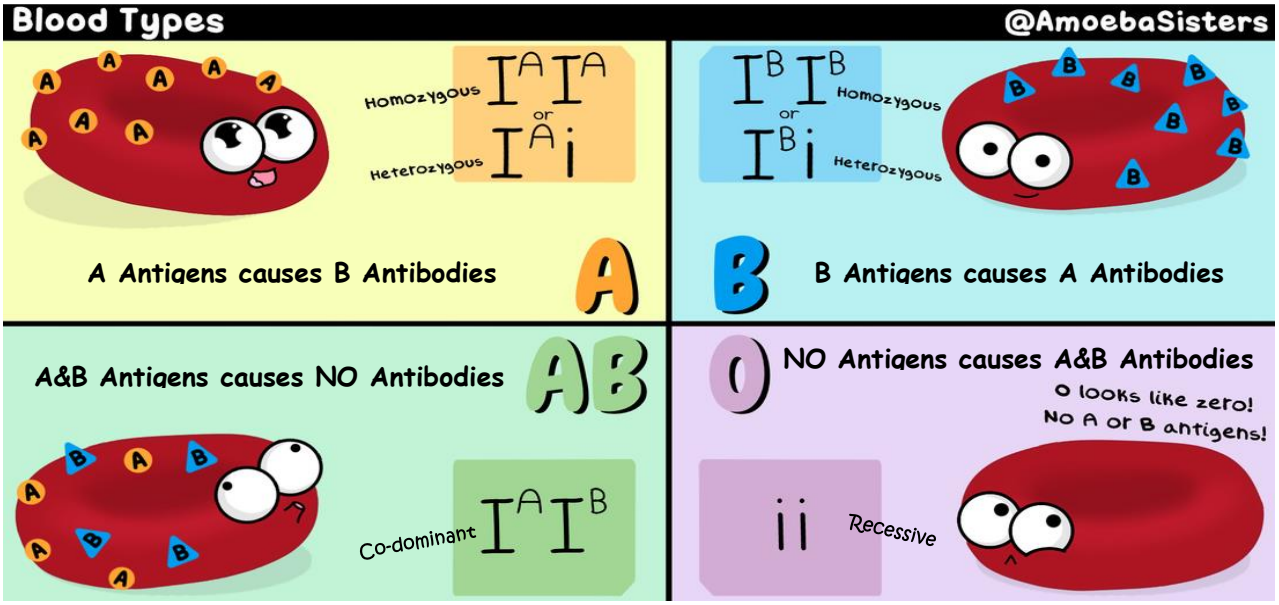
<u>Multiple Alleles</u> = 2+ alleles for the species

Although a single individual cannot have more than two alleles for each trait, different individuals can have different pairs of alleles when multiple alleles exist.

<u>Examples:</u> Human blood typing, eye color and hair color.

In some ways, every person's blood is the same. But, when analyzed under a microscope, distinct differences are visible. In the early 20th century, an Austrian scientist named Karl Landsteiner classified blood according to these differences. He was awarded the Nobel Prize for his achievements.

Landsteiner observed two distinct chemical molecules present on the surface of the red blood cells. He labeled one molecule "A" and the other molecule "B". We now know these molecules as being "A" and "B" antigens. If the red blood cell had only "A" antigens on it, that blood was called **Type A**. If the red blood cell had only "B" antigens on it, that blood was called **Type B**. If the red blood cell had a mixture of both "A" and "B" antigens, that blood was called **Type AB**. If the blood had neither "A" or "B" antigens, that blood was called **Type O**.



If two blood types are mixed together, the blood cells may begin to clump together in the blood vessels, causing a potentially fatal situation. Therefore, it is important that blood types be matched before blood transfusions take place. In an emergency, **Type O blood is known as the Universal Donor** and can be given because it is most likely to be accepted by all blood types. However, there is still a small risk involved if the Rh factors don't completely match. **Type AB blood is known as the Universal Recipient** as is can receive all blood types.

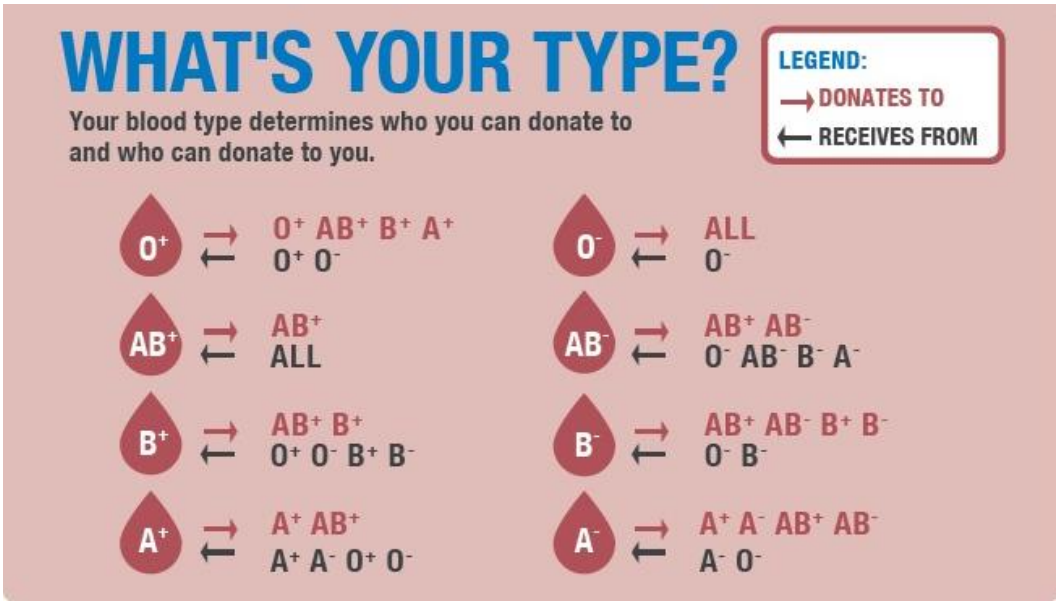
Are You Positive or Negative?

Scientist sometimes study Rhesus monkeys to learn more about human anatomy because there are certain similarities between the two species. While studying Rhesus monkeys, a certain blood protein was discovered. This protein is also present in the blood of some people. Other people, however, do not have this protein. The presence of the protein, or lack of it, is referred to as the **Rh (for Rhesus) factor**.

If your blood does contain the protein, your blood is said to be **Rh positive (Rh+)**. If your blood does not contain the protein, your blood is said to be **Rh negative (Rh-)**.

This Rh factor is connected to your blood type. For example, your blood may be AB+ which means that you have Type AB blood with a positive Rh factor. Or you might have O- blood which means that you have Type O blood with a negative Rh factor.

It is particularly important for expectant mothers to know their blood's Rh factor. Great **pre-natal** care will include **Rh screening around 26 weeks**. Occasionally, a baby will inherit an Rh positive blood type from its father while the mother has an Rh negative blood type. The mother's immune system identifies the baby's blood as foreign and starts attacking the fetus. The baby's life could be in great danger if the mother's Rh negative blood attacks the baby's Rh positive blood. If this happens, an exchange transfusion may save the baby's life. The baby's blood can be exchanged for new blood that matches the mother's.



Type O = "Universal Donor"

Type AB = "Universal Recipient"

Human Blood Types:
ABO Blood Typing System & The RH Factor

Blood Type	Possible Genotypes (Allele Form)	Antigen Present On Red Blood Cell	Antibodies Present In the Plasma	Rhesus (RH) Factor Present	Blood Types They Can Give To	Blood Types They Can Receive From
A	$I^A I^A$ or $I^A i$	A	anti-B	✓	A^+, AB^+	A^+, A^-, O^+, O^-
				×	A^+, A^-, AB^+, AB^-	A^-, O^-
B	$I^B I^B$ or $I^B i$	B	anti-A	✓	B^+, AB^+	B^+, B^-, O^+, O^-
				×	B^+, B^-, AB^+, AB^-	B^-, O^-
AB	$I^A I^B$	A, B	none	✓	AB^+	Universal Recipient
				×	AB^+, AB^-	A^-, B^-, O^-, AB^-
O	*ii*	None	anti -A, anti-B	✓	A^+, B^+, AB^+, O^+	O^+, O^-
				×	Universal Donor	O^-

Name: _____ Date: _____

Bio30: GB1 Genetics Intro **Blood Transfusions**

Nobel Prize Educational Games: Blood Typing & Transfusions

Using the link below, play up to three rounds of the Quick Start-Random Blood Typing Game before handing in at the end of class.

Be sure to record your results.
✓= saved on 1st attempt
X = harmed on 1st attempt

The game is designed so that you cannot completely kill a patient. You must problem solve the correct solution before moving on to help your next patient.

https://www.nobelprize.org/educational/medicine/bloodtypinggame

Trial Round

Patients	Saved	Harmed	Ratio of Saved to Harmed
1			
2			
3			
4			
5			
6			
7			
8			
9			

Round 1

Patients	Saved	Harmed	Ratio of Saved to Harmed
1			
2			
3			
4			
5			
6			
7			
8			
9			

Round 2

Patients	Saved	Harmed	Ratio of Saved to Harmed
1			
2			
3			
4			
5			
6			
7			
8			
9			

Miss Foley

Bio30: GB1 Genetics Intro **Hybrid Crosses**

Monohybrid (Incomplete Dominance)

PROBLEM: Cross two heterozygous plants. Give genotypic and phenotypic ratios. The tall gene is this plant is incompletely dominant over the short gene. TT=Tall, Tt=medium & tt=short.

STEP 1: Determine what kind of problem you are trying to solve.

- Does it involve simple dominant and recessive traits, Incomplete dominance, or Co- dominance?
- Is it a monohybrid or dihybrid?
- In this case there is only one trait.....this is a monohybrid cross involving incomplete dominant traits.

STEP 2: Determine letters you will use to specify traits.

- In this case it is a incomplete dominant problem. ***TT=tall, Tt=medium, and tt=short***

STEP 3: Determine parent's genotypes.

- In this case you were told the parents were heterozygous. You therefore know that the parents must be ***Tt*** and ***Tt***
- The Cross is: ***Tt X Tt***

STEP 4: Make your punnett square and make gametes (these go on the top and side of your punnett square).

- ***Tt*** would make a ***T*** and a ***t***

STEP 5: Complete cross and determine possible offspring.

Incomplete Dominance
(TT = Tall & Tt = Medium & tt = short
Cross: Tt x Tt

	T	t
T	TT	Tt
t	Tt	tt

Genotypic ratio: 1 : 2 : 1 (TT=25% Tt=50% tt=25%)

Phenotypic ratio: 1 : 2 : 1 (Tall=25% Medium=50% Short=25%)

STEP 6: Determine genotypic and phenotypic ratios.

- **Genotypic ratio:** Make a list of all the different genotypes (the letter combinations) and determine how many of each you have.
  - In your problem this would be: ***TT = 1, Tt = 2,*** and ***tt - 1.*** The genotypic ratio would therefore be ***1 : 2 : 1***
- **Phenotypic ratio:** Make a list of all the different phenotypes (physical characteristics.
  - In you problem this would be: ***Tall = 1, medium = 2, and short = 1***. The phenotypic ratio would therefore be ***1 : 2 : 1***

Monohybrid (Co-dominant)

PROBLEM: Cross two heterozygous tan cows. Give genotypic and phenotypic ratios. BB=Black, BW=tan, and WW=white

STEP 1: Determine what kind of problem you are trying to solve.

- Does it involve simple dominant and recessive traits, Incomplete dominance, or Co-dominance?
- Is it a monohybrid or dihybrid?
- In this case there is only one trait.....this is a ***monohybrid cross involving co-dominant traits.***

STEP 2: Determine letters you will use to specify traits.

- In this case it is a incomplete dominant problem. ***TT=tall, Tt=medium, and tt=short***

STEP 3: Determine parent's genotypes.

- In this case you were told the parents were heterozygous. You therefore know that the parents must be ***BW*** and ***BW***
- The Cross is: ***BW x BW***

STEP 4: Make your punnett square and make gametes (these go on the top and side of your punnett square.

- ***BW*** would make a ***B*** and a ***W*** for both parents

STEP 5: Complete cross and determine possible offspring.

co dominance
(BB = Black & BW = tan & WW = white
Cross: BW x BW

	B	W
B	BB	BW
W	BW	WW

Genotypic ratio: 1 : 2 : 1 (BB=25% BW=50% WW=25%)

Phenotypic ratio: 1 : 2 : 1 (White=25% Tan=50% Black=25%)

STEP 6: Determine genotypic and phenotypic ratios.

- **Genotypic ratio:** Make a list of all the different genotypes (the letter combinations) and determine how many of each you have.
  - In your problem this would be: ***BB = 1, BW = 2,*** and ***WW = 1.*** The genotypic ratio would therefore be ***1 : 2 : 1***
- **Phenotypic ratio:** Make a list of all the different phenotypes (physical characteristics.
  - In you problem this would be: ***Black = 1, Tan = 2, and White = 1***. The phenotypic ratio would therefore be ***1 : 2 : 1***

Miss Foley

Bio30: GB1 Genetics Intro **Hybrid Crosses**

Monohybrid (sex-linked)

PROBLEM: Cross a female carrier for hemophilia with a male with hemophilia.
H=normal, and h=hemophilia

STEP 1: Determine what kind of problem you are trying to solve.

- Does it involve simple dominant and recessive traits, Incomplete dominance, or Co-dominance?
- Is it a monohybrid or dihybrid?
- In this case there is only one trait.....this is a ***monohybrid cross involving sex linked traits.***

STEP 2: Determine letters you will use to specify traits.

- In this case it is a sex-linked problem. Remember that ***XX*** is female, and ***XY*** is male. H=normal and h=hemophilia. Normally you would not write the capital letters on the genotypes, only the small case (the recessive gene responsible for the disorder)

STEP 3: Determine parent's genotypes.

- In this case you were told the parents were: ***Female carrier = X^hX***, and a ***male with hemophilia = X^hY***.
- The Cross is: ***X^hX x X^hY***

STEP 4: Make your punnett square and make gametes (these go on the top and side of your punnett square.

- ***X^hX*** would make a ***X^h*** and ***X***
- ***X^hY*** would make a ***X^h*** and ***Y***
- ***NOTE***: The female's gametes always go on top of the punnett square and the males on the side.

STEP 5: Complete cross and determine possible offspring.

STEP 6: Determine genotypic and phenotypic ratios.

- **Genotypic ratio:** Make a list of all the different genotypes (the letter combinations) and determine how many of each you have.
  - In your problem this would be: ***X^hX = 1, X^hX^h = 1,*** and ***XY= 1, and X^hY = 1*** The genotypic ratio would therefore be ***1 : 1 : 1 : 1***
- **Phenotypic ratio:** Make a list of all the different phenotypes (physical characteristics.
  - In you problem this would be: Female Carrier = 1, Female w/ hemophilia = 1, Normal male = 1, and Male w/ hemophilia = 1. The phenotypic ratio would be ***1 : 1 : 1 : 1***

Sex-linked
H = normal & h = hemophilia
Cross: XX^h x X^hY

	X	X^h
X^h	X^hX	X^hX^h
Y	XY	X^hY

Genotypic ratio: 1:1:1:1
(X^hX =25% X^hX^h=25% XY=25% X^hY=25%)

Phenotypic ratio: 1:1:1:1
Female carrier =25% Female hemophilia =25%
Male normal =25% Male hemophilia =25%

Monohybrid (Multiple Alleles)

PROBLEM: Cross a person with type AB blood with a person who is heterozygous for type A blood.

STEP 1: Determine what kind of problem you are trying to solve.

- Does it involve simple dominant and recessive traits, Incomplete dominance, or Co-dominance, or multiple alleles?
- Is it a monohybrid or dihybrid?
- In this case there is only one trait.....this is a ***monohybrid cross involving multiple alleles***

STEP 2: Determine letters you will use to specify traits.

- There are more than two-choices for the allele. Example is human blood group genes. There are three possible alleles for this gene. ***I^A, I^B, and i.*** I^A and I^B are ***co-dominant.*** There are four possible phenotypes: ***A, B, AB, and O.***

STEP 3: Determine parent's genotypes.

- In this case you were told one has ***type AB blood = I^AI^B***. The other is ***heterozygous for type A = I^Ai***

STEP 4: Make your punnett square and make gametes (these go on the top and side of your punnett square.

- ***I^AI^B*** would make a ***I^A*** and ***I^B***
- ***I^Ai*** would make a ***I^A*** and ***i***

STEP 5: Complete cross and determine possible offspring.

STEP 6: Determine genotypic and phenotypic ratios.

- **Genotypic ratio:** Make a list of all the different genotypes (the letter combinations) and determine how many of each you have.
  - In your problem this would be: ***I^AI^A = 1, I^AI^B= 1,*** and ***I^Ai = 1, and I^Bi = 1*** The genotypic ratio would therefore be ***1 : 1 : 1 : 1***
- **Phenotypic ratio:** Make a list of all the different phenotypes (physical characteristics.
  - In you problem this would be: ***Type A = 2, Type AB = 1, and Type B = 1***
  - Therefore the phenotypic ratio is: ***2 : 1 : 1***

Multiple Alleles
Cross: AB x AO

Blood Type	
Phenotype	Genotype
Type A	AA and AO
Type B	BB and BO
Type AB	AB
Type O	00

	A	B
A	AA	AB
O	AO	BO

Genotypic ratio: 1:1:1:1
(AA =25% AB=25% AO=25% BO=25%)

Phenotypic ratio: 1:1:1:1
(Type A =50% Type AB =25% Type B =25%

Miss Foley

Bio30: GB1 Genetics Intro **Sex Traits**

Sex Determination – x and y chromosomes are sex chromosomes; other homologous chromosomes are known as autosomes

xx = girl xy = boy xxy = transexual

Sex-Influenced – when genes on autosomal chromosomes (not on the x and y chromosomes) show up differently in the presence of different hormones.

Example: Baldness allele is dominant, but testosterone is needed for it to show up which results in more men being bald & females being the carries of the allele.

Sex-Linked – a trait that is controlled by a gene found directly on the x or y chromosomes. *Most are determined by genes found on the x chromosome

Examples: Hemophilia, Muscular Dystrophy, Night & Color Blindness

x^1 = affected chromosome Affected Girls = x^1x^1

Affected Boys = x^1y Carrier Girls = x^1x

Genotype (Phenotype)		X^HY (Normal)	
	Gametes ♀ / Gametes ♂	X^H	Y
X^HX^h (Carrier)	X^H	X^HX^H (Normal)	X^HY (Normal)
	X^h	X^hX^H (Carrier)	X^hY (Haemo-philiac)

Genotype (Phenotype)		X^hY (Haemophiliac)	
	Gametes ♀ / Gametes ♂	X^h	Y
X^HX^h (Carrier)	X^H	X^HX^h (Carrier)	X^HY (Normal)
	X^h	X^hX^h (Haemo-philiac)	X^hY (Haemo-philiac)

Punnett squares for the sex-linked trait haemophilia

Miss Foley

Bio30: GB1 Genetics Intro **Cells Defined**

Cell – basic structural & functional unit of life

Prokaryote Cell (Pro carry oat)	**Eukaryote Cell** (You carry oat)
Only Example: Bacteria	Examples: Fungi, Protista, Plants, Animals
• Has DNA strands for genetic information therefore ***lacks*** a nucleus and other membrane-enclosed organelles. • Simplest & smallest cell	• Has membrane-enclosed organelles therefore has a nucleus for genetic information. • Most complex & larger cell

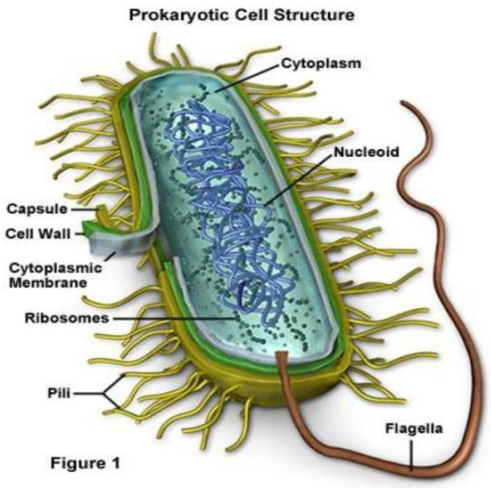
Cell Theory:

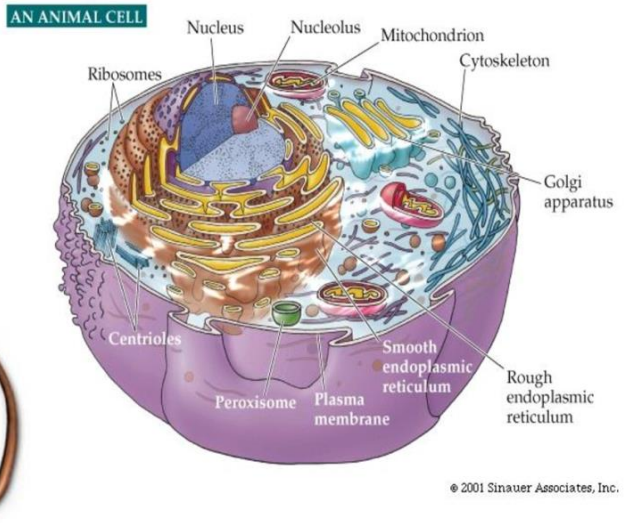
1. **Cells are units of structure & function of all living things.**
2. **All cells come from pre-existing cells.**

Organelle – a tiny organ with a specific job/function within a cell surrounded by a membrane.

DNA – Deoxyribonucleic Acid; contains genetic information for cells…the "blueprint for life".

Prokaryotic vs Eukaryotic Cells





Cell Parts & Function

Sketch	Cell Part	Function
		Stores nutrients and waste products.
		Site where photosynthesis happens.
		Duplicate prior to mitosis and produce the spindle apparatus during cell division.
		Semi-fluid material surrounding organelles.
		Sorts, modifies & packages vesicles for delivery to other organelles.
		Site of digestion within the cell.
		Network of hollow tubes that provides shape & internal organization.
		Compartmentalizes the cytosol/cytoplasm. There are 2 types; one with ribosomes & one without.
		The control center of the cell containing DNA (genetic information).
		Site where cellular respiration happens.
		The semi-fluid boundary that controls what passes in and out of the cell.
		Site where proteins are made.
		Provides rigidity to plant cells allowing turgor pressure to develop.

Prokaryote Only – DNA in Strand Form, Capsule
Animal Only – Lysosomes, Centrioles, Vacuole (movement)
Plant Only – Chloroplast, Cell Wall, Vacuole (storage)

Cell Parts & Function

Sketch	Cell Part	Function
	Vacuole	Stores nutrients and waste products.
	Chloroplast	Site where photosynthesis happens.
	Centrioles	Duplicate prior to mitosis and produce the spindle apparatus during cell division.
	Cytoplasm	Semi-fluid material surrounding organelles.
	Golgi Apparatus	Sorts, modifies & packages vesicles for delivery to other organelles.
	Lysosome	Site of digestion within the cell.
	Cytoskeleton	Network of hollow tubes that provides shape & internal organization.
	Endoplasmic Reticulum	Compartmentalizes the cytosol/cytoplasm. There are 2 types; one with ribosomes & one without.
	Nucleus	The control center of the cell containing DNA (genetic information).
	Mitochondria	Site where cellular respiration happens.
	Plasma Membrane	The semi-fluid boundary that controls what passes in and out of the cell.
	Ribosomes	Site where proteins are made.
	Cell Wall	Provides rigidity to plant cells allowing turgor pressure to develop.

Prokaryote Only – DNA in Strand Form, Capsule
Animal Only – Lysosomes, Centrioles, Vacuole (movement)
Plant Only – Chloroplast, Cell Wall, Vacuole (storage)

Life Span Of Human Cells Defined: Most Cells Are Younger Than The Individual

Until now, defining the life span of specific human cell populations was limited by an inability to mark the exact time when cells were born in a way that can be detected over many years. However, a team of Swedish researchers from the Karolinska Institute in Stockholm, led by Dr. Jonas Frisen, has announced that cells can be dated by applying carbon-14 techniques to DNA, a method commonly used in archaeology and palaeontology to pinpoint the age of fossils.

Using this method, Dr. Frisen has shown that most cells in the body are less than 10 years old. Moreover, the team has also discovered why people behave their birth age, rather than the physical age of their cells: This is because a few of the body's cell types endure from birth to death without renewal, and this special minority includes some or all of the cells of the cerebral cortex.

The new dating approach relies on a peak in the atmospheric levels of C14 as a result of aboveground nuclear arms testing during the Cold War. C14 dating looks at the ratio of radioactive carbon, naturally present at low levels in the atmosphere and food, to normal carbon within an organism. While a creature lives, eats and breathes, its ratio of radioactive to normal carbon will equal the ratio in its environment. But when it dies, this ratio will fall, as the carbon-14 decays.

Until now, the main obstacle to applying this technique was that radioactive carbon decays slowly, such that a given amount of carbon-14 halves every 6,000 years. Detecting the subtle change in the ratio of normal to naturally occurring radioactive carbon over just a few years proved too difficult. But Dr. Frisen maintains that it can be done if one takes advantage of the signal left by nuclear testing, which vastly increased the levels of carbon-14 in the atmosphere during the Cold War.

According to Dr. Frisen, by the time aboveground nuclear testing ended in 1963, the levels of atmospheric C14 had doubled beyond natural background levels. Since the halt, this has halved every 11 years. By taking this into account, one can see detectable changes in levels of C14 in modern DNA.

'Most molecules of the cell will turn over all the time. But DNA is a material that does not exchange carbon after cell division, so it serves as a time capsule for carbon,' he says. All the C14 in a cell's DNA is acquired on the cell's birth date, the day its parent cell divided. By measuring C14 levels in their DNA, it would be possible to pinpoint individual cells' birth dates to within two years.

In practice, the method has to be performed on tissue samples, not individual cells, because not enough C14 gets into any single cell to reveal its age. Dr. Frisen worked out a scale for converting carbon 14 enrichment into calendar dates by measuring the carbon 14 incorporated into individual tree rings in Swedish pine trees. Having validated the method with various tests, the team reported the results of their first tests using body tissues in the July 15 issue of the journal Cell.

Dr. Frisen and his team looked at tissue samples from more than a dozen deceased subjects, about half of whom were born after the mid-1960s.

Each kind of tissue has its own turnover time, related at least partially to the workload endured by its cells. Epidermic cells, forming the easily damaged skin of the body, are recycled every two weeks or so. Red blood cells, in constant motion on their journey through the circulatory system, last only 4 months. As for the liver, the human body's detoxifier, its cells' lives are quite short - an adult human liver cell has a turnover time of 300 to 500 days.

Cells lining the surface of the gut, known by other methods to last for only five days, are among the shortest-lived in the whole body. Ignoring them, the average age of intestinal cells is 15.9 years, Dr. Frisen found. Skeletal cells are a bit older than a decade and cells from the muscles of the ribs have an average age of 15.1 years. When looking into the brain cells, all of the samples taken from the visual cortex, the region responsible for processing sight, were as old as the subjects themselves, supporting the idea that these cells do not regenerate. 'The reason these cells live so long is probably that they need to be wired in a very stable way,' Dr. Frisen speculates. Other brain cells are more short-lived. Dr. Frisen found that the heart, as a whole, does generate new cells, but he has not yet measured the turnover rate of the heart's muscle cells. And the average age of all the cells in an adult's body may turn out to be as young as 7 to 10 years, according to him.

Why then, if the body remains so eminently capable of renewing its tissues, doesn't the regeneration continue forever? Some scientists believe this is explained by the accumulation of mutations in the DNA, which gradually degrades its information. Another theory blames mitochondrial DNA, which lack the repair mechanisms available for the chromosomes, whilst a third theory postulates that stem cells, which are the source of new cells in each tissue, eventually grow feeble with age.

'The notion that stem cells themselves age and become less capable of generating progeny is gaining increasing support,' Dr. Frisen said. He hopes to see if the rate of a tissue's regeneration slows as a person ages, which could point to stem cells being the impediment to immortality.

Source Reference Document: Retrospective Birth Dating of Cells in Humans. Kirsty L. Spalding, Ratan D. Bhardwaj, Bruce A. Buchholz, Henrik Druid, and Jonas Frisen. Cell, Vol 122, 133-143, 15 July 2005.

Source: www.timeshighereducation.com/news/life-span-of-human-cells-defined-most-cells-are-younger-than-the-individual/198208.article

Always Be Evaluator's of Information…Things To Notice about This Article:

The Animal Cell Cycle

Mitosis – somatic/autosomal (a.k.a "normal") cell division

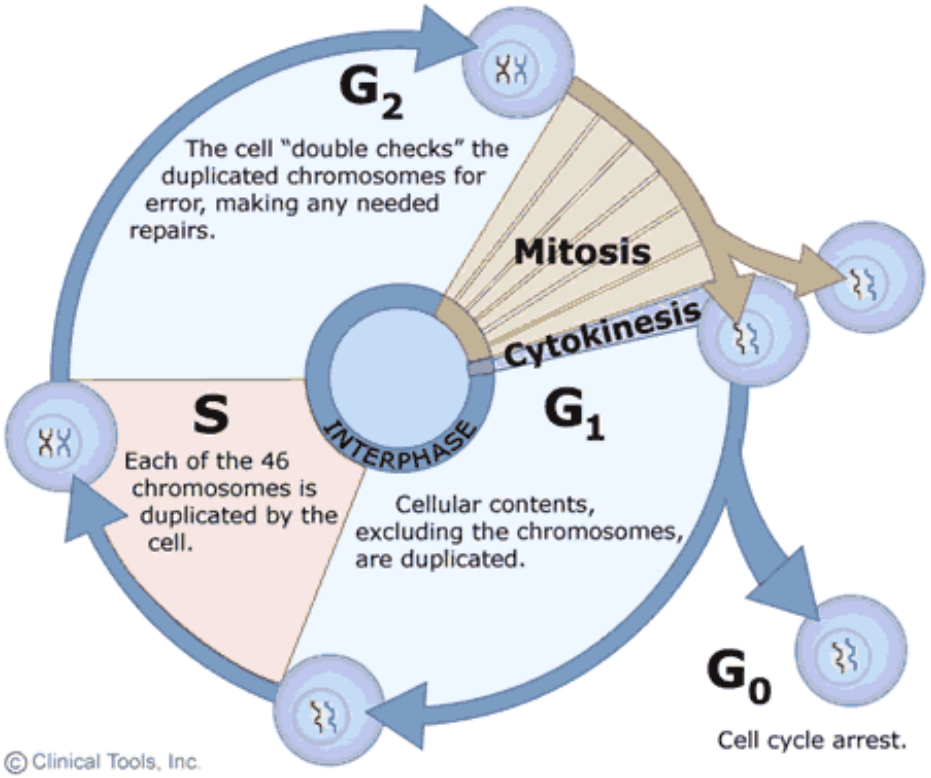
Meiosis – sex/gamete/germ (a.k.a "sex") cell division.

Diploid – 2 sets of chromosomes (2n)

Haploid – 1 set of chromosomes (n)

Interphase – G1 + S + G2

Somatic Cell = autosomal chromosomes

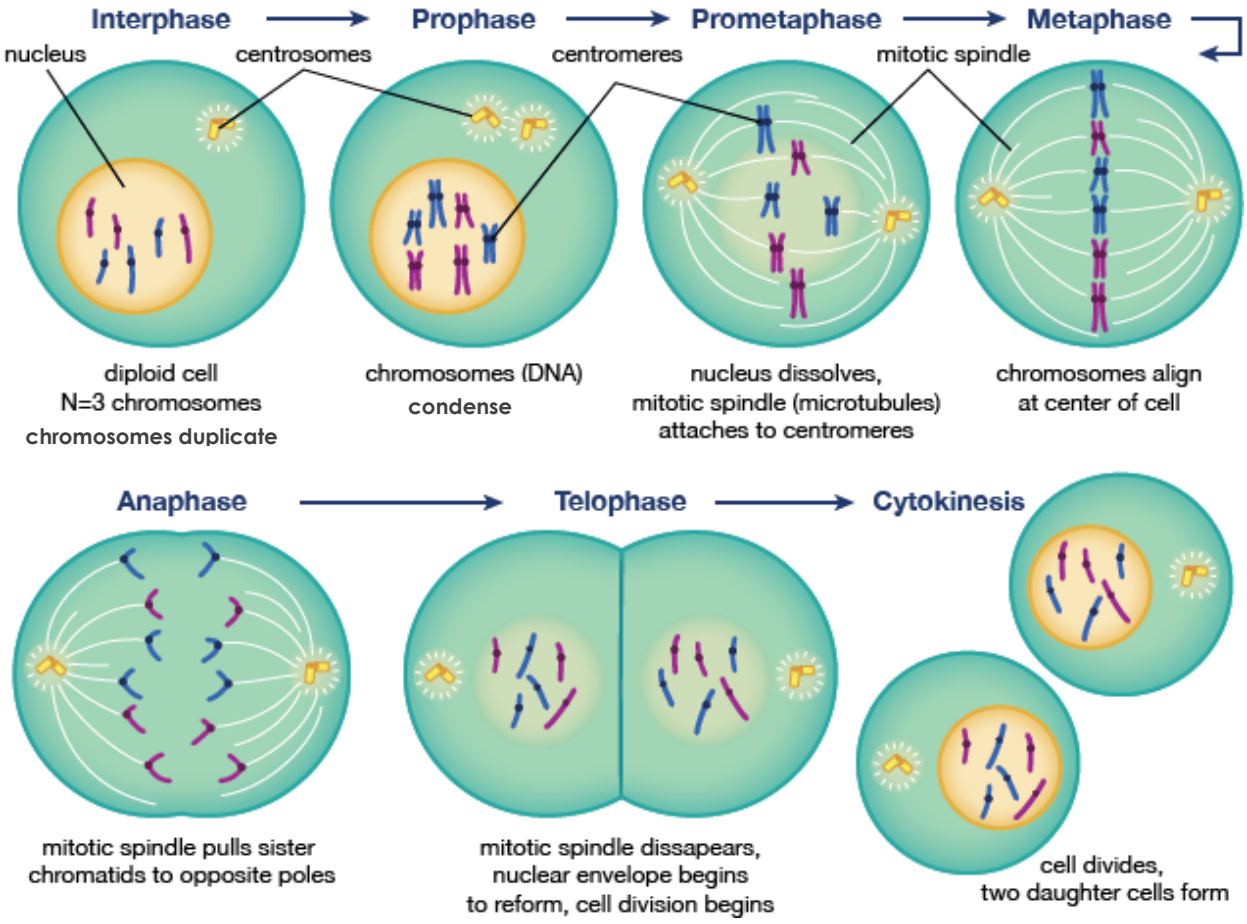


MITOSIS =

A form of eukaryotic cell division that produces two daughter cells with the same genetic component as the parent cell.

<u>One</u> Diploid Parent Cell (2n) =

<u>Two</u> Diploid Daughter Cells (2n)

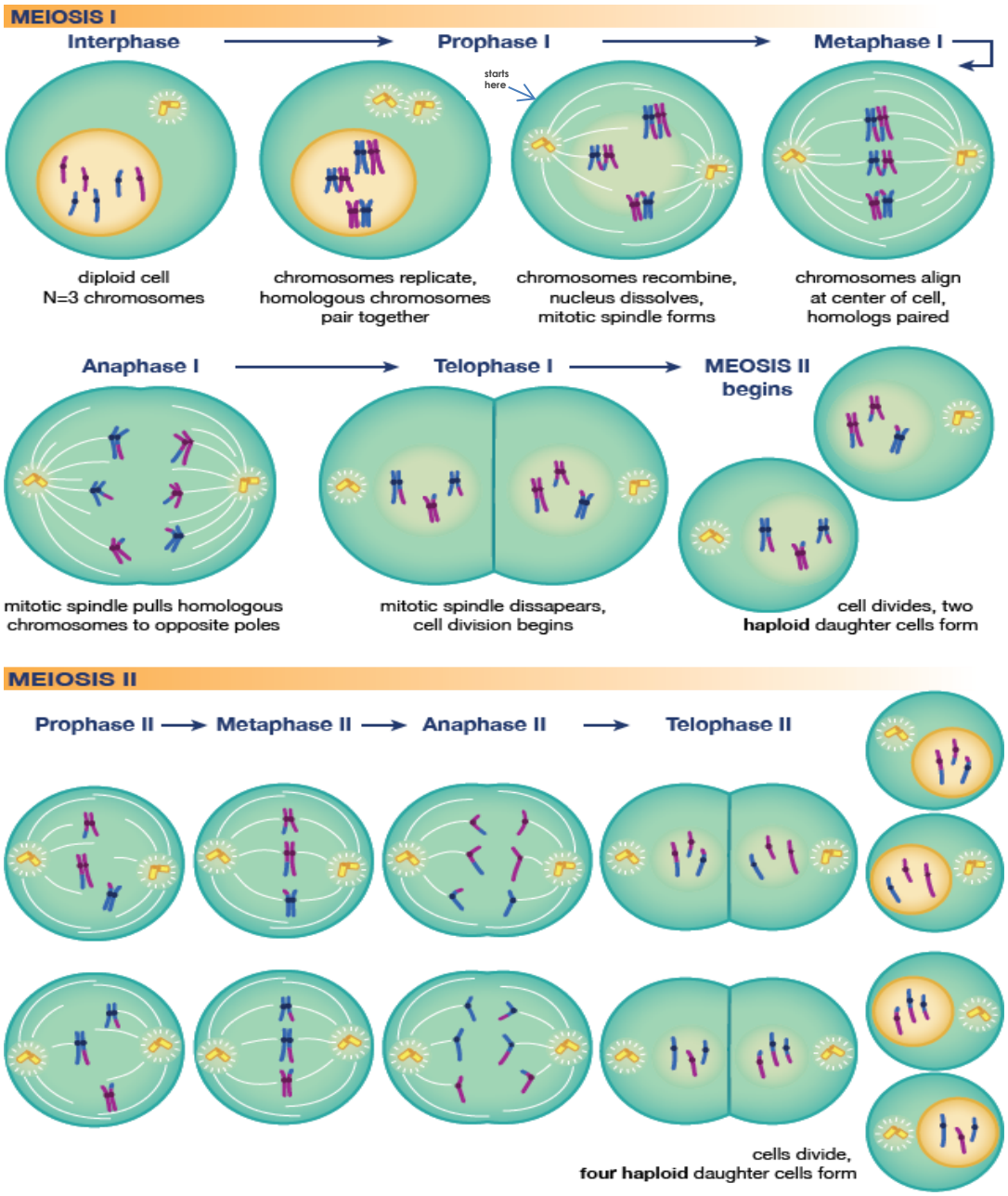


Somatic/autosomal cells (every type of cell except sex cells) divide using the process of mitosis.

MEIOSIS =

A form of eukaryotic cell division that produces four daughter cells with the <u>half</u> the genetic component as the parent cell.

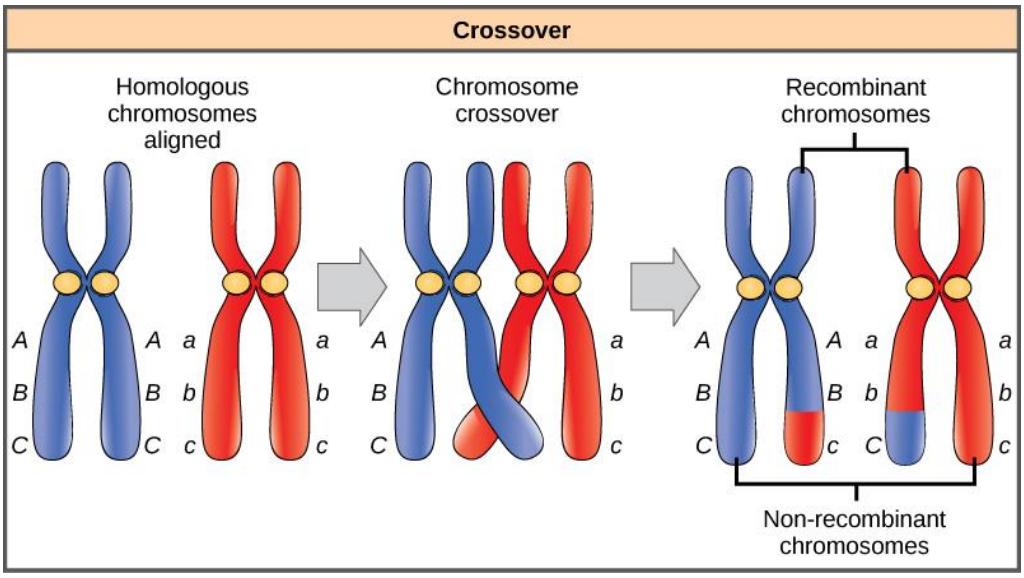
<u>One</u> Diploid Parent Cell (2n) = <u>Four</u> Haploid Daughter Cells (n)



Sex cells (ova & sperm) divide using the process of meiosis.

Crossing Over =

The exchange of genetic material between homologous chromosomes that occurs during meiosis (specifically prophase I) that contributes to genetic variation.



Mitosis vs Meiosis

Use your notes to fill in this comparison table.

	Mitosis	Meiosis
# of Cell Divisions?		
# of Daughter Cells?		
Diploid or Haploid Cells Produced?		
Needed for…?		
Daughter Cells Identical?		

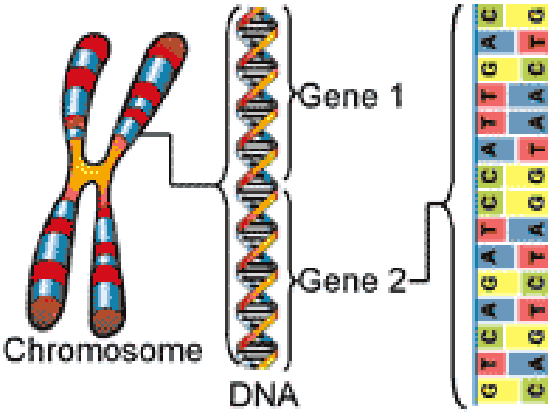
Nucleic Acids

Nucleic acids are compounds that contain phosphorous and nitrogen in addition to carbon, hydrogen, and oxygen. There are two kinds of nucleic acids: **deoxyribonucleic acid (DNA)** and **ribonucleic acid (RNA)**.

Each living cell has its own DNA and RNA. Information stored in DNA controls all cell activities and determines the genetic/hereditary characteristics of the cell and, as a result, the organism. RNA is required for protein synthesis, including enzymes.

DNA = deoxyribonucleic acid

(dē-ŏk′sē-rī′bō-noō-klē′ĭk acid)

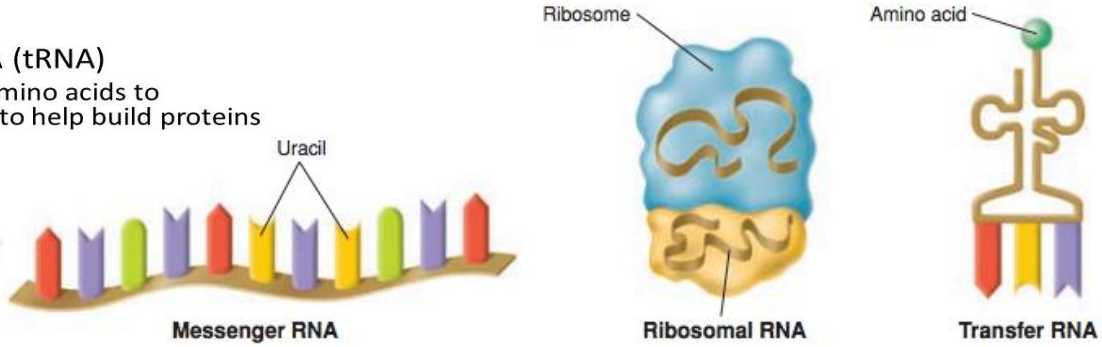


Three Types of RNA

- Messenger RNA (mRNA)
  - Carries information from DNA in the nucleus to ribosomes in the cytoplasm
- Ribosomal RNA (rRNA)
  - Combines with protein to form ribosomes
- Transfer RNA (tRNA)
  - Transfers amino acids to ribosomes to help build proteins

RNA = ribonucleic acid

(rī′bō-noō-klē′ĭk acid)



Types of RNA The three main types of RNA are messenger RNA, ribosomal RNA, and transfer RNA. Ribosomal RNA is combined with proteins to form ribosomes.

Name: _____ Date: _____

Bio30: GB2 Role of DNA **Discovering DNA**

IMPACT OF DISCOVERING DNA

Using website resources below,
fully answer the following questions:

https://www.chemheritage.org/historical-profile/james-watson-francis-crick-maurice-wilkins-and-rosalind-franklin

http://highered.mheducation.com/sites/dl/free/0072320419/20534/watson.html

https://www.chemistryworld.com/news/the-dna-story/1013130.article

https://www.khanacademy.org/science/biology/dna-as-the-genetic-material/dna-discovery-and-structure/a/discovery-of-the-structure-of-dna

https://www.theguardian.com/science/2015/jun/23/sexism-in-science-did-watson-and-crick-really-steal-rosalind-franklins-data

1. How did the discovery of the DNA molecule as the chemical basis of inheritance fundamentally transform the field of Biology?

2. Explain the scientific contributions of the following scientists regarding investigating the chemical basis of inheritance:

   Erwin Chargaff –

Name: _____ Date: _____

Bio30: GB2 Role of DNA **Discovering DNA**

Rosalind Franklin –

Maurice Wilkins –

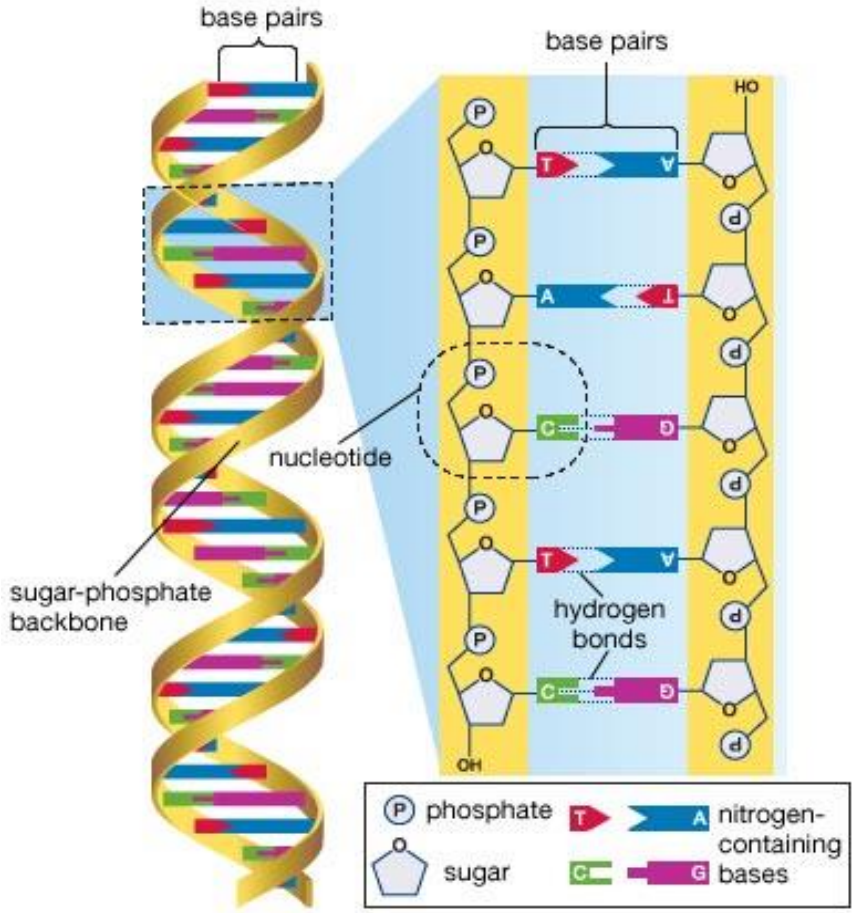
James Watson & Francis Crick -

3. How would you describe the scientific culture predominant during the time era of the scientists researched above?

DNA is long chain of repeating units called nucleotides.

NUCLEOTIDE =
5 carbon sugar bonded to a phosphate group and a nitrogen base

There are four **nitrogen bases:**
Adenine - Thymine
Guanine – Cytosine
***Always bond in this manner.**



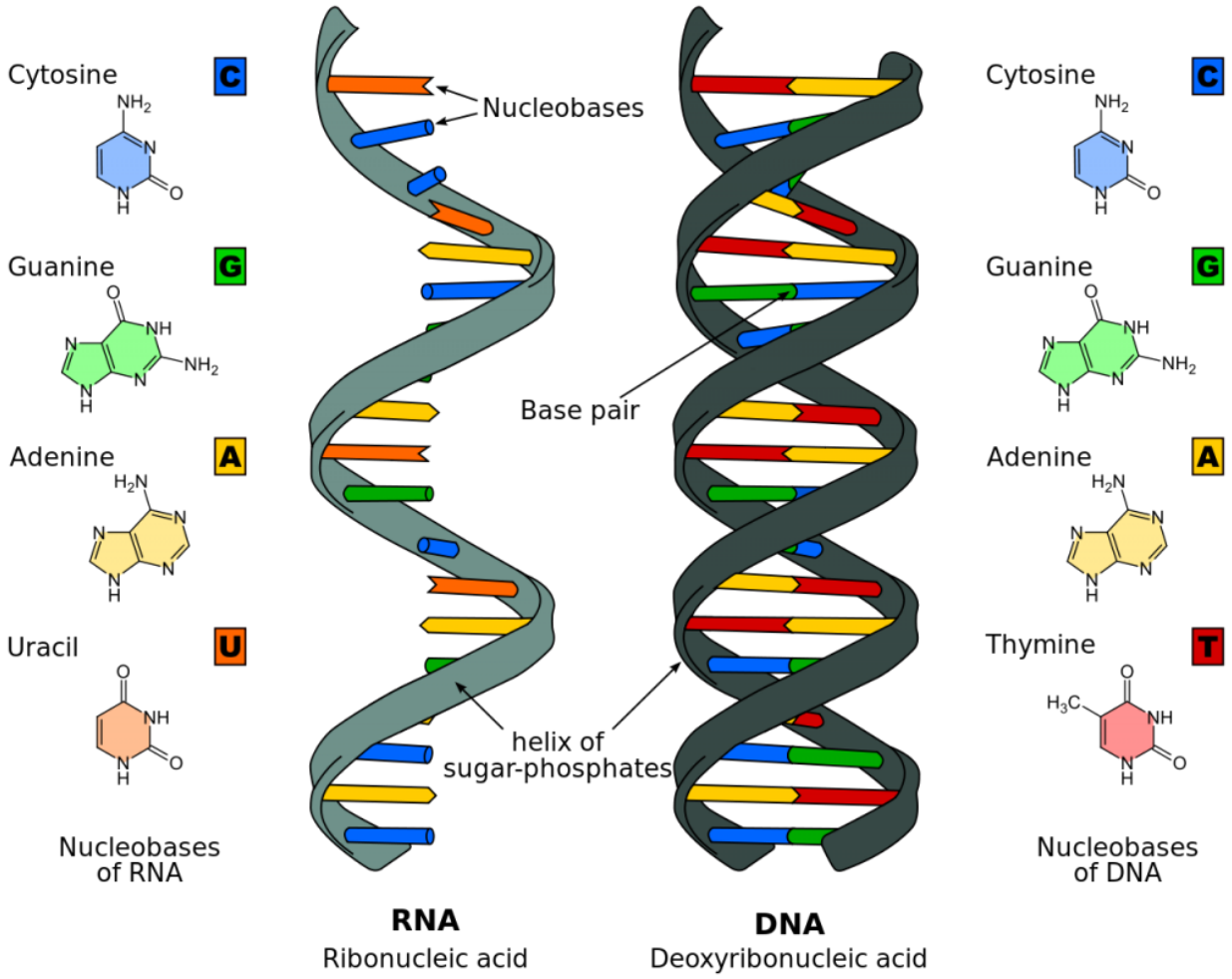
These four bases can be attached in any sequence along the length of the molecule. This sequence provides **genetic variation**.

The shape of the **DNA molecule represents the shape of a ladder** – two sides connected to each other by the rungs.

On each of the **side of the chains are deoxyribose sugar and phosphate**. The **nitrogen base pairs make up the rungs** of the ladder. In human cells, a single DNA molecule may have as many as 3 billion nitrogen base pairs.

The entire DNA molecule is then twisted/coiled into a form called a **double helix**. A human DNA strand would be ~4cm long if it were stretched out along a line.

Ribonucleic Acid is required for **protein synthesis**, including enzymes.



There are differences in the chemical composition of RNA when contrasted with DNA:

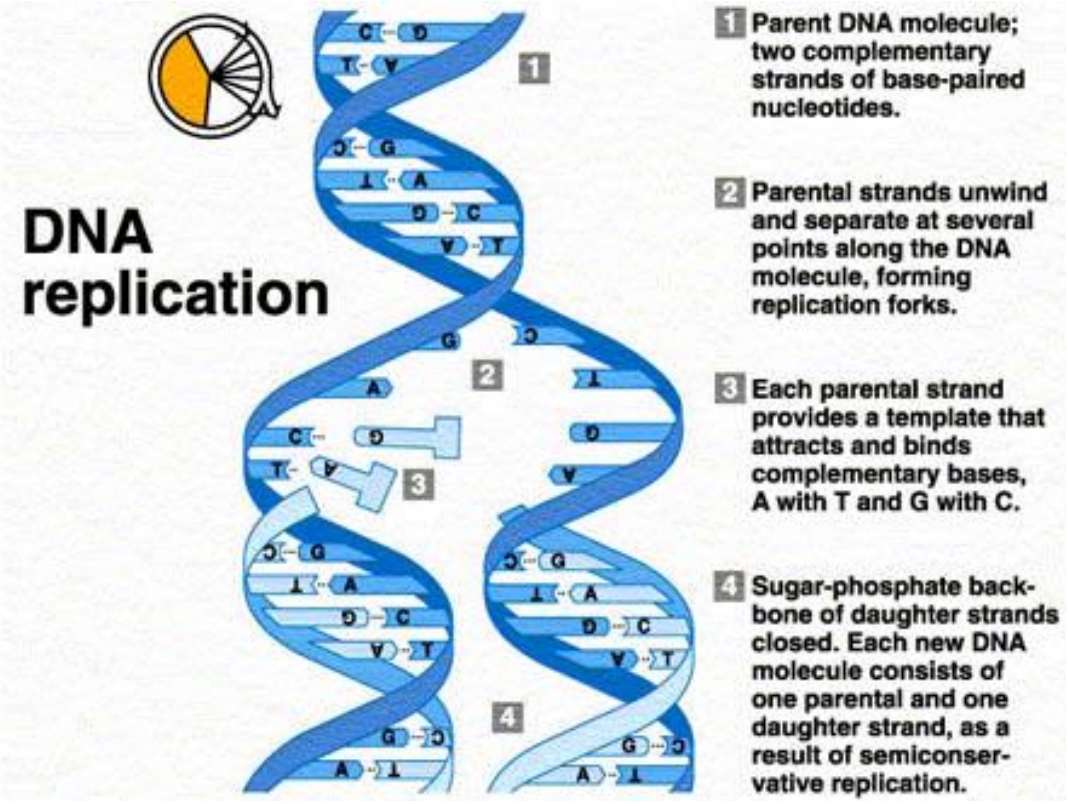
1. RNA molecules consist of only **ONE chain/strand** of nitrogen bases.
2. Sugar is **ribose instead of deoxyribose**.
3. The nitrogen base **thymine is replaced by uracil** who also pairs up with adenine.

DNA REPLICATION -

Process where DNA is used as a template to create an identical strand of DNA

Replication happens during the **synthesis (S) stage of Interphase** as the cell prepares to divide (mitosis/meiosis) during its' life cycle. This allows the cell to pass its code from one generation to the next.

The **hydrogen bonds** that hold base pairs together are weak – **easy to break and easy to form**. DNA strands are too large to physically pass through the nuclear poles in the membrane of the nucleus.



DNA Polymerase - main enzyme (organic catalyst) used in replication to unzip DNA strand and rebuild new DNA strands

Living Cells = **Reproduce**
Non-Living DNA and Viruses = **Replicate**

-ase = a type of enzyme (special protein that acts as organic catalyst)

-ose = a type of sugar

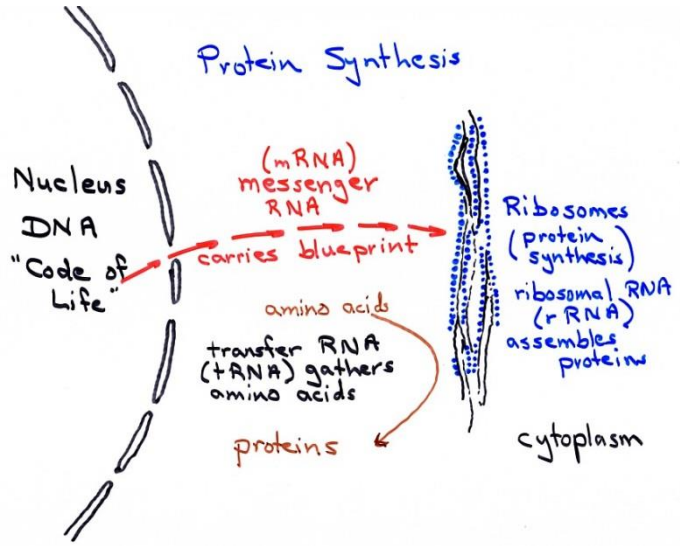
Miss Foley

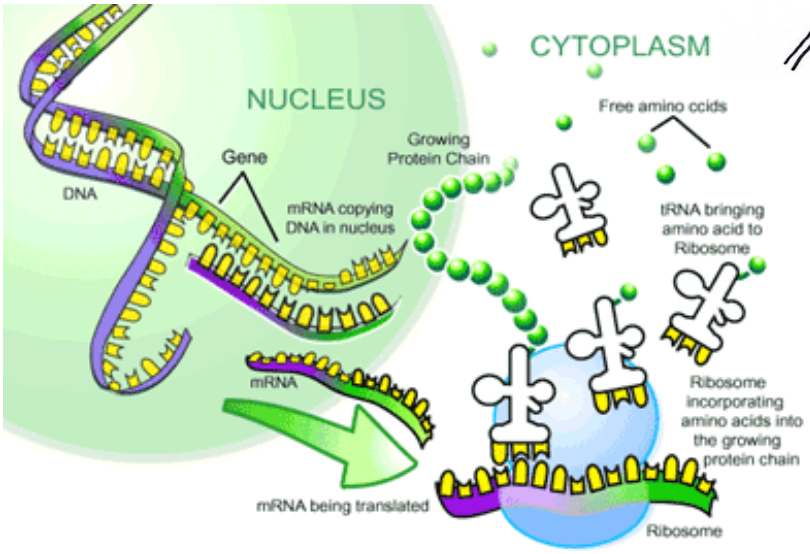
Bio30: GB2 Role of DNA

Protein Synthesis

Transcription + Translation =

PROTEIN SYNTHESIS





DNA

↓

Transcription

↓

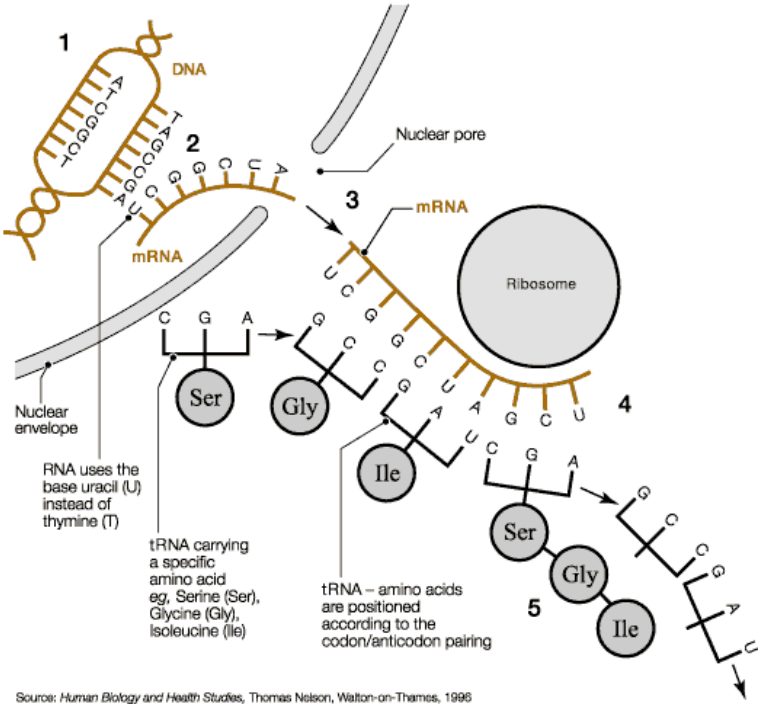
RNA

↓

Translation

↓

PROTEIN



Source: *Human Biology and Health Studies*, Thomas Nelson, Walton-on-Thames, 1996

1. **Transcription:** the genetic code is transferred from the DNA to messenger RNA (mRNA)

2. mRNA leaves nucleus through the nuclear pores.

3. **Translation:** proteins are synthesized at the ribosomes using the genetic code of the mRNA.

   mRNA attaches to a ribosome (site of protein synthesis) where codons on the mRNA receive the anticodon of the transfer RNA (tRNA) which codes for a specific amino acid that is attached to the tRNA.

4. tRNA are released as bonds are formed between the amino acids to form proteins

5. After reaching a stop codon, the completed protein (polypeptide) is released.

All About Mutations

Mutations – sudden change in the structure or amount of genetic material.

Mutants – first individual to show the new trait.

Mutagens – factors in the environment that cause mutations (radiation, chemical, BPA, etc.)

Types of Mutations

Gene **=**
a change in a nitrogen base(s) on the gene itself

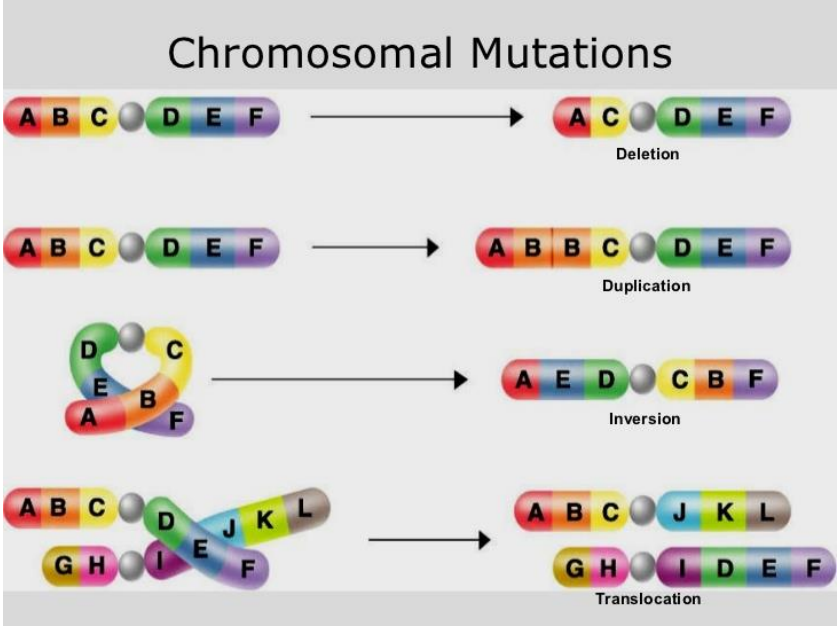
A.K.A. Point Mutations

***Are Most Common**

Non-Disjunction **=**
the addition or loss of an entire chromosome.

Ex: Down Syndrome, Trisomy 13, Klinefelter and Turner Syndrome

Chromosomal **=**
a change on the chromosome larger than just a gene



Types of Chromosomal:

Translocation/Addition:

a piece is transferred to another chromosome

Inversion:

a piece is rotated to reverse the genetic code

Deletion:

a piece breaks off resulting in loss of genetic material

Duplication:

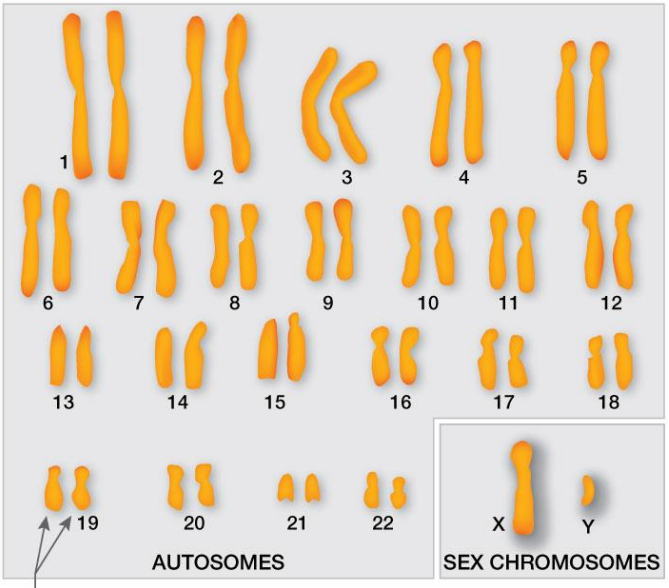
a piece is repeated

Karyotype =
A rearranged photo of the number, size, and shape of paired chromosomes in an organism

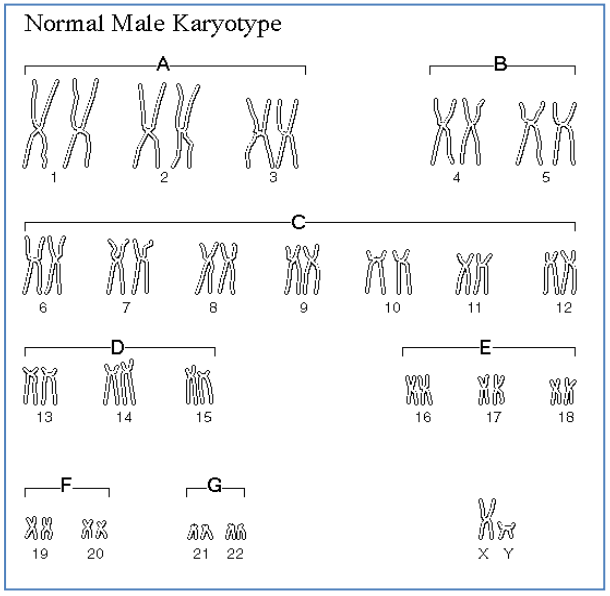
Humans have a total of **46 chromosomes** (23 from each parent), which you can see in the karyograms. In **karyograms**, homologous chromosomes, or pairs of chromosomes that are the same size and shape, are grouped together. Humans have 22 of these pairs called autosomes.

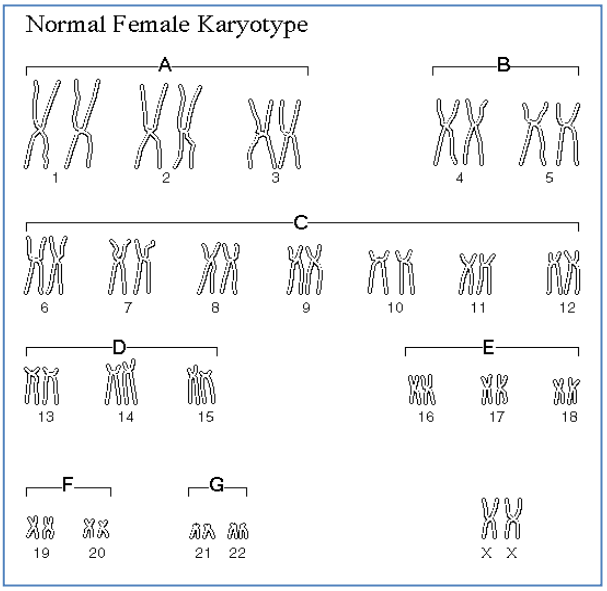
Autosomes are chromosomes that have genes for everything but the determination of the sex. In humans, autosomes are numbered 1 through 22, and you have two of each number because one came from your mom and one came from your dad. Chromosome 1 is the largest, and chromosome 22 is the smallest.

The remaining two chromosomes in humans are called **sex chromosomes** because they are the ones that determine whether you are male or female. They are placed after autosomes in a karyogram.



Pair of homologous chromosomes:
- *One from mom and one from dad*
- *Have the same genes arranged in the same order*
- *Slightly different DNA sequences*





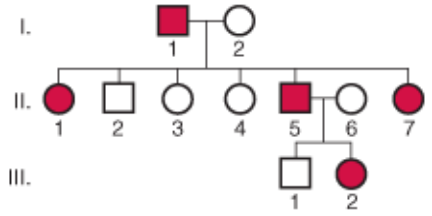
Patterns of Inheritance

Some genetic conditions are caused by mutations in a single gene. These conditions are usually inherited in one of several patterns, depending on the gene involved:

Autosomal Dominant - One copy of the gene in each cell **with a mutation** is sufficient for a person to be affected by an autosomal dominant disorder. In some cases, an affected person inherits the condition from an affected parent (see figure 1). In others, the condition may result from a new mutation in the gene and occur in people with no history of the disorder in their family.

Examples: Huntington disease, Marfan syndrome

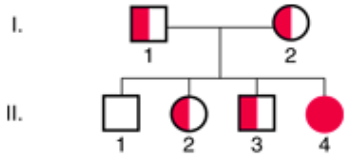
Autosomal dominant inheritance.



Autosomal Recessive - Both copies of the gene in each cell have to **have mutations** for a person to be affected. The parents of an individual with an autosomal recessive condition each carry one copy of the mutated gene, but they typically do not show signs and symptoms of the condition. Autosomal recessive disorders are typically not seen in every generation of an affected family.

Examples: Cystic fibrosis, Sickle cell disease

Autosomal recessive inheritance.



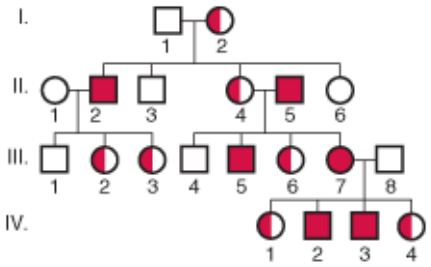
Y-Linked Recessive - A condition is considered Y-linked if the **mutated gene** that causes the disorder is **located on the Y chromosome**, one of the two sex chromosomes in each of a male's cells. Because only males have a Y chromosome, in Y-linked inheritance, a mutation can only be passed from father to son.

Examples: Y chromosome infertility, some cases of Swyer syndrome

X-Linked Dominant - X-linked dominant disorders are caused by **mutations** in genes **on the X chromosome**, one of the two sex chromosomes in each cell. In **females** (who have two X chromosomes), a **mutation in one of the two copies of the gene in each cell is sufficient to cause the disorder**. In males (who have only one X chromosome), a mutation in the only copy of the gene in each cell causes the disorder. In most cases, males experience more severe symptoms of the disorder than females. A characteristic of X-linked inheritance is that fathers cannot pass X-linked traits to their sons (no male-to-male transmission).

Examples: Fragile X Syndrome

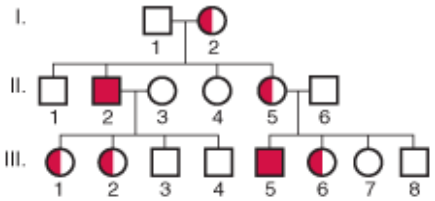
X-linked dominant inheritance.



X-Linked Recessive - X-linked recessive disorders are also caused by **mutations** in genes **on the X chromosome**. In males (who have only one X chromosome), one altered copy of the gene in each cell is sufficient to cause the condition. In **females** (who have two X chromosomes), a **mutation would have to occur in both copies of the gene to cause the disorder**. Because it is unlikely that females will have two altered copies of this gene, males are affected by X-linked recessive disorders much more frequently than females. A characteristic of X-linked inheritance is that fathers cannot pass X-linked traits to their sons (no male-to-male transmission).

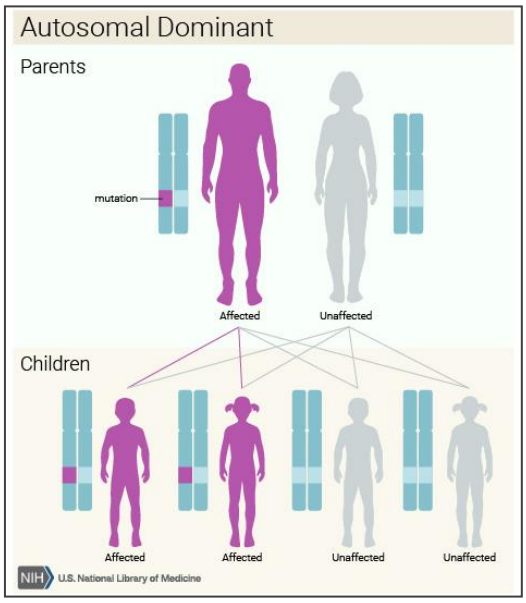
Examples: Hemophilia, Fabry Disease

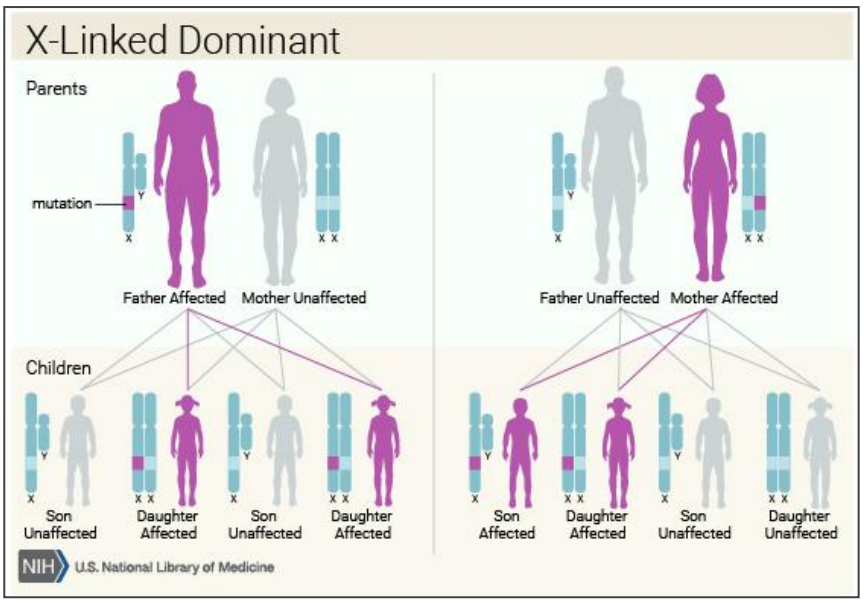
X-linked recessive inheritance.

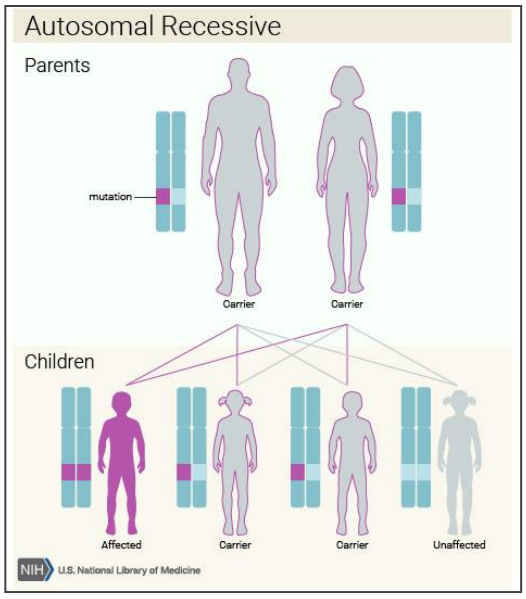


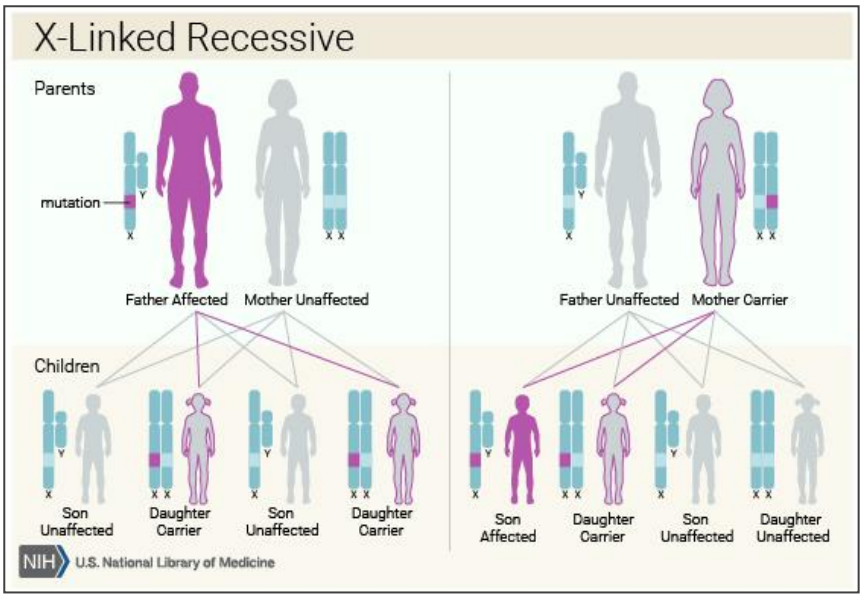
Miss Foley

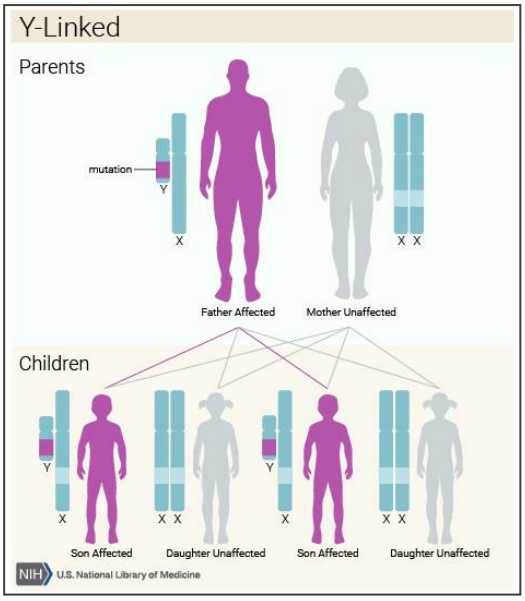
Bio 30: GB1 Genetics Intro **Inheritance Patterns**











Hemophilia

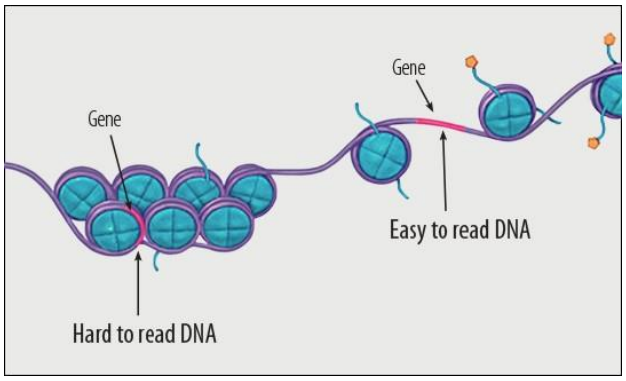
FilNISH converting power point notes!!!!!

Hemophilia

FiINISH converting power point notes!!!!!

Epigenetics = "Above" The Genome

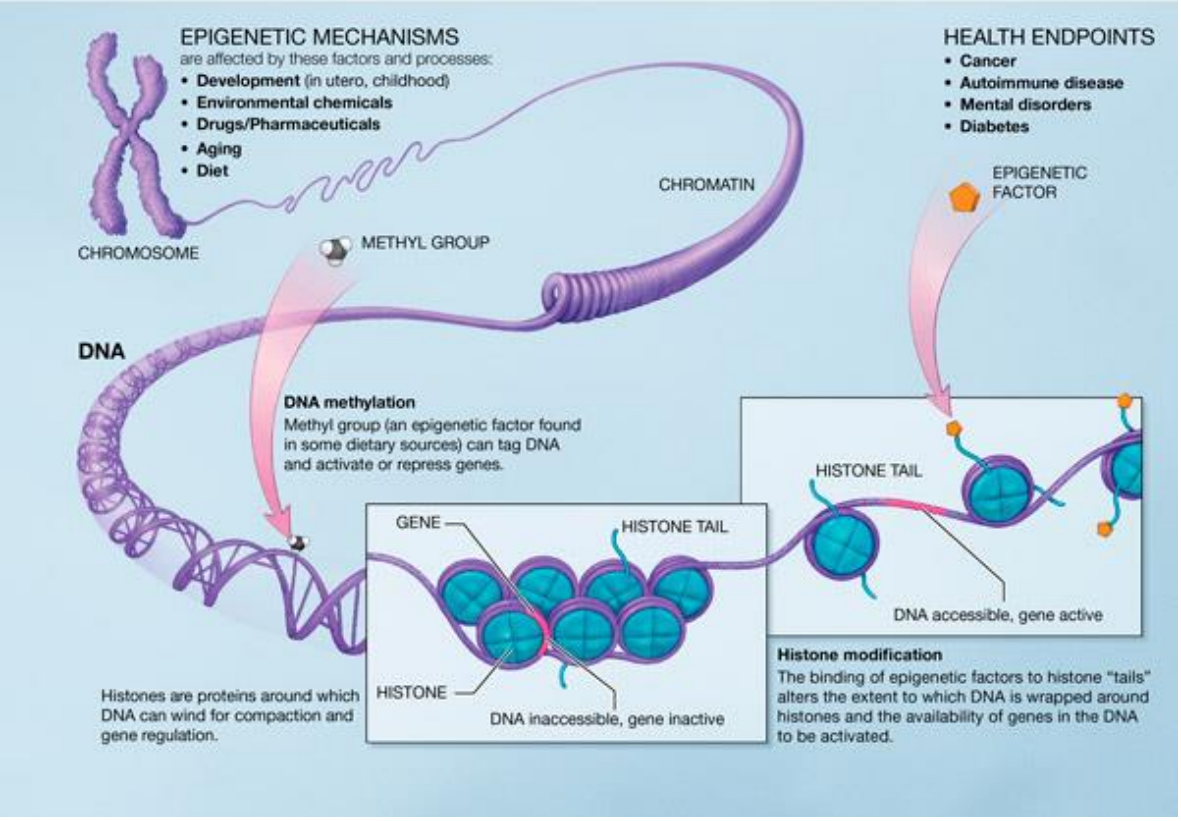
how the environment influences our genes



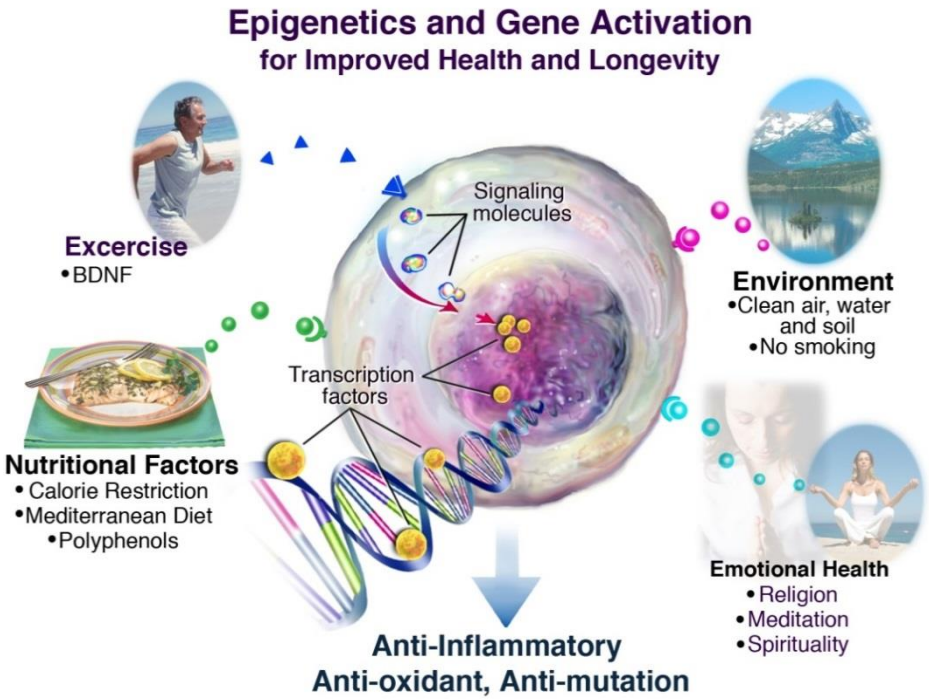
Under the influence of external factors, epigenetic mechanisms regulate which genes are turned on and off with **methyl groups** working like "on/off switches" and **histones** working like "how much" regulating knobs. This helps our fixed genetic material to be more flexible. At the biochemical micro level, **epigenetic regulators** are responsible for how closely packed individual genomic regions are and therefore how accessible or not accessible they are.

Environmental <u>epigentetic factors/regulators</u> consist of:

1. **Sleep**
2. **Nutrition**
3. **Smoking/Drinking/Substance Use**
4. **Exercise (BDNF Exposure)**
5. **Environmental Pollutants Exposure**
6. **Stress Levels/Emotional Healt**



Epigenetic changes, however, are so-called **soft changes**, **as they can be undone**. And that is medicine's great hope – to be able to intervene in the control mechanism from the outside in order to be able to work with or against the genome, for example, senile dementia.



The question now arises as to what evolutionary sense an epigenetic inheritance mechanism actually has. Does the inheritance of negative experiences only cause additional damage in the next generation? In recent studies the focus has shifted towards finding out whether it could lead to a higher resilience to stress in following generations. In one other area, faster therapeutic success is expected: in Alzheimer's research. In Alzheimer's patients the genes responsible for learning are suppressed. Animal studies have demonstrated that medication can inhibit the suppression of these cognitive abilities. Not only did the medication prevent neurons from being destroyed, but fresh neurons were actually formed. Another promising fact is that there are already approved 'epigenetic' drugs for cancer therapy, which could also turn out to be suitable for neurodegenerative diseases.

Epigenetics is a heritable process and differs from Mendelian genetics. In Medelian genetics, changes in the base pair sequence of a gene can be a critical determining factor in the outcome of the phenotype. In fact, the current underlying mechanisms of epigenetics provide scientific evidence how **environment can trigger heritable changes**. There is ample evidence in animals and even in human beings that environmental factors shape health and disease via epigenetic mechanisms that mediate gene-environment interactions.

Genetic Techniques Used By Geneticists

Make notes using the website resources below to describe the **purpose and process** of each genetic technique below:

Polymerase Chain Reaction

https://www.youtube.com/watch?v=iQsu3Kz9NYo

http://www.yourgenome.org/facts/what-is-pcr-polymerase-chain-reaction

https://www.genome.gov/10000207/pcr-fact-sheet/

https://www.youtube.com/watch?v=2KoLnIwoZKU

https://www.youtube.com/watch?v=DkT6XHWne6E

Name: _____ Date: _____

Bio30: GB2 Role of DNA **Genetic Techniques**

DNA Sequencing

https://www.youtube.com/watch?v=91294ZAG2hg

https://www.genome.gov/10001177/dna-sequencing-fact-sheet/

https://www.dnalc.org/view/15479-Sanger-method-of-DNA-sequencing-3D-animation-with-narration.html

http://www.yourgenome.org/video/sanger-dna-sequencing

Gel Electrophoresis

https://www.addgene.org/plasmid-protocols/gel-electrophoresis/

https://www.reference.com/science/purpose-agarose-gel-775bc7cc09de8df0

https://www.youtube.com/watch?v=mN5IvS96wNk

NEED TO FINISH!!!!

NEED

Biotechnology =

the use of biological processes, organisms, or systems to manufacture products intended to improve the quality of human life and our planet.

The word biotechnology has received unprecedented importance and significance during the last two decades due to its unlimited potential to serve and benefit humanity. Biotechnology has touched our lives in all aspects, especially food, health, and animal life. We have also noticed the importance and potential of biotechnology for the improvement of our environment and for better living.

A few examples of biotechnology include:

- pest resistant crops
- new bacterial strains, or novel pharmaceuticals
- using bacteria to make yogurt, cheese, and vinegar
- bioreactors in manufacturing
- microorganisms to degrade oil slicks or organic waste
- genetically engineered bacteria to produce human hormones
- using plant or animal cross-breeding techniques to produce stock with enhanced qualities

The science of biotechnology can be broken down into sub-disciplines:

1. **Red Biotechnology** involves **medical processes** such as getting organisms to produce new drugs, or using stem cells to regenerate damaged human tissues and perhaps re-grow entire organs.
2. **White/Gray Biotechnology** involves **industrial processes** such as the production of new chemicals or the development of new fuels for vehicles.
3. **Green Biotechnology** applies to **agriculture** and involves such processes as the development of pest-resistant grains or the accelerated evolution of disease-resistant animals.
4. **Blue Biotechnology** encompasses processes in **marine and aquatic environments**, such as controlling the proliferation of noxious water-borne organisms.

Biotechnology, like any other advanced technology, has the potential for misuse. Concern about this has led to efforts by some groups to enact legislation restricting or banning certain processes or programs, such as human cloning and embryonic stem-cell research. There is also concern that if biotechnological processes are used by groups with nefarious intent, the end result could be biological warfare.

Name: _____ Date: _____

Bio30: GB3 Biotechnology **Biotechnology Defined**

Research an application of biotechnology of your choosing. Be able to address the following questions:

1. Which biotechnology did you choose?

2. What type of biotechnology is it classified as?

3. What is all involved in your chosen biotechnology?

4. What will the impact of this biotechnology be on you as an individual?

5. What will the impact of this biotechnology be on society?

6. What will the impact of this biotechnology be on the environment?

Compilation of resources from:
https://www.bio.org/articles/history-biotechnology
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3178936/
http://www.biotechinstitute.org/go.cfm?do=Page.View&pid=22

Historical Examples (Prior to 1800)

Most of the developments in the ancient period i.e., before the year 1800, can be termed as 'discoveries' or 'developments'. If we study all these developments, we can conclude that all these inventions were based on common observations about nature, which could be put to test for the betterment of human life at that point in time.

- **2500-2000 B.C.:** Antique Egyptians made **wine using fermentation** techniques based on the microbiological processes that happen in the absence of oxygen. Egyptians also useful fermentation technologies to create dough rise throughout bread making.
- **500 B.C.:** In China, the first antibiotic, moldy soybean curds, is put to use to treat boils.
- **A.D. 100:** The first insecticide is produced in China from powdered chrysanthemums.
- **1492:** Christopher Columbus introduces corn, native to the Americas, to the rest of the world. **European growers modified the corn plant** to their unique growing conditions. Spanish navigators also returned to North America with potatoes, which are native to the Andes in South America.
- **1761:** English surgeon Edward Jenner pioneers vaccination, inoculating a child with a viral smallpox vaccine.

Classic Examples (1800-1950)

The second phase of evolution and development of biotechnology can be called 'Classical Biotechnology'.

- **Mid 1800's:** Austrian monk Gregor Mendel successfully **cross-bred traits** experimenting with garden peas**.** Mendel showed that differences, such as a plant's height or color, could be credited to the passing of traits and genes as the basic building blocks of life.
- **1864:** French chemist Louis Pasteur developed the process known today as **pasteurization**, which uses heat to destroy damaging microorganisms in products. The products are then sealed airtight for safety and can be transported without spoiling.
- **1870:** Breeders crossbreed cotton, developing hundreds of varieties with superior qualities.
- **1870:** The first experimental corn hybrid is produced in a laboratory.

- **1911:** American pathologist Peyton Rous discovers the first cancer-causing virus.
- **1926:** Agricultural expert Henry Wallace worked with the principles of hybridization to expand new, higher-yielding seeds. **Hybridization** is the process of combining genes from two or more varieties of a plant species to create improved seed.
- **1928:** Scottish scientist Alexander Fleming discovers penicillin.
- **1933:** Hybrid corn is commercialized.
- **1942:** Penicillin is mass-produced in microbes for the first time.

Current Examples (1950-Present)

During this period various observations started pouring in, with scientific evidences. They were all very helpful toward solving the puzzle/s of biotechnology. Each and every contribution from different individuals helped to solve the puzzle and pave the path for new discoveries. The basics for the transfer of genetic information are the core of biotechnology.

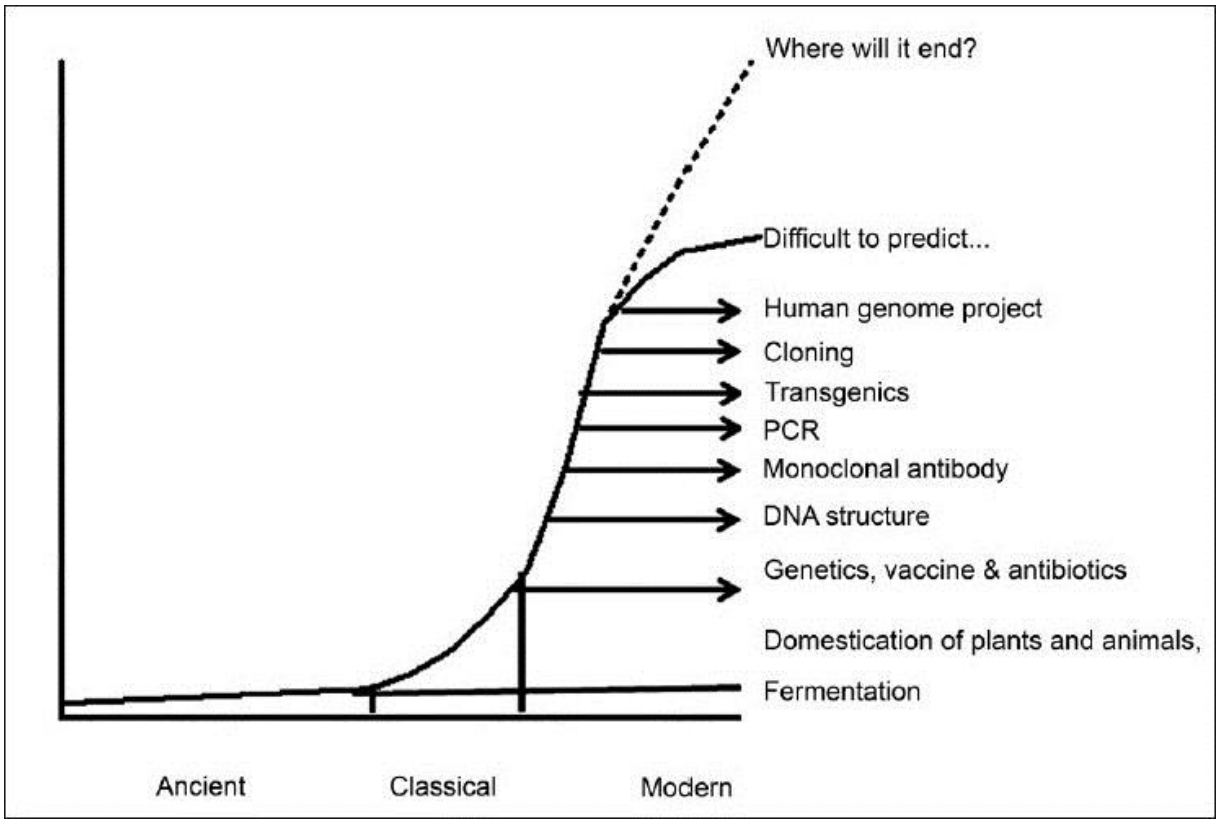
- **1950s:** The first synthetic antibiotic is created.
- **1951:** Artificial insemination of livestock is accomplished using frozen semen.
- **1953:** DNA, or deoxyribonucleic acid, was "discovered". British scientist Rosalind Franklin's DNA research shaped the foundation for James Watson and Francis Crick's 1953 detection of the structure of DNA, the ladder-like double helix. Watson and Crick perfected the DNA structural replica that Franklin explores earlier.
- **1958:** DNA is made in a test tube for the first time.
- **1973**: Working to help people living with diabetes, Stanley Cohen and Herbert Boyer lifted hereditary materials from one organism's DNA and copy them into another's. It's the story of insulin.
- **1978:** Recombinant human insulin is produced for the first time.
- **1979:** Human growth hormone is synthesized for the first time.
- **1980:** Smallpox is globally eradicated following 20-year mass vaccination effort.
- **1980:** The U.S. Supreme Court approves the principle of patenting organisms, which allows the Exxon oil company to patent an oil-eating microorganism.
- **1981:** Scientists at Ohio University produce the first transgenic animals by transferring genes from other animals into mice.
- **1982:** The first recombinant DNA vaccine for livestock is developed.
- **1982:** The first biotech drug, human insulin produced in genetically modified bacteria, is approved by FDA. Genentech and Eli Lilly developed the product.

- **1985:** Genetic markers are found for kidney disease and cystic fibrosis.
- **1986:** The first recombinant vaccine for humans, a vaccine for hepatitis B, is approved.
- **1986:** Interferon becomes the first anticancer drug produced through biotech.
- **1988:** The first pest-resistant corn, Bt corn, is produced.
- **1990:** The first successful gene therapy is performed on a 4-year-old girl suffering from an immune disorder.
- **1992:** FDA approves bovine somatotropin (BST) for increased milk production in dairy cows.
- **1993:** FDA approves Betaseron®, the first of several biotech products that have had a major impact on multiple sclerosis treatment.
- **1994:** The first breast cancer gene is discovered.
- **1994:** The Americas are certified polio-free by the International Commission for the Certification of Polio Eradication.
- **1995:** Gene therapy, immune-system modulation and recombinantly produced antibodies enter the clinic in the war against cancer.
- **1996:** A gene associated with Parkinson's disease is discovered.
- **1996:** The first genetically engineered crop is commercialized.
- **1997:** A sheep named Dolly in Scotland becomes the first animal cloned from an adult cell.
- **1998:** FDA approves Herceptin®, a pharmacogenomic breast cancer drug for patients whose cancer overexpresses the HER2 receptor.
- **1999:** A diagnostic test allows quick identification of Bovine Spongicorm Encephalopathy (BSE, also known as "mad cow" disease) and Creutzfeldt-Jakob Disease (CJD)
- **2000:** Kenya field-tests its first biotech crop, virus-resistant sweet potato.
- **2001:** FDA approves Gleevec® (imatinib), a gene-targeted drug for patients with chronic myeloid leukemia. Gleevec is the first gene-targeted drug to receive FDA approval.
- **2002:** EPA approves the first transgenic rootworm-resistant corn.
- **2002:** The banteng, an endangered species, is cloned for the first time.
- **2003:** China grants the world's first regulatory approval of a gene therapy product, Gendicine (Shenzhen SiBiono GenTech), which delivers the p53 gene as a therapy for squamous cell head and neck cancer.
- **2003:** The Human Genome Project completes sequencing of the human genome.

- **2004:** UN Food and Agriculture Organization endorsed biotech crops, stating biotechnology is a complementary tool to traditional farming methods that can help poor farmers and consumers in developing nations.
- **2004:** FDA approves the first anti-angiogenic drug for cancer, Avastin®.
- **2005:** The Energy Policy Act is passed and signed into law, authorizing numerous incentives for bioethanol development.
- **2006:** FDA approves the recombinant vaccine Gardasil®, the first vaccine developed against human papillomavirus (HPV), an infection implicated in cervical and throat cancers, and the first preventative cancer vaccine.
- **2006:** USDA grants Dow Agro Sciences the first regulatory approval for a plant-made vaccine.
- **2007:** FDA approves the H5N1 vaccine, the first vaccine approved for avian flu.
- **2009:** Global biotech crop acreage reaches 330 million acres.
- **2009:** FDA approves the first genetically engineered animal for production of a recombinant form of human anti-thrombin.

Emerging Examples (Moving Forward)

- **2016:** 3-D Printing, stem cell research, genetically modified food supply, others?



Recombinant DNA =

When DNA from two different species is joined together

Genetic Engineering (A.K.A. Gene Splicing) =

The direct manipulation of a genome using biotechnology

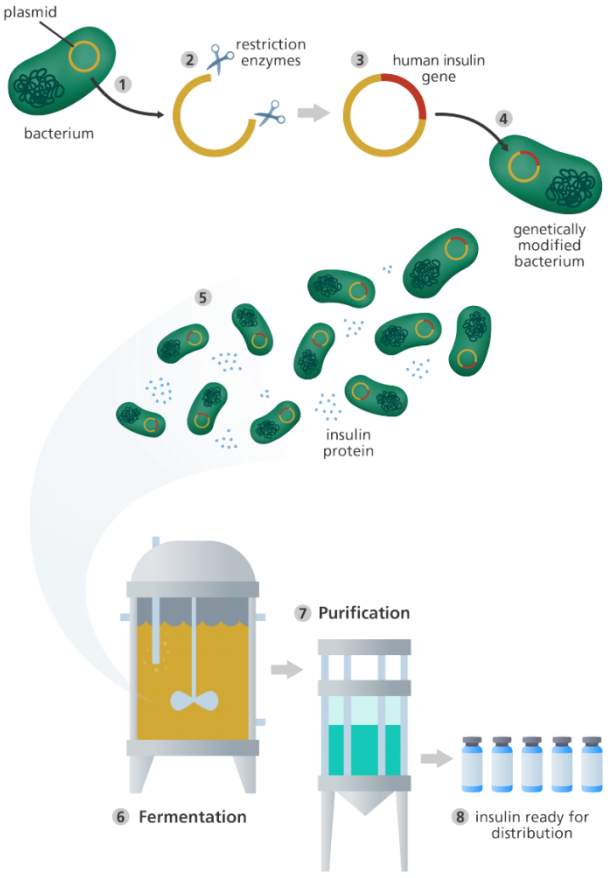
This may mean changing one base pair (A-T or C-G), deleting a whole region of DNA, or introducing an additional copy of a gene. It may also mean extracting DNA from another organism's genome and combining it with the DNA of that individual. Genetic engineering is used by scientists to enhance or modify the characteristics of an individual organism and can be applied to any organism. For example, genetic engineering can be used to produce plants that have a higher nutritional value or can tolerate exposure to herbicides.

Genetic Engineering At Work: Diabetes

Insulin is a protein that helps regulate sugar levels in our blood. Normally insulin is produced in the pancreas, but in people with Type 1 Diabetes there is a problem with insulin production. People with diabetes therefore have to inject insulin to control their blood sugar levels. Genetic engineering has been used to produce a type of insulin, very similar to our own, from yeast and bacteria like *E. coli*. This genetically modified insulin, 'Humulin' was licensed for human use in 1982.

The Process

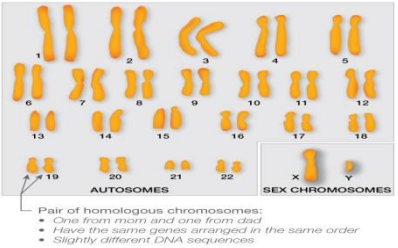
1. A small piece of circular DNA called a **plasmid** is extracted from the bacteria or yeast cell.
2. A small section is then cut out of the circular plasmid by **restriction enzymes**, 'molecular scissors'.
3. The gene for human insulin is inserted into the gap in the plasmid. This plasmid is now genetically modified.
4. The genetically modified plasmid is introduced into a new bacteria or yeast cell.
5. This cell then divides rapidly and makes insulin.
6. To create large amounts of the cells, the genetically modified bacteria or yeast are grown in large fermentation vessels that contain all the nutrients they need. The more the cells divide, the more insulin is produced.
7. When fermentation is complete, the mixture is filtered to release the insulin.
8. The insulin is then purified and packaged into bottles/insulin pens for distribution to patients with diabetes.



Miss Foley

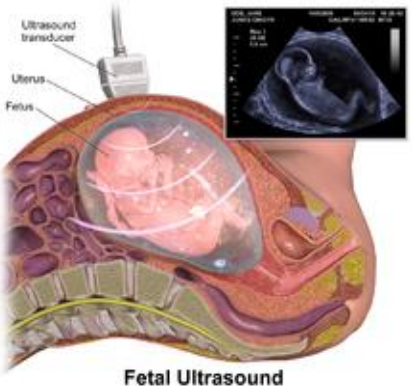
Bio30: GB3 Biotechnology **Genetic Screening**

Karyotyping - A picture taken during metaphase of mitosis is then cut apart and rearranged in matching chromosome pairs representing the number, size, and shape of paired chromosomes in an organism.



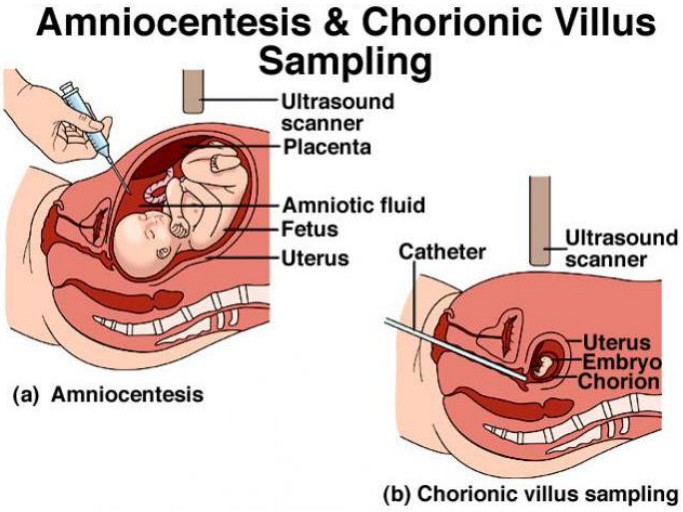
Ultra-Sound Imaging

(a.k.a. ultrasound scanning or sonography) – a non-invasive diagnostic test that involves the use of a small transducer (probe) and ultrasound gel placed directly on the skin. High-frequency sound waves are transmitted from the probe through the gel into the body. The transducer collects the sounds that bounce back and a computer then uses those sound waves to create an image. They can show the structure and movement of the body's internal organs, as well as blood flowing through blood vessels. Ultrasound waves are disrupted by air or gas; therefore ultrasound is not an ideal imaging technique for air-filled bowel or organs obscured by the bowel. Ultrasound has difficulty penetrating bone and, therefore, can only see the outer surface of bony structures and not what lies within (except in infants who have more cartilage in their skeletons than older children or adults). By studying this image, doctors can detect abnormalities in bone, muscle and heart formation. They may also confirm the presence of more than one fetus.



Fetal Ultrasound

Amniocentesis - a prenatal procedure in which amniotic fluid is removed from the uterus around the 16th week of pregnancy for testing or treatment. Amniotic fluid is the fluid that surrounds and protects a baby during pregnancy. This fluid contains fetal cells and various chemicals produced by the baby. The fluid and cells are examined for abnormalities, such as Tay Sachs. The fetal cells can also be karyotyped to determine whether they contain any abnormal, missing or extra chromosomes.



Chorionic Villus Sampling –

is a prenatal test in which a sample of chorionic villi is removed from the placenta for testing; either through the cervix (transcervical) or the abdominal wall (transabdominal). During pregnancy, the placenta provides oxygen and nutrients to the growing baby and removes waste products from the baby's blood. The chorionic villi are wispy projections of placental tissue that share the baby's genetic makeup. It is usually done between weeks 10 and 13 of pregnancy — earlier than other prenatal diagnostic tests, such as amniocentesis. Chorionic villus sampling can reveal whether a baby has a chromosomal condition, such as Down syndrome or other genetic conditions, such as cystic fibrosis. However, chorionic villus sampling can't detect certain birth defects, such as neural tube defects. Health care providers might caution against both types of chorionic villus sampling if you're Rh negative, your baby is Rh positive and your body has already begun to produce Rh antibodies. Bleeding caused by the procedure could increase your antibody response and cause pregnancy complications.

Information, Media, Legislation & Intellectual Property Debates

Day 1 & 2: Create Research Notes & Debate Prep

Obtain a copy of the Debate Format from your teacher. Create research notes on your assigned topic and position as you prepare to contribute to the debate fully. Your personal Research Notes will be handed in following the debate. Be sure to build support, think of possible counter arguments, and prepare possible rebuttals for your position.

Focus on researching the following:

- ❒ Background information on your assigned biotechnology.
- ❒ How individuals and groups use and misuse information to support their positions regarding your assigned biotechnology.
- ❒ How media plays a role in creating or influencing public perception regarding your assigned biotechnology.
- ❒ How do regulations/legislation provide public safety regarding your assigned biotechnology.
- ❒ Defend your assigned position that intellectual property rights or patents should or should not be allowed for your assigned biotechnology.

Day 3: Short Debate Format

Debate will follow the provided debate format; taking approximately 20 minutes. Classmates not involved in your debate will complete debate ballets during your debate. Hand in your individual Research Notes following the debate.

A Few Important Thoughts

Be sure to cite your information. You can do this using www.easybib.com as a resource. If any form of plagiarism occurs you will initially be given a grade of 0, until you submit your own intellectual work with proper citations - give credit where credit is due.

Topic: Genetically Modified Organisms (GMO's)
Pro – Kortlyn Fuller & Ellery Audette
Con – Kirsten Bahnuick & Hannah MacNeil

Topic: Stem Cell Research
Pro – Ryan Krause & Patrick Wickham
Con – Kerigan Stevenson & Jensen Piquette

Topic: Genetic Screening
Pro – Kyle Smith & Hannah Lingenfelter
Con – Julia Goldstein & Cayden Nicolson

Classroom Debate[1]

The classroom debates are exercises designed to allow you to strengthen your skills in the areas of leadership, interpersonal influence, teambuilding, group problem solving, and oral presentation.

Short Debate Format
(Time Required: 20 minutes)

3 minute Position Presentation - PRO 3 minute Position Presentation - CON	**Focusing on the lenses of how people use information, how media creates our perception, how regulations/legislation keep us safe and should people own your example of biotech as intellectual property, answer the following:** Position – What position do you take/propose? Inherency – Why do you think it isn't already this way? Harms – What are the problems with the current situation or oppositions position? Solvency – What are reasons why you could solve it or what are advantages to your position being right?
3 minute Work Period	
2 minute Rebuttal – PRO 2 minute Rebuttal - CON	Address any issues presented by the opposition Present predicted counter arguments Prove opposition's position brings more problems that solutions
2 minute Work Period	
1 minute Response – PRO 1 minute Response - CON	Explain again (extend) why your position is a better idea Respond to all negative arguments as to why it is a bad idea Overview: "If you only remember three things…the most important three things are…"
1 minute Work Period	
1 minute Position Summary – PRO or CON 1 minute Position Summary – PRO or CON	What is your position or plan? Why is it a good idea? Why is the world better off aligning with your position? Refute any negative statements presented in the rebuttal
5 minute Tallying of Ballots/Announcement of Winner (If used)	

[1]©2003, David M. Leuser, Ph.D. Plymouth State University. All rights reserved.

DEBATE BALLOT

Debate _____ **Class** _____

Name of Evaluator _____ **Date** _____

1	2	3	4	5
Poor	**Fair**	**Average**	**Good**	**Excellent**

PRO **CON**

3 Minute Position Presentation

Rating = ____ Comments:	Rating = ____ Comments:

***** ***3 Minute Work Period*** *****

2 Minute Rebuttal

Rating = ____ Comments:	Rating = ____ Comments:

***** ***2 Minute Work Period*** *****

Continued on Reverse --------->

Miss Foley

Bio30: GB3 Biotechnology **Biotech Debate**

1 Minute Response

Rating = ____ Comments:	Rating = ____ Comments:

***** *1 Minute Work Period* *****

1 Minute Position Summary

Rating = ____ Comments:	Rating = ____ Comments:

[ ] Total Points **[ ] Total Points**

Circle Winner Below:

PRO **CON**

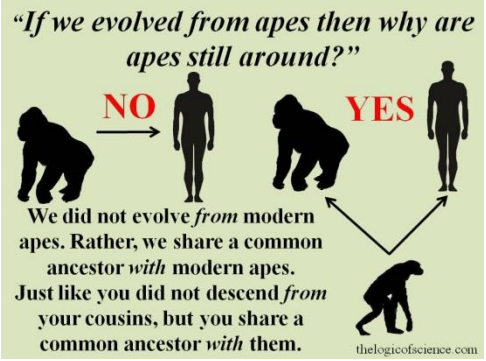
General Comments:

Signature of Evaluator:

_____

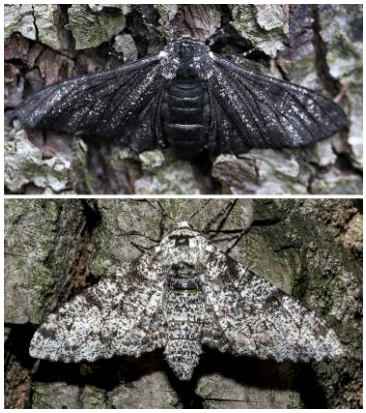
Evolution Defined…Change Over Time

- Change in the gene pool of a population over successive generations by processes such as mutation, natural selection, and genetic drift.
- This change in the properties of populations of organisms transcends the lifetime of a single individual.
- This change results in a process by which modern organisms have descended from ancient organisms.



Adaptations are a particular structure, physiology, or behavior that helps a organisms to survive and reproduce in a particular environment. Examples include: camouflage, a human's thumb, an Eagle's eyesight, etc. Adaptations help an organism survive; therefore that organism has a better chance of passing on to its offspring the particular characteristic which was advantageous to its survival. Changes in an organism's environment can determine if an adaptation will or will not help an organism survive.

Case Study: The Peppered Moth



The English peppered moth is an example of how characteristics can change in response to changes in an organism's environment. The peppered moth has two colors: Greyish (white with black dots) <u>and</u> Black (black with white dots)

In 1848, estimates determined that there were many more greyish-white peppered moths (about 98%) than black ones (about 2%). In 1898, approximately 95% of the moths in Manchester, England were of the black color with only about 5% being greyish-white. The reason for the change is due to a change in the moth's environment.

Prior to the Industrial Revolution, the greyish-white moths were able to camouflage themselves against the light colored lichens on tree trunks while the black colored moths stood out and were eaten by predators. Once the Industrial Revolution began, air pollution from the factories killed the lichens and soot began to cover the tree trunks. As a result of this, the greyish-white moths were easily seen by predators and eaten while the black moths could camouflage themselves, survive and pass on their genes to their offspring. The difference between the two colors of peppered moth is a single gene. Before the Revolution, more greyish-white moths survived and thus passed on their form of the gene for color to the gene pool. Once the Revolution started, the black moths were able to survive and pass on their form of the gene. This occurred over a number of generations.

In the 1950s, due to clean air legislation, lichens began to grow on trees again. This began to change the peppered moth once again. In 1959, 9 / 10 moth were black in color. In 1985, 5 / 10 were black and by 1989, only 3 / 10 were black.

Based on the above example we can define evolution as:
"Any shift in the gene pool of a population."

Common Evolution Myths

MISCONCEPTION #1: Evolution is a theory about the origin of life.

CORRECTION: Evolutionary theory *does* encompass ideas and evidence regarding life's origins (e.g., whether or not it happened near a deep-sea vent, which organic molecules came first, etc.), but this is not the central focus of evolutionary theory. Most of evolutionary biology deals with how life changed *after* its origin. Regardless of how life started, afterwards it branched and diversified, and most studies of evolution are focused on those processes.

MISCONCEPTION #2: Evolutionary theory implies that life evolved (and continues to evolve) randomly, or by chance.

CORRECTION: Chance and randomness *do* factor into evolution and the history of life in many different ways; however, some important mechanisms of evolution are non-random and these make the overall process non-random. For example, consider the process of natural selection, which results in adaptations — features of organisms that appear to suit the environment in which the organisms live (e.g., the fit between a flower and its pollinator, the coordinated response of the immune system to pathogens, and the ability of bats to echolocate). Such amazing adaptations clearly did not come about "by chance." They evolved via a combination of random and non-random processes. The process of mutation, which generates genetic variation, is random, but selection is non-random. Selection favored variants that were better able to survive and reproduce (e.g., to be pollinated, to fend off pathogens, or to navigate in the dark). Over many generations of random mutation and non-random selection, complex adaptations evolved. To say that evolution happens "by chance" ignores half of the picture.

MISCONCEPTION #3: Evolution results in progress; organisms are always getting better through evolution.

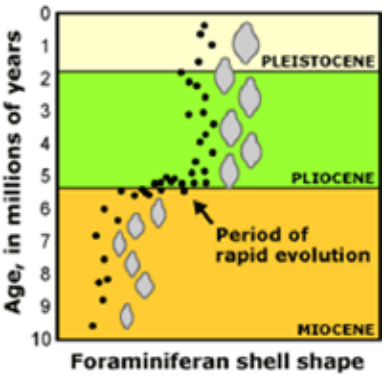
CORRECTION: One important mechanism of evolution, natural selection, *does* result in the evolution of improved abilities to survive and reproduce; however, this does not mean that evolution is progressive — for several reasons. First, as described in a misconception below, natural selection does not produce organisms perfectly suited to their environments. It often allows the survival of individuals with a range of traits — individuals that are "good enough" to survive. Hence, evolutionary change is not always necessary for species to persist. Many taxa (like some mosses, fungi, sharks, opossums, and crayfish) have changed little physically over great expanses of time. Second, there are other mechanisms of evolution that don't cause adaptive change. Mutation, migration, and genetic drift may cause populations to evolve in ways that are actually harmful overall or make them less suitable for their environments. For example, the Afrikaner population of South Africa has an unusually high frequency of the gene responsible for Huntington's disease because the gene version drifted to high frequency as the population grew from a small starting population. Finally, the whole idea of "progress" doesn't make sense when it comes to evolution. Climates change, rivers shift course, new competitors invade — and an organism with traits that are beneficial in one situation may be poorly equipped for survival when the environment changes. And even if we focus on a single environment and habitat, the idea of how to measure "progress" is skewed by the perspective of the observer. From a plant's perspective, the best measure of progress might be photosynthetic ability; from a spider's it might be the efficiency of a venom delivery system; from a human's, cognitive ability. It is tempting to see evolution as a grand progressive ladder with Homo sapiens emerging at the top. But evolution produces a tree, not a ladder — and we are just one of many twigs on the tree.

MISCONCEPTION #4: Individual organisms can evolve during a single lifespan.

CORRECTION: Evolutionary change is based on changes in the genetic makeup of populations over time. Populations, not individual organisms, evolve. Changes in an individual over the course of its lifetime may be developmental (e.g., a male bird growing more colorful plumage as it reaches sexual maturity) or may be caused by how the environment affects an organism (e.g., a bird losing feathers because it is infected with many parasites); however, these shifts are not caused by changes in its genes. While it would be handy if there were a way for environmental changes to cause adaptive changes in our genes — who wouldn't want a gene for malaria resistance to come along with a vacation to Mozambique? — evolution just doesn't work that way. New gene variants (i.e., alleles) are produced by random mutation, and over the course of many generations, natural selection may favor advantageous variants, causing them to become more common in the population.

MISCONCEPTION #5: Evolution only occurs slowly and gradually.

CORRECTION: Evolution occurs slowly and gradually, but it can also occur rapidly. We have many examples of slow and steady evolution — for example, the gradual evolution of whales from their land-dwelling, mammalian ancestors, as documented in the fossil record. But we also know of many cases in which evolution has occurred rapidly. For example, we have a detailed fossil record showing how some species of single-celled organism, called foraminiferans, evolved new body shapes in the blink of a geological eye, as shown to the right. Similarly, we can observe rapid evolution going on around us all the time. Over the past 50 years, we've observed squirrels evolve new breeding times in response to climate change, a fish species evolve resistance to toxins dumped into the Hudson River, and a host of microbes evolve resistance to new drugs we've developed. Many different factors can foster rapid evolution — small population size, short generation time, big shifts in environmental conditions — and the evidence makes it clear that this has happened many times.



MISCONCEPTION #6: Because evolution is slow, humans cannot influence it.

CORRECTION: As described in the misconception about evolutionary rates above, evolution sometimes occurs quickly. And since humans often cause major changes in the environment, we are frequently the instigators of evolution in other organisms. Here are just a few examples of human-caused evolution for you to explore:

- Several species have evolved in response to climate change.
- Fish populations have evolved in response to our fishing practices.
- Insects like bedbugs and crop pests have evolved resistance to our pesticides.
- Bacteria, HIV, malaria, and cancer have evolved resistance to our drugs.

MISCONCEPTION #7: Genetic drift only occurs in small populations.

CORRECTION: Genetic drift has a larger effect on small populations, but the process occurs in all populations — large or small. Genetic drift occurs because, due to chance, the individuals that reproduce may not exactly represent the genetic makeup of the whole population. For example, in one generation of a population of captive mice, brown-furred individuals may

reproduce more than white-furred individuals, causing the gene version that codes for brown fur to increase in the population — not because it improves survival, just because of chance. The same process occurs in large populations: some individuals may get lucky and leave many copies of their genes in the next generation, while others may be unlucky and leave few copies. This causes the frequencies of different gene versions to "drift" from generation to generation. However, in large populations, the changes in gene frequency from generation to generation tend to be small, while in smaller populations, those shifts may be much larger. Whether its impact is large or small, genetic drift occurs *all* the time, in *all* populations. It's also important to keep in mind that genetic drift may act at the same time as other mechanisms of evolution, like natural selection and migration.

MISCONCEPTION #8: Humans are not currently evolving.

CORRECTION: Humans are now able to modify our environments with technology. We have invented medical treatments, agricultural practices, and economic structures that significantly alter the challenges to reproduction and survival faced by modern humans. So, for example, because we can now treat diabetes with insulin, the gene versions that contribute to juvenile diabetes are no longer strongly selected against in developed countries. Some have argued that such technological advances mean that we've opted out of the evolutionary game and set ourselves beyond the reach of natural selection — essentially, that we've stopped evolving. However, this is not the case. Humans still face challenges to survival and reproduction, just not the same ones that we did 20,000 years ago. The direction, but not the fact of our evolution has changed. For example, modern humans living in densely populated areas face greater risks of epidemic diseases than did our hunter-gatherer ancestors (who did not come into close contact with so many people on a daily basis) — and this situation favors the spread of gene versions that protect against these diseases. Scientists have uncovered many cases of recent human evolution, such as:

- genetic evidence regarding recent human evolution
- the recent evolution of adaptations that allow humans to thrive at high altitudes
- the recent evolution of human genetic traits that protect against malaria
- the recent evolution of lactose tolerance in humans

MISCONCEPTION #9: Species are distinct natural entities, with a clear definition, that can be easily recognized by anyone.

CORRECTION: Many of us are familiar with the biological species concept, which defines a species as a group of individuals that actually or potentially interbreed in nature. That definition of a species might seem cut and dry but in many other cases, this definition is difficult to apply. For example, many bacteria reproduce mainly asexually. How can the biological species concept be applied to them? Many plants and some animals form hybrids in nature, even if they largely mate within their own groups. Should groups that occasionally hybridize in selected areas be considered the same species or separate species? The concept of a species is a fuzzy one because humans invented the concept to help get a grasp on the diversity of the natural world. It is difficult to apply because the term species reflects our attempts to give discrete names to different parts of the tree of life — which is not discrete at all, but a continuous web of life, connected from its roots to its leaves.

Adaptations =

Descent With Modification – Charles Darwin did not use the word "evolution" in his book Origin of Species, rather he

FINISH!!!!

Adaptations =

Descent With Modification – Charles Darwin did not use the word "evolution" in his book Origin of Species, rather he

FINISH!!!!!

Microevolution: Key Principles

Descent With Modification – Charles Darwin did not use the word "evolution" in his book Origin of Species, rather he used the idea of "descent with modification". This idea is based on two main ideas:

1. Present forms of life have arisen by descent and modification from an ancestral species.
2. The mechanism for modification is natural selection working continuously for long periods of time.

Adaptations Bring Fitness – Fitness describes how good a particular genotype is at leaving offspring in the next generation relative to how good other genotypes are at it. So if brown beetles consistently leave more offspring than green beetles because of their color, you'd say that the brown beetles had a higher fitness.

Number that survive compared to total	95 %	33 %

The brown beetles have a greater fitness relative to the green beetles.

Of course, fitness is a relative thing. A genotype's fitness depends on the environment in which the organism lives. The fittest genotype during an ice age, for example, is probably not the fittest genotype once the ice age is over.

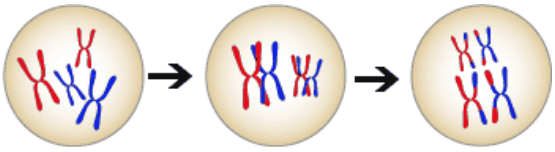
Fitness is a handy concept because it lumps everything that matters to natural selection (survival, mate-finding, reproduction) into one idea. The fittest individual is not necessarily the strongest, fastest, or biggest. A genotype's fitness includes its ability to survive, find a mate, produce offspring — and ultimately leave its genes in the next generation.

Struggle for Existence – Charles Darwin claimed that there was a continual 'struggle for existence' in nature, in which only the fittest would survive. Any individual plants and animals that happened to vary in an advantageous way would be more likely to triumph over their competitors. Only the survivors would produce offspring.

Genetic Variation - Without genetic variation, some of the basic mechanisms and processes of evolutionary change cannot operate.

Primary sources of genetic variation are:

1. **Mutations** are changes in the DNA. A single mutation can have a large effect, but in many cases, evolutionary change is based on the accumulation of many mutations.
2. **Genetic Drift** is when the frequencies of particular alleles change drastically completely by chance.
3. **Gene flow (a.k.a. migration)** is any movement of genes from one population to another and is an important source of genetic variation.
4. **Mating** can introduce new gene combinations into a population. This genetic shuffling, also known as crossing over during meiosis, is another important source of genetic variation.

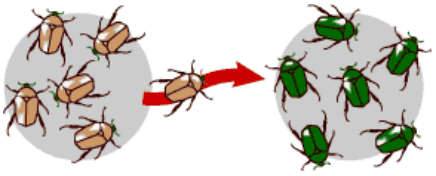


5. **Natural Selection** allows for the frequency of an allele to increase from one generation to the next if that allele gives a slight selective advantage to the population.

Microevolution: Key Processes

Mutation - A mutation could cause parents with genes for bright green coloration to have offspring with a gene for brown coloration. That would make genes for brown coloration more frequent in the population than they were before the mutation.

Migration (a.k.a. Gene Flow) - Some individuals from a population of brown beetles might have joined a population of green beetles. That would make genes for brown coloration more frequent in the green beetle population than they were before the brown beetles migrated into it.



Natural Selection is a process in which the characteristics of a population of organisms change because individuals with certain heritable traits survive specific environmental conditions and pass on traits to their offspring. Because nature plays a role in selecting certain characteristics, we can say that the environment exerts a **selective pressure** on a population. Natural selection is considered to be situational meaning adaptations which are beneficial to an organism in one situation may be useless or even detrimental in another situation. Behavior can also be shaped by natural selection.

Genetic Drift - Imagine that in one generation, two brown beetles happened to have four offspring survive to reproduce. Several green beetles were killed when someone stepped on them and had no offspring. The next generation would have a few more brown beetles than the previous generation — but just by chance.

Unlike natural selection, some individuals leave behind a few more descendants (and genes!) than other individuals in each generation **purely by random chance**. The genes of the next generation will be the genes of the "lucky" individuals, not necessarily the healthier or "better" individuals. It happens to ALL populations as there is no avoiding chance. So although genetic drift is a mechanism of evolution, it doesn't work to produce adaptations.

Selective Breeding (a.k.a. Artificial Selection) – Instead of nature, people select which organisms get to reproduce.

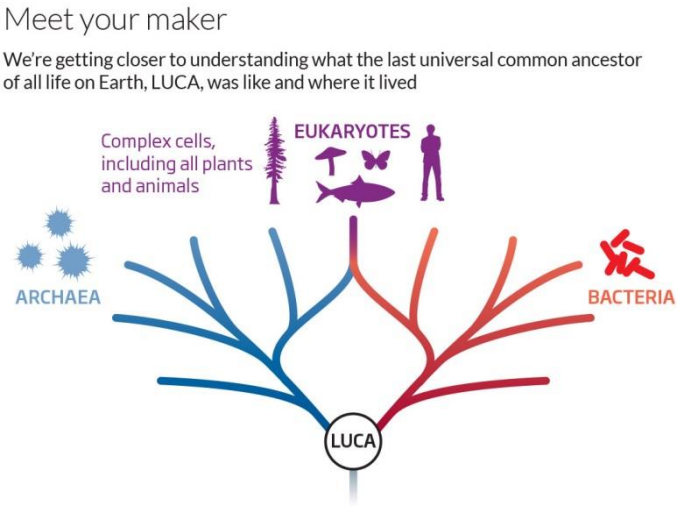
Farmers have cultivated numerous popular crops from the wild mustard, by artificially selecting for certain attributes. All of these vegetables were cultivated from forms of wild mustard.

Last Universal Common Ancestor (LUCA) = common ancestor that unites all life on Earth

Behold LUCA, the Last Universal Common Ancestor of Life on Earth

By Jason Daley

SMITHSONIAN.COM JULY 26, 2016



In the last few years, DNA analysis has allowed researchers to redraw the tree of life in incredible detail, but there's always been a question mark at the base of the tree. While it's unlikely that researchers will ever find the exact species that started it all, they recently came up with a pretty good description of LUCA, the Last Universal Common Ancestor of all of Earth's creatures, sometimes referred to as microbial Eve.

Life as we know it is currently divided into six kingdoms: plants, animals, fungus, protists, eubacteria and archaebacteria. The first four belong to the a domain known as eukaryotes, sporting cells with distinct nuclei. The other two kingdoms, eubacteria and archaebacteria are single-celled organisms without a distinct nucleus. All of them evolved from a single-celled ancestor that lived about 4 billion years ago when Earth was celestial baby. After all those billions of years of change, LUCA's fingerprints are still visible in the genes of modern organisms. That's why William Martin, an evolutionary biologist at Heinrich Heine University in Düsseldorf, Germany, set out to study LUCA's trail in the genes of bacteria and archaea, the two groups researchers believe became eukaryotes.

Tracking genes in bacteria is particularly difficult because they can swap genetic material, making it hard to discern whether the single-celled organisms received a gene from an ancestor or picked it up from another species along the evolutionary road, reports Robert F. Service at Science. So Martin and his team decided to search for genes shared by at least two species of modern bacteria and two archaea, an indicator that the gene was likely inherited and not an evolutionary hitchhiker. The researchers combed through DNA databanks, analyzing the genomes of 2,000 modern microbes sequenced over the last two decades. From six million total genes, they found 355 gene families that were widespread among the microbes, which means they were likely to be genes LUCA passed down. They published their results in Nature Microbiology.

LUCA's genes are those of an extremophile organism that likely lived in an area where seawater and magma meet on the ocean floor, known as hydrothermal vents, reports Nicholas Wade at The New York Times. Similar creatures still haunt these environments among the toxic plumes of sulfides and metals. And many researchers already believe this is where life first began. "I was flabbergasted at the result, I couldn't believe it," Martin tells Michael Le Page at New Scientist. "It's spot on with regard to the hydrothermal vent theory."

The genes show that LUCA lived in habitat with no oxygen, Service writes. It also fed on hydrogen gas, meaning it was likely an organism that lived near super-heated volcanic vents where hydrogen gas was likely produced. LUCA's lifestyle is similar to two types of microbes that researchers have uncovered, the anaerobic bacteria in the genus clostridium and the hydrogen gobbling archaea in the methanogens group, James Lake, an evolutionary biologist at UCLA tells Service where hydrogen gas was likely produced. LUCA's lifestyle is similar to two types of microbes that researchers have uncovered, the anaerobic bacteria in the genus clostridium and the hydrogen gobbling archaea in the methanogens group, James Lake, an evolutionary biologist at UCLA tells Service.

But not everyone is convinced that the hydrogen gobbling vent-dweller Martin uncovered is really

LUCA. John Sutherland of the University of Cambridge in England, whose research suggests the origins of life began on land and not deep in the ocean, tells Wade that life could have developed elsewhere and then been shoved down into places like hydrothermal vents during global disasters like the Late Heavy Bombardment, a catastrophic period in Earth's history between 4 billion and 3.8 billion years ago in which the planet was reshaped by a shower of asteroids and comets.

In fact, he argues that basic chemistry shows life likely originated in pools of water on land, Darwin's "warm little ponds." Ultraviolet light from the sun, which does not reach down to hydrothermal vents, he argues, is a key element in that chemistry. More research is necessary for scientists to unravel the twisting branches of the tree of life and to determine if Martin's LUCA is a super-great aunt or the microbial Eve.

Scientists find Luca, a single-cell, bacterium-like organism that is the common ancestor of all life on Earth

By Andrew Griffin July 26, 2016

Scientists might have found the common ancestor that unites all life on Earth – and it's called Luca. Our ultimate relative was a single-cell, bacterium-like organism known as Last Universal Common Ancestor or Luca. And it could help establish how life on Earth began, at the very start.

The findings could be a huge new contribution to arguments about how life actually got going on Earth. Researchers argue about whether life began somewhere extreme – like Luca's apparent home near a deep sea vent – or whether it in fact began somewhere more pedestrian, like a small pond.

The researchers started by looking at nearly 2000 genes of modern microbes, exploring the traces that have been passed down from the beginning of life on Earth. That meant that they could explore the bits that appeared to be able to be tracked down to the common ancestor – and use their characteristics to assemble a picture of LUCA itself.

LUCA arrived about 3.8 billion years ago, and would eventually give rise to two different kinds of simple cells: bacteria and archaea. The realisation that it did so helps settle a big problem – the fact that the three domains of life, which include bacteria and archaea as well as the eukaryotes like plants and animals, didn't seem to have a single point of origin.

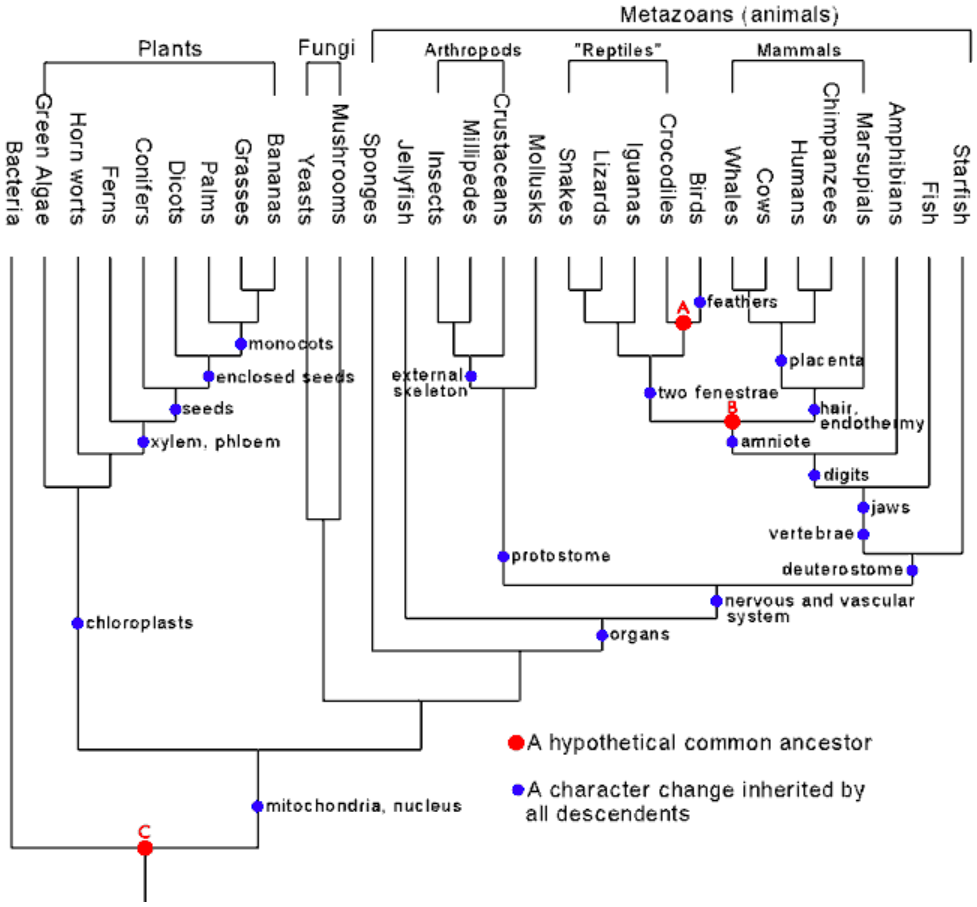
It also allows scientists to explore the 355 genes that appear to have originated in Luca and understand what they share. The organism appears to have lived in vents deep in the sea, where metallic, gassy plumes erupt from seawater that interacts with magma that comes up from the ocean floor. In the words of the author of the article – published in Nature Microbiology this week – LUCA was "anaerobic, CO2-fixing, H2-dependent with a Wood–Ljungdahl pathway, N2-fixing and thermophilic".

Deep sea vents continue to be a breeding ground for strange, exotic and extreme life-forms, and have long been thought to be a candidate for the place where life first came into being. Many of the genes that belong to Luca appear to support that theory, because they are the kinds only found in places with extremely high temperatures.

But the findings could also prove controversial because the scientists behind them have argued that Luca could be very close to the origin of life. Luca is well-suited to its environment – but was still lacking important genes that would have kept it alive, and so would have relied on its environment, making it only "half alive" and so very early in the development of life itself.

Other scientists have disputed that picture, arguing that it is equally possible that Luca was a long way down the development of life. And it might not even have begun in deep sea vents, they say – instead, life might have been forced down there because of some huge event, like a collision with meteorites that wiped out life elsewhere.

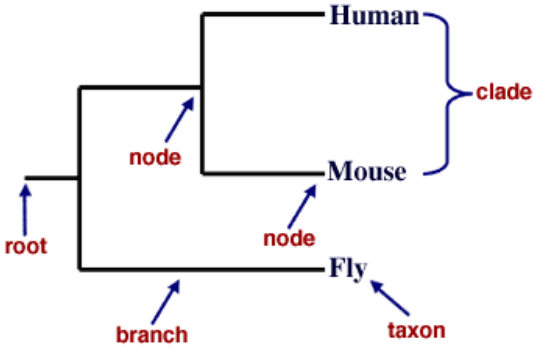
Phylogeny (a.k.a. Phylogenetics) = study of evolutionary relationships



Consensus Phylogenetic Tree of <u>ALL</u> Life

In the past, biologists grouped organisms based solely on their physical appearance. Today, with the advances in genetics and biochemistry, biologists look more closely at individuals to discover their pattern of evolution, and group them accordingly - this is called **evolutionary systematics**.

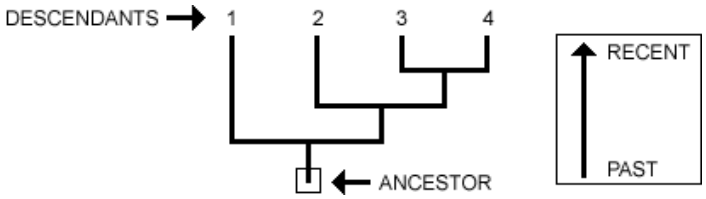
Evolutionary systematics makes an attempt to construct **phylogenetic trees** that **accurately show phyletic lineages** (proper branching on the family tree), along with a consideration of when and how new species arose and moved into new habitats and niches (established a 'new' way of life as opposed to some trivial character change).



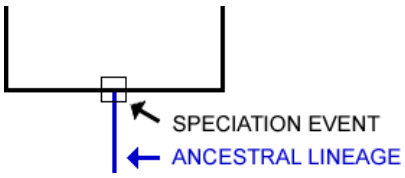
A phylogenetic tree has several parts. **Nodes** represent taxonomic units, such as an organism, a species, a population, a common

ancestor, or even an entire genus or other higher taxonomic group. **Branches** connect nodes uniquely and represent genetic relationships and timelines. The specific pattern of branching determines the tree's topology. Scaled trees have branch lengths that are proportional to some important biological property. Trees may also be rooted or unrooted. Rooted trees have a **special node, known as the root**, that represents a common ancestor of all taxa shown in the tree. Rooted trees are thus directional, since all taxa evolved from the root. Unrooted trees illustrate relationships only, without reference to common ancestors.

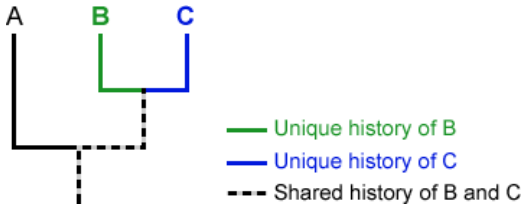
Understanding a phylogeny is a lot like reading a family tree. The root of the tree represents the ancestral lineage, and the tips of the branches represent the descendants of that ancestor. As you move from the root to the tips, you are moving forward in time.



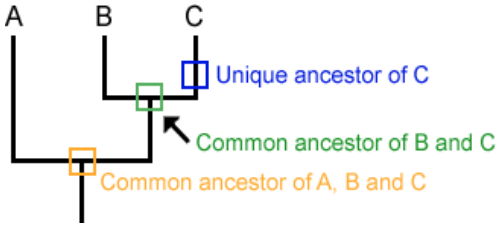
When a lineage splits (**speciation**), it is represented as branching on a phylogeny. When a speciation event occurs, a single ancestral lineage gives rise to two or more daughter lineages.



Phylogenies trace patterns of shared ancestry between lineages. Each lineage has a part of its history that is unique to it alone and parts that are shared with other lineages.



Similarly, each lineage has ancestors that are unique to that lineage and ancestors that are shared with other lineages — **common ancestors**.

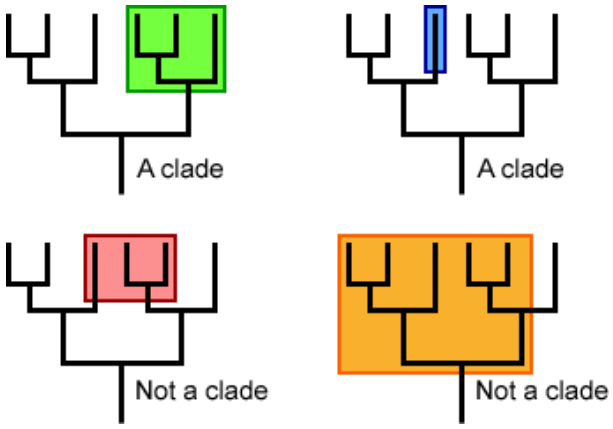


Miss Foley

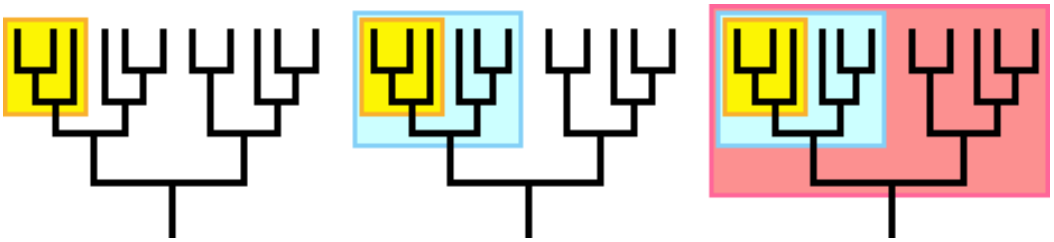
Bio30: LE2 Evolution **Phylogenetic Trees**

Cladistics is a form of analysis that looks at features of organisms that are considered "innovations", or newer characteristics that serve some kind of purpose and are called **derived characteristics**. These characteristics appear in later organisms but not earlier ones. Phylogenetic trees and cladograms attempt to visually demonstrate these evolutionary relationships. Both methods have their strengths and weaknesses. Cladistics, however, ignores when and where a branch occurs, tries to use purely objective criteria, and defines each branch point by a fundamental character of evolutionary significance. Cladistics gets its name from the branches on the family tree called clades. A **clade** is a grouping that includes a common ancestor and all the descendants (living and extinct) of that ancestor.

Using a phylogeny, it is easy to tell if a group of lineages forms a clade. Imagine clipping a single branch off the phylogeny — all of the organisms on that pruned branch make up a clade.



Clades are nested within one another — they form a nested hierarchy. A clade may include many thousands of species or just a few. Some examples of clades at different levels are marked on the phylogenies below. Notice how clades are nested within larger clades.

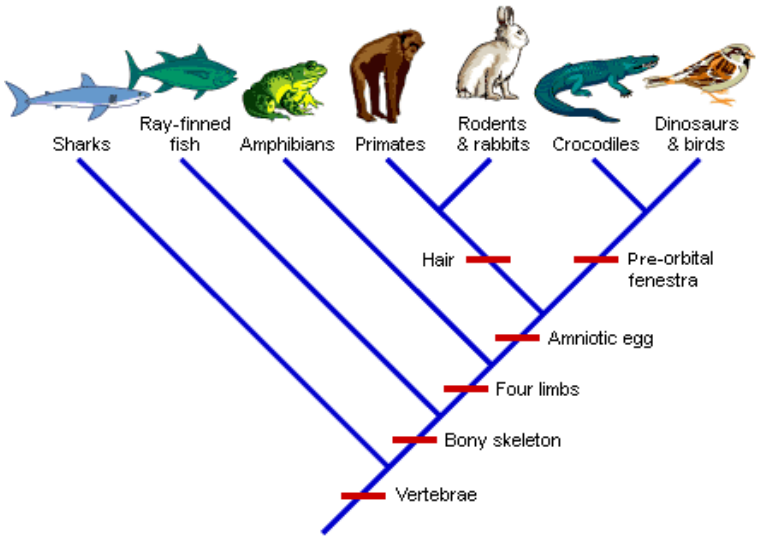


A **cladogram** is a stylized diagram that visually represents these clades and derived characteristics. At each branch, or "Y" junction, derived characters of evolutionary origin are used to separate off one group from the rest. At every branch, one of the organisms that does not share a common character with the rest of the group is "branched off" into its own clade. The order, or sequence, of these branches depends on how many characters are left within the larger group.

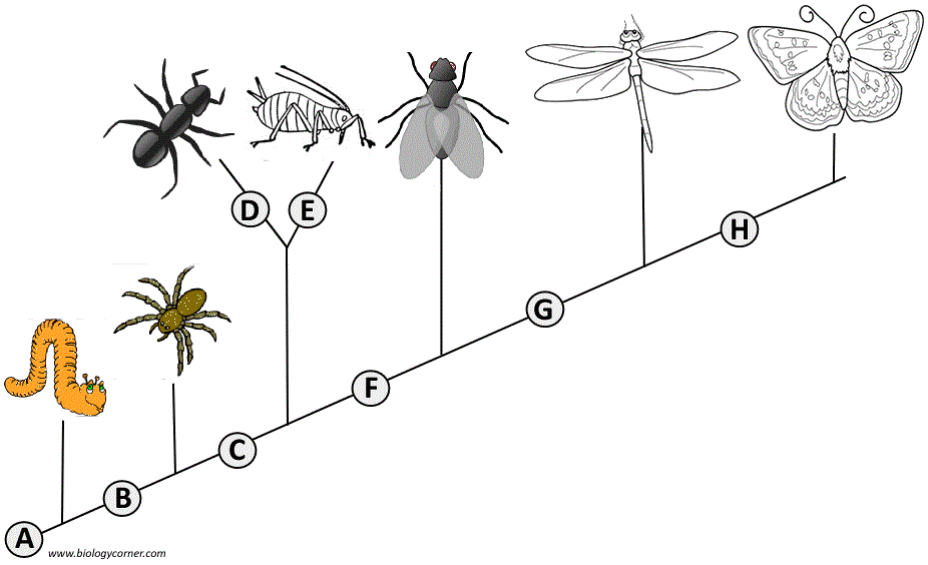
Miss Foley

Bio30: LE2 Evolution **Cladograms**

Cladograms emphasize the sequence or order in which derived characters arise from a central phylogenetic tree. That is their main strength. However, nothing in a cladogram indicates how strong or profound the derived character is, and its evolutionary importance. Equal weight is given to all the characters used. This can sometimes lead to unusual groupings which may be technically correct, but questionable.



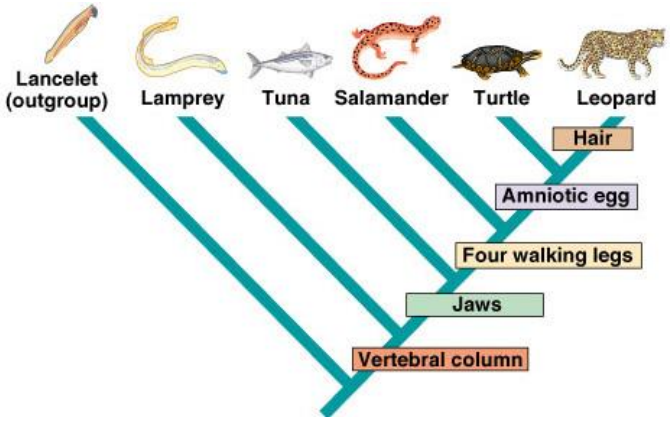
Examine the sample cladogram, each letter on the diagram points to a derived character, or something different (or newer) than what was seen in previous groups. Match the letter to its character. *Note: this cladogram was created for simplicity and understanding, it does not represent the established phylogeny for insects and their relatives.*



1. ____ Wings
2. ____ Six Legs
3. ____ Segmented Body
4. ____ Double set of wings
5. ____ Cerci (abdomenal appendages)
6. ____ Crushing mouthparts
7. ____ Legs
8. ____ Curly Antennae

Name: _____ Date: _____

Bio30: LE2 Evolution **Cladograms**

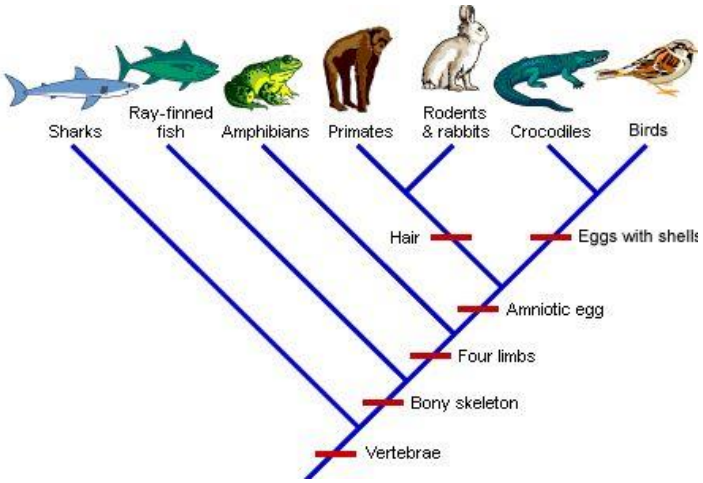


_____ /27 = _____%

1. What trait separates Lampreys from tuna on this cladogram? _____
2. What separates a salamander from a turtle? _____
3. Which organism is most related to the leopard? _____
4. What 4 traits do these two organisms share? _____

_____ _____ _____

5. Which organism will have DNA most similar to the turtle? _____
6. Which organism's DNA will differ the most from the leopard? _____



7. What trait separates amphibians from primates on this cladogram? _____
8. What separates rabbits & primates from crocodiles on this cladogram? _____
9. Which organism is most related to the bird on this cladogram? _____
10. What 5 traits do these two organisms share? _____

_____ _____

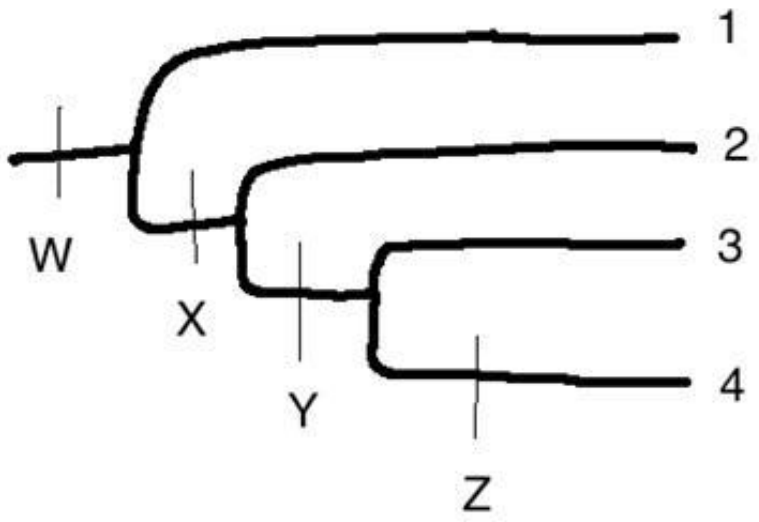
_____ _____

11. Which organism will have DNA most similar to the bird? _____
12. Which organsism's DNA will differ the most from the bird? _____

Name: _____ Date: _____

Bio30: LE2 Evolution **Phylogenetic Trees**

Trait	Snoozle	Bleeker	LooHoo	Floof
Green Skin	yes	yes	yes	yes
Giant eyes	yes	no	yes	yes
Fur	yes	no	yes	no
Suction cup feet	no	no	yes	no



Complete the following labels:

W – _____

X – _____

Y – _____

Z – _____

1- _____

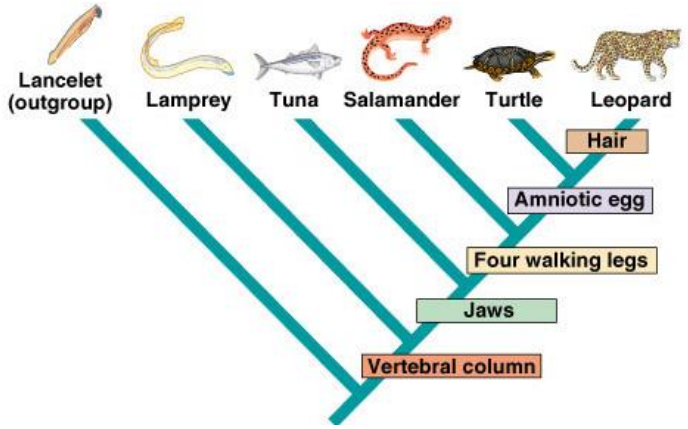
2 - _____

3 - _____

4 - _____

Name: _____ Date: _____

Bio30: LE2 Evolution **Cladograms KEY**



_____ /27 = _____%

1. What trait separates Lampreys from tuna on this cladogram? _____**Jaws**_____

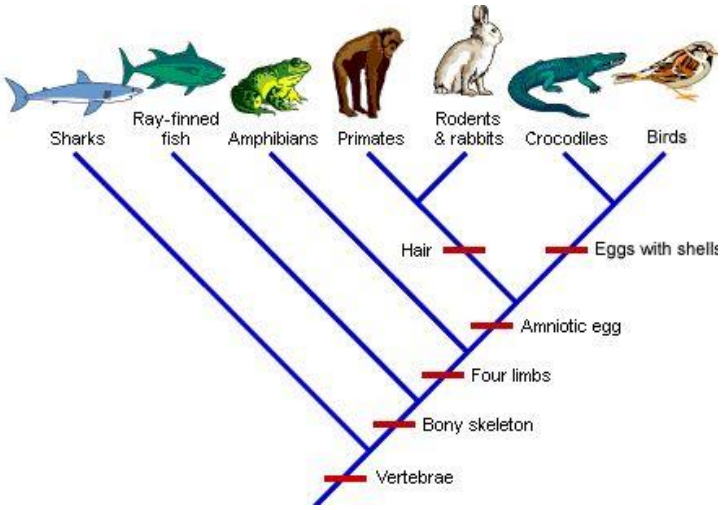
2. What separates a salamander from a turtle? _____ **Amniotic Egg**_____

3. Which organism is most related to the leopard? _____ **Turtle**_____

4. What 4 traits do these two organisms share? _____ **Amniotic Eggs**_____ _____ **Four Walking Legs**_____ ____**Jaws** _____ _____ **Vetebral Column**_____

5. Which organism will have DNA most similar to the turtle? _____ **Salamander**_____

6. Which organism's DNA will differ the most from the leopard? _____ **Lancelet**_____



7. What trait separates amphibians from primates on this cladogram? __**Amniotic Egg**__

8. What separates rabbits & primates from crocodiles on this cladogram? **Eggs w/Shells**

9. Which organism is most related to the bird on this cladogram? ___**Crocodile**_____

10. What 5 traits do these two organisms share? _____**Vertebrae**_____

_____**Bony Skeleton**_____ _____**Four Limbs**_____

_____**Amniotic Eggs**_____ _____**Eggs With Shells**_____

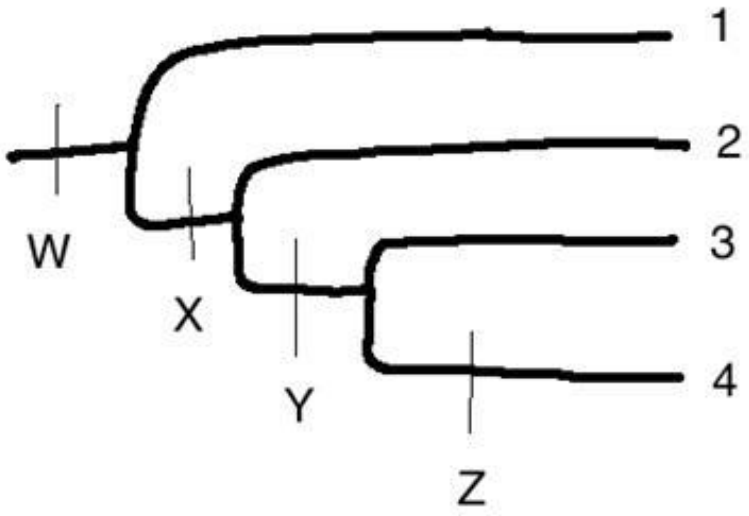
11. Which organism will have DNA most similar to the bird? ____**Crocodiles**_____

12. Which organsism's DNA will differ the most from the bird? _____**Sharks**_____

Name: _____ Date: _____

Bio30: LE2 Evolution **Phylogenetic Trees KEY**

Trait	Snoozle	Bleeker	LooHoo	Floof
Green Skin	yes	yes	yes	yes
Giant eyes	yes	no	yes	yes
Fur	yes	no	yes	no
Suction cup feet	no	no	yes	no



Complete the following labels:

W – Green Skin

X – Giant Eyes

Y – Fur

Z – Suction Cup Feet

1- Bleeker

2- Floof

3- Snoozle

4- LooHoo

Modern Taxonomies Notes
Cladogram ANSWER KEY:

1. __F__ Wings
2. __C__ Six Legs
3. __A__ Segmented Body
4. __G__ Double set of wings
5. __E__ Cerci (abdomenal appendages)
6. __D__ Crushing mouthparts
7. __B__ Legs
8. __H__ Curly Antennae

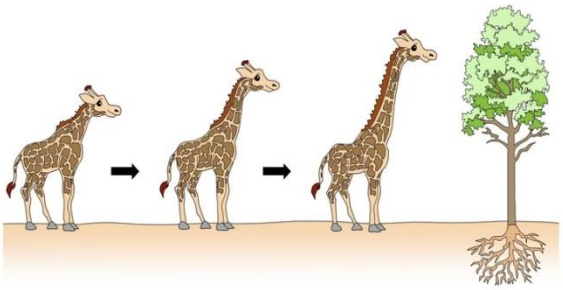
Key Historical Contributions

Various theories have attempted to explain how evolution occurs. Two disagreeing theories of evolution were presented in the 19th century by the French biologist Jean Lamarck and the English scientist Charles Darwin. A similar natural selection theory to Darwin's was also proposed by Wallace. In 1901, De Vries presented his mutation theory of evolution which also supported Darwin's theories of variation & survival of the fittest. As a result, Charles Darwin's theory of Natural Selection is the most widely accepted basis for the theory of evolution at this time.

Jean Baptiste Lamarck (1744-1829)

The Principle of Need - organisms change because of an inner need to change.

Example: Giraffes needed longer necks to reach higher branches because of their competition for food. This caused the giraffes to stretch their necks to reach the leaves.



The Principle of Use & Disuse - use it or lose it. The more you use a characteristic the stronger it gets and vice versa. The less you use it, the weaker it will get & eventually disappear.

Example: Giraffes would have to keep stretching their necks to keep their longer necks. Your little toe and the muscles that move your ears are disappearing because they are not used just as leg bones in snakes such as the boa constrictor.

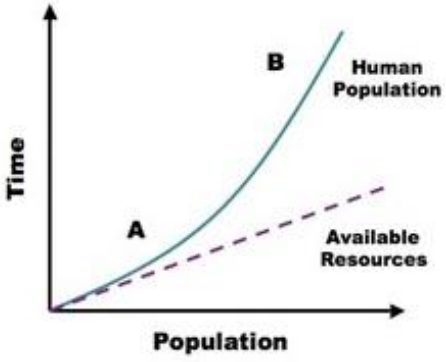
The Principle of Acquired Characteristics - the characteristics that an individual has acquired over its' lifetime would be passed on to its' offspring.

Example: The giraffes that had stretched their necks would pass that acquired trait on to their offspring. As a result, their offspring would be born with long necks. However, trained RCMP dogs DO NOT pass on their acquired characteristics to their offspring nor does cutting off a rat's tail produce tailless rats.

Lamarck believed that the environment could change an organism in order to survive. His theory made sense except for the fact that there is yet to be evidence showing that the acquired characteristics can be passed on by heredity. As a result, Lamarck's theory can still be discredited and unaccepted as the basis for a theory of evolution.

Thomas Robert Malthus (1766-1834)

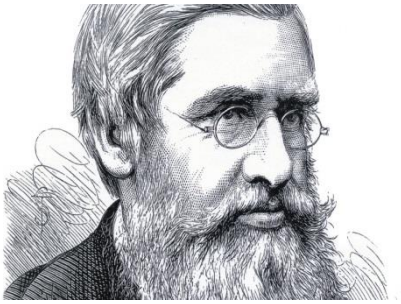
The **Malthusian Dilemma** was proposed by English clergyman, Thomas Malthus, who stated that populations multiply *geometrically*, while food resources only increase *arithmetically*. If left to follow course, a stable population (A) would inevitably outgrow it's resource base (B), leading to mass starvation and resource wars. This phenomenon - that **more offspring are born than will survive to reproduce** - became central to Darwin's understanding of *competition for survival.* The idea that certain traits may be beneficial in such a struggle for survival led to laying the foundation for the concept of evolution via natural selection.



Miss Foley

Bio30: LE2 Evolution **Historical Contributions**

Alfred Russel Wallace: Theory of Natural Selection (1823-1913)

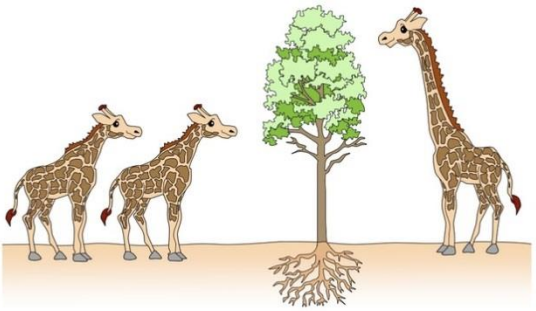


Alfred is famously overshadowed for **jointly publishing the theory of evolution by natural selection with Charles Darwin** in 1858. His pioneering work on evolutionary biogeography (the study of how plants and animals are distributed) led to him becoming recognized as that subject's 'father'. By the time of his death Wallace was probably the world's most famous scientist, but since then his intellectual legacy has been overshadowed by Darwin's. Many of the important contributions made by Darwin's contemporaries, like Wallace, are currently underestimated and undervalued.

Charles Darwin: Theory of Natural Selection (1809-1882)

Darwin's major work over 20 years was shared in his book *On the Origins of Species*, which was published in 1859:

- All organisms produce more offspring than can actually survive.
- Each organism faces a constant struggle to survive. Those who win the struggle survive while the others die.
- The individuals of any given species vary because they inherit different traits.
- The individuals that are best adapted to their environment survive. The "survival of the fittest".
- The organisms that survive pass their favorable traits on to their offspring.



Example: There were many giraffes born, some with short necks and some with longer necks. As the competition for food grew, the giraffes with the longer necks, who had the favorable variation for that environment, could reach the taller branches for food. These giraffes survived and reproduced offspring that had longer necks also. As a result, the giraffes with shorter necks had the unfavorable variation for that environment eventually died off and were unable to reproduce leaving us with giraffes that have long necks.

In this way, **favorable variations pass from generation to generation and collect in a population's gene pool**. Like Lamarck, Darwin believed that the environment was important. Unlike Lamarck, Darwin said that organisms do not change because of a need to survive in their environment. Organisms vary whether they need to or not. Whether a variation is harmful or helpful depends on the environment. It is the environment that determines which organisms have a chance to survive through natural selection.

Alfred Wegener (1880-1930)

Alfred Wegener proposed the **theory of continental drift** – the idea that Earth's continents move. Despite publishing a large body of compelling fossil and rock evidence for his theory between 1912 and 1929, it was rejected by most other scientists. It was only in the 1960s that continental drift finally became part of mainstream science. Today we recognize that Wegener's **ancient continent** actually existed. Its name is the one Wegener gave it – **Pangaea**.

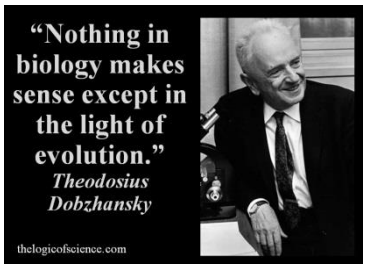
Miss Foley

Bio30: LE2 Evolution

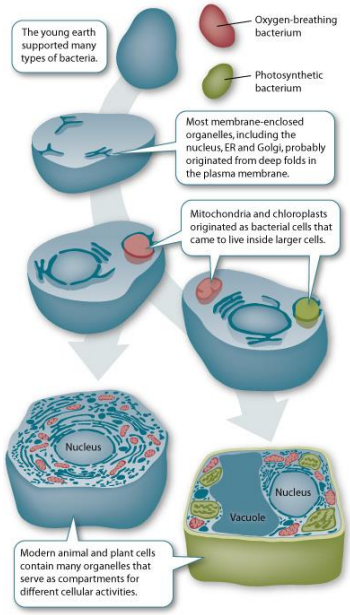
Historical Contributions

Theodosius Dobzhansky (1900-1975)

Dobzhansky's ability to combine genetics and natural history attracted many other biologists to join him in the effort to find a unified explanation of how genetics and Darwin both contribute to evolution. Their combined work, known as "**The Modern Synthesis or Evolutionary Synthesis**," brought together genetics, paleontology, systematics, and many other sciences into one powerful explanation of evolution, showing how mutations and natural selection could produce large-scale evolutionary change. His 1937 book *Genetics and the Origin of Species* was one of the cornerstones of the modern synthesis. The key revelation was that mutation, by creating genetic diversity, supplied the raw material for natural selection to act on. The Modern Synthesis certainly did not bring the study of evolution to an end, but it became the foundation for future research.



Lynn Margulis (1938-2011)



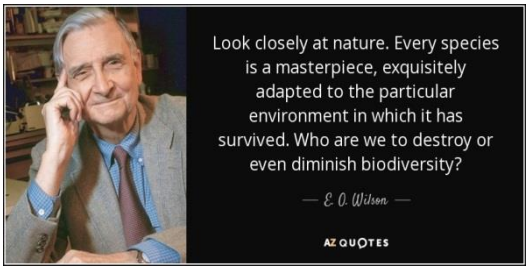
There is compelling evidence that mitochondria and chloroplasts were once primitive bacterial cells. Symbiosis occurs when two different species benefit from living and working together. When one organism actually lives inside the other it's called endosymbiosis. As proposed by Lynn Margulis, the **endosymbiotic theory** describes how a large host cell and ingested bacteria could easily become dependent on one another for survival, resulting in a permanent relationship. Over millions of years of evolution, mitochondria and chloroplasts have become more specialized and today they cannot live outside the cell. This theory was advanced and substantiated with microbiological evidence in 1967.

Stephen Jay Gould (1941-2002)

One of the most influential evolutionary biologists of the 20th century and perhaps the best known since Charles Darwin, Dr. Gould touched off numerous debates, forcing scientists to rethink sometimes entrenched ideas about evolutionary patterns and processes. One of his best known theories, developed with Niles Eldredge, argued that **evolutionary change in the fossil record came in fits and starts** rather than a steady process of slow change. This theory, known as **punctuated equilibrium**, was part of Dr. Gould's work that brought a forsaken paleontological perspective to the evolutionary mainstream.

E. O. Wilson (1929 – Current)

Harvard professor & widely respected entomologist, has been called the "**father of sociobiology**" and the "**father of biodiversity**" for his environmental advocacy. Among his greatest contributions to ecological theory is the **theory of island biogeography**, which was the foundation of the development of conservation area design, as well as the unified neutral theory of biodiversity of Stephen Hubbell. Drawing from his deep knowledge of the Earth's "little creatures" and his sense that their contribution to the planet's ecology is underappreciated, **an intricately interconnected natural system is threatened by man's encroachment**, in a crisis he calls the "sixth extinction" (the fifth one wiped out the dinosaurs).



Historical Contributions

Name: _____ Date: _____

Bio30: LE2 Evolution **What Darwin Never Knew**

What Darwin Never Knew Video (1:54:00) Comprehension Questions

1. What do some scientists, and the narrator, call "the best idea anyone ever had?

2. What 2 occupations was Darwin training for before he sailed on *HMS Beagle*?

3. What was Darwin's first important discovery?

4. What was the importance of tortoises and finches in leading Darwin to believe that species can change over time?

5. What did Darwin notice when looking at human embryos that lead him to believe we had a common ancestor with fish?

6. What evidence of evolution is displayed by the pocket mouse?

Name: _____ Date: _____

Bio30: LE2 Evolution **What Darwin Never Knew**

7. What was determined to be the cause of the color variation in pocket mice?

8. How many genes do humans have?

9. What percent of our DNA does not code for proteins?

10. What is a gene switch? What evidence is there that they exist?

11. What are hox genes?

12. How can hox genes and gene switches control an organisms development when the protein coding genes themselves have not changed?

13. What is Tiktaalik, and why is it important?

Name: _____ Date: _____

What Darwin Never Knew Video (1:54:00) Comprehension Questions

1. What do some scientists, and the narrator, call "the best idea anyone ever had?

2. What 2 occupations was Darwin training for before he sailed on *HMS Beagle*?

3. What was Darwin's first important discovery?

4. What was the importance of tortoises and finches in leading Darwin to believe that species can change over time?

5. What did Darwin notice when looking at human embryos that lead him to believe we had a common ancestor with fish?

6. What evidence of evolution is displayed by the pocket mouse?

Name: _____ Date: _____

Bio30: LE2 Evolution **What Darwin Never Knew KEY**

7. What was determined to be the cause of the color variation in pocket mice?

8. How many genes do humans have?

9. What percent of our DNA does not code for proteins?

10. What is a gene switch? What evidence is there that they exist?

11. What are hox genes?

12. How can hox genes and gene switches control an organisms development when the protein coding genes themselves have not changed?

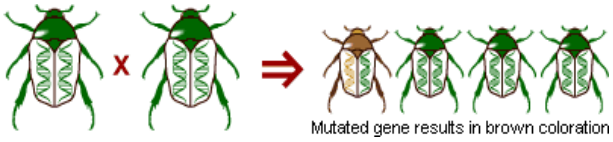
13. What is Tiktaalik, and why is it important?

Microevolution =
any evolutionary change *below* the level of species

Change happens within a group, but the descendant is clearly of the same type as the ancestor. The small **changes occur by recombining existing genetic material within the population** and are often referred to as **variations** or **adaptations**.

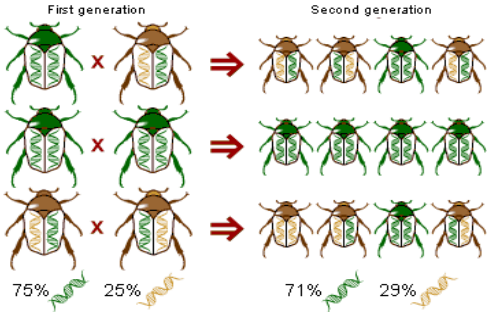
Mechanisms of Microevolution

Imagine that you observe an increase in the frequency of brown coloration genes and a decrease in the frequency of green coloration genes in a beetle population. Any combination of the mechanisms of microevolution might be responsible for the pattern, and part of the scientist's job is to figure out which of these mechanisms caused the change:



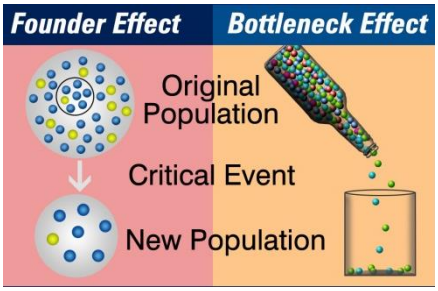
Mutation
Some "green genes" randomly mutated to "brown genes" (although since any particular mutation is rare, this process alone cannot account for a big change in allele frequency over one generation).

Migration (or gene flow)
Some beetles with brown genes immigrated from another population, or some beetles carrying green genes emigrated.

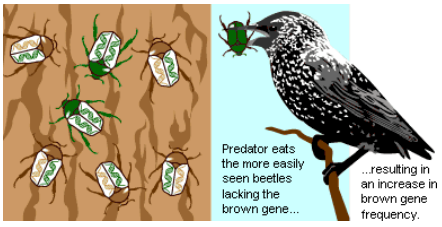


Genetic drift
When the beetles reproduced, just by random luck more brown genes than green genes ended up in the offspring. In the diagram at right, brown genes occur slightly more frequently in the offspring (29%) than in the parent generation (25%). Two impactful ways genetic drift happens:

Bottleneck Effect – results in a drastic reduction in the size of the population. Think of the checkout lines at a store on Black Friday. There are hundreds of people trying to purchase their items, but only so many checkout lines available for people to go through. Natural disasters and human activities are major causes of population bottlenecks. Earthquakes, hurricanes, fires, floods, urban development, logging, and building roads may all kill a large portion of a natural population, leaving a smaller subset behind.



Founders Effect - when a few individuals establish a new population. Here we have a small group leading the way as a new population, which means that there is likely a smaller variety of alleles among them. The founder effect may occur when individuals colonize an island or any other new habitat. Settling new continents, islands, or other areas leads to a decrease in allele variety among many founding human populations because these establishing groups were only a subset of the original population.



Natural selection
Beetles with brown genes escaped predation and survived to reproduce more frequently than beetles with green genes, so that more brown genes got into the next generation.

Selective Pressures =

any reason for organisms with certain phenotypes to have either a survival benefit or disadvantage

Many phenotypic variations are neutral, which means that they don't give organisms a benefit or disadvantage when it comes to survival and reproduction. However, **some phenotypes are either selected for or against by the conditions in which an organism lives**. For example, people that live in places with strong sunlight (i.e. equator) are likelier to survive and reproduce if they have dark skin to protect them from UV damage. In this example, strong sunlight is a selective pressure that favors darker-skinned people; lighter skin would be a disadvantage in these regions.

Selective pressures drive natural selection. Some members of the population will not survive and reproduce and, thus, will not pass on their genes into the next generation. Gradually, the population changes, and genes that improve survival and reproduction will become more common, while genes that are disadvantageous to survival and reproduction will become rarer.

Selective pressures can take many forms including:

1. **Resource Availability**: competition for food, habitat & reproductive mates
2. **Environmental Conditions:** Temperature, weather, pollution or geographical access
3. **Biological Factors**: Predators, parasitism, pathogens (disease-causing organisms) & disease

Density Dependent Factors
Predators
Availability of resources (e.g. shelter, water)
Nutrient supply (i.e. food source)
Disease / pathogenic spread
Accumulation of wastes

Density Independent Factors
Phenomena (e.g. natural disasters)
Abiotic factors (e.g. temperature, CO_2 levels)
Weather conditions (e.g. floods, storms, etc.)

Mnemonic: PANDA PAW

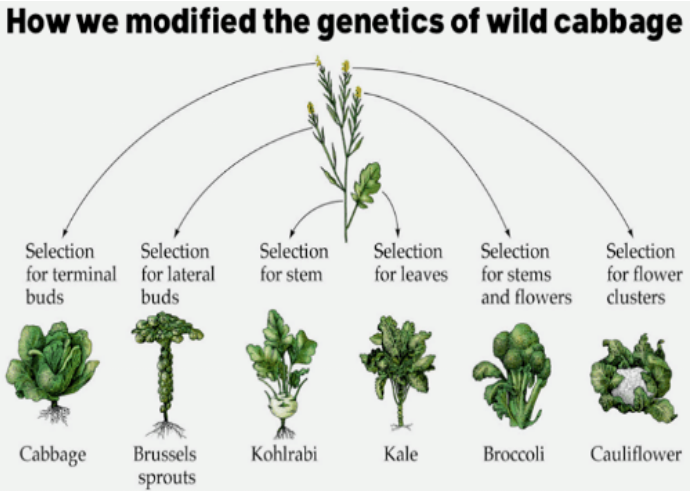
Climate - In a cold climate, animals need certain characteristics to survive, like a warm furry coat, the ability to make burrows to live in and the ability to collect and store food for the winter. The selective pressure of cold weather means that animals that don't have these characteristics are less likely to survive and reproduce. In a hot, dry climate, plants will have an advantage if they have phenotypes such as the ability to store water, large root systems to absorb what little water is in the soil and, perhaps, ways to prevent water loss even at high temperatures.

Food & Energy Sources - In a dense rainforest, plants on the forest floor will survive & reproduce better if they are able to gather as much light as possible, perhaps by having very large leaves. Thus, light availability can be a selective pressure for plants. Food acquisition is also a selective pressure. For example, sharp teeth and the ability to hunt prey are advantages for carnivores.

Predation - carnivores are a selective pressure for their prey. Animals that have sharp eyesight, are poisonous to their predators, can run very fast or can camouflage themselves or hide from predators will be likelier to survive and reproduce than animals without these phenotypes.

Diseases - One well-known example is the sickle cell trait in humans, caused by having one copy of the mutated hemoglobin allele that causes sickle cell anemia. People that have two copies of this mutated allele are likely to die of anemia at a young age, so you'd think that the allele would be strongly selected against, right? However, people with only one copy of the sickle cell allele have a survival advantage in malarial regions because they are more resistant to malaria. Scientists don't yet know exactly why they are more resistant, but in these regions, malaria is a selective pressure that keeps the sickle cell allele circulating in the population.

Now, let's put ourselves in the pathogens' shoes. For microbes such as the malaria parasite, as well as many other bacteria, viruses, and fungi, animals' **immune systems** are a major selective pressure. Pathogens that have phenotypes that increase their resistance to immune defenses are likelier to replicate and go on to infect another host. This leads pathogens to evolve very interesting abilities, such as disguising themselves from the immune system by changing their outer coats, or even hijacking our immune cells to make them into comfortable places to live.



Direct Human Influence - For hundreds and perhaps thousands of years, people have been domesticating and breeding animals and plants. Choosing organisms with specific phenotypes and allowing them to reproduce passing on their genetic material means that human manipulation is a selective pressure leading to **artificial selection**.

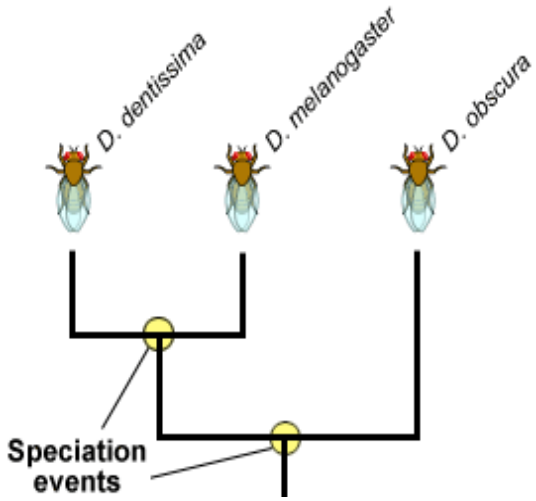
Selective Pressure and Reproduction

One very important concept about selective pressure is that it must occur before reproduction in order to have any effect on the population. Many selective pressures are present throughout an organism's life, such as predators and other threats in the environment, diseases that are common in a population, and things that an organism must be able to do to survive and reproduce.

However, some selective pressures appear suddenly in an organism's life; for example, climate changes or pesticide treatment. What's more, some beneficial or detrimental phenotypes appear later in an organism's life. In order for genetic traits to be selected for or against, the selective pressure has to be there before the organism reproduces.

Macroevolution =
any evolutionary change
at or above the level of species

Macroevolution results in the origin of new types of organisms from previously existing, but different, ancestral types. Examples of this would be terrestrial plants descending from colonial algae, fish descending from an invertebrate animal, or whales descending from a land mammal. **Two central ideas** to evolution is that **life has a history**, and that **there is a common ancestor for all species**. We can't always see what is happening at this level because it is happening so slowly, but we can look to geology, fossils, and living organisms to determine what has occurred over time. The patterns of evolution help explain what has happened with the gene pool of different creatures over time. For example, rather than focusing on genetic variations within a single species of reptile, we might focus on reptiles in general and study why they arose in the first place.



Speciation =
a lineage-splitting event that produces two or more separate species

Imagine that you are looking at a tip of the tree of life that constitutes a species of fruit fly. Move down the phylogeny to where your fruit fly twig is connected to the rest of the tree. That branching point, and every other branching point on the tree, is a **speciation event**. At that point genetic changes resulted in two separate fruit fly lineages, where previously there had just been one lineage.

Sympatric Speciation =
speciation without physical separation/barriers
(rare form of speciation)

"Sym" = together & "patris" = country

This is a relatively uncommon form of speciation, though it has been observed in hawthorn flies and orcas. The divergence of the two species living in the same area without separation/barriers will generally take place over a long period of time, and it can be the effect of differences in things such as diet, behavior and mate selection. Eventually, if mating no longer occurs between populations and there is a variation in their gene pool, sympatric speciation has occurred.

Allopatric =
speciation via physical separation/barriers
(most common form of speciation)

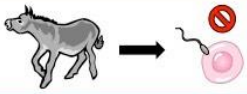
"Allo" = different & "patris" = country

PRE-Zygotic Barriers/Mechanisms *(Before fertilization)*:

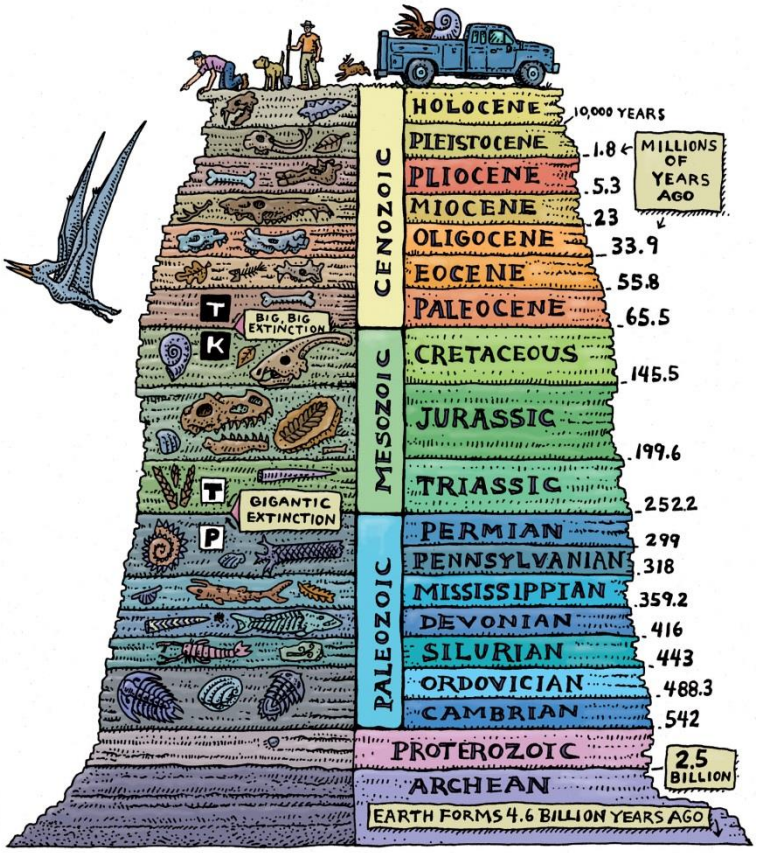
1. **Geographic Isolation** – The same species occurs in different areas, separated by a physical barrier, such as a mountain range, canyon or body of water
2. **Ecological Isolation** - The same species inhabits and mates in different habitats; for example, one group lives in trees and the other on the ground, and they rarely interact
3. **Reproductive Isolation** – Two groups of animals live close enough to one another to interact but are unable to interbreed with one another.
4. **Temporal Isolation** - Groups within the same species do not mate because they are active at different times of day or have different mating seasons or times.
5. ***Behavioral Isolation*** - Potential mates meet but choose members of their own species.
6. **Mechanical Isolation** - Animals actually try to mate, but are physically unable.

POST-Zygotic Barriers/Mechanisms *(After fertilization)*:

1. **Incompatible Gametes** – Sperm transfer takes place, but egg is not fertilized.
2. **Zygote Mortality** - Egg is fertilized, but zygote does not develop.
3. **Inviable Offspring** – Embryo forms but is inviable (offspring that doesn't thrive).
4. **Sterile Offspring** – Embryo is viable (offspring that thrives) but resulting adult is sterile.
5. ***Hybrid Breakdown*** - First generation (F1) hybrids are viable and fertile, but further hybrid generations (F2 and backcrosses) may be inviable or sterile.

Pre-zygotic Isolating Mechanisms		Example	
Temporal	Occurs when two species mate at different times of year	Frogs live in same pond but breed during different seasons (summer vs spring)	
Ecological	Occurs when two species occupy different habitats	Lions and tigers can potentially interbreed, but usually occupy different habitats	
Behavioural	Occurs when two species have different courtship behaviours	Certain groups of birds will only respond to species-specific mating calls	
Mechanical	Occurs when physical differences prevent copulation / pollination	Certain breeds of dog are morphologically incapable of mating due to size	
Post-zygotic Isolating Mechanisms		**Examples**	
Hybrid Inviability	Hybrids are produced but fail to develop to reproductive maturity	Certain types of frogs form hybrid tadpoles that die before they can become a frog	
Hybrid Infertility	Hybrids fail to produce functional gametes (sterility)	Mules are sterile hybrids resulting from mating between a horse and a donkey	
Hybrid Breakdown	F_1 hybrids are fertile, but F_2 generation fails to develop properly	The offspring of hybrid copepods have less potential for survival or reproduction	

Evidence of Macroevolution



There are no firsthand accounts of when the first reptile or the first mammal arrived. Evidence of macroevolution is obtained through the study of fossils, geologic data, and modern organisms. Here we see what's called a **geologic column**, an illustration that depicts the history of life on Earth.

In geology, older layers of sedimentary rock tend to be found deeper underground. This is because they were laid down first and then covered up by additional layers. So the deeper we dig, the older things tend to get. Now, let's connect that concept to fossils.

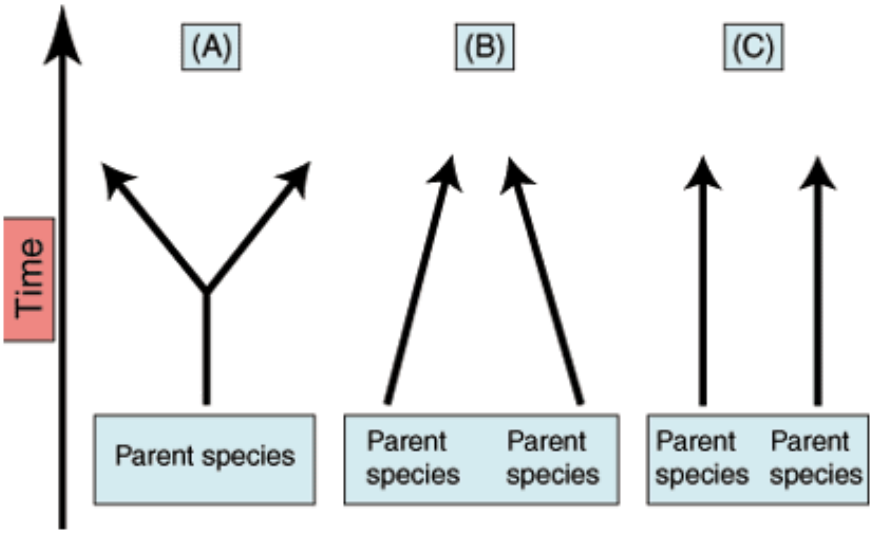
Suppose we dug down through our geologic column and discovered the fossil of a mammal somewhere near the top. Let's also say there were no other mammal fossils anywhere below that point, but there were reptile fossils. What does this tell us? It tells us that reptiles came before mammals because reptile fossils were found in older layers of rock.

Patterns of Macroevolution

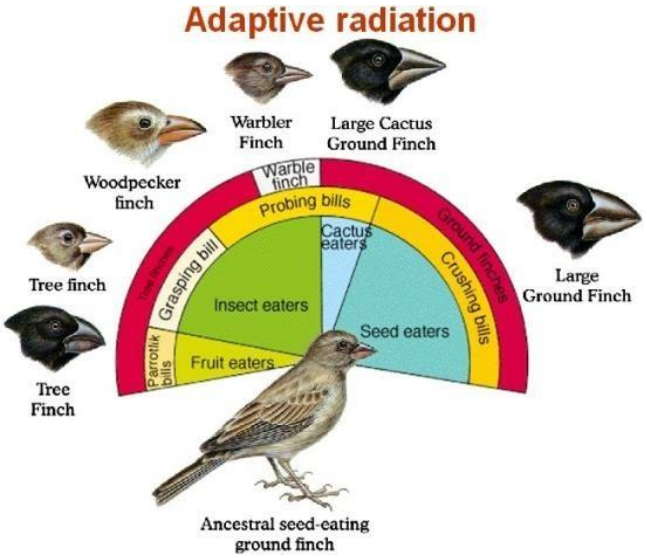
Divergent (A)

Convergent (B)

Coevolution (C)



Divergent Evolution (Diagram A) - members of a species become more and more different, eventually resulting in two (or more) new species.



Adaptive radiation is a type of divergent evolution where a group of organisms quickly diverges into new species - when you hear the word 'quickly' think like 500,000 years or more. This process gets the name 'radiation' because new species radiate from a common ancestor. This tends to occur when organisms move into a new environment with a lot of available opportunities.

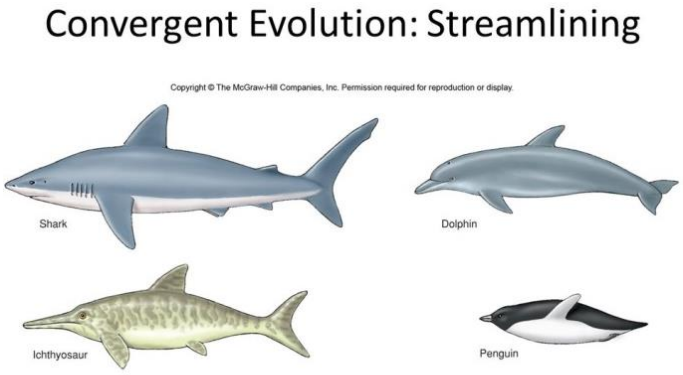
Example: On the Galapagos Islands, there are many species of finch. When Charles Darwin visited the Galapagos, he noted that the islands' finches looked a lot alike, yet some had key differences like the size and shape of their beaks. As the population of finches encountered each new island, those best suited to eat the food on that island would survive and reproduce. The common ancestor of the finches underwent adaptive radiation, with several new species developing. For example, on one island where seeds were plentiful, the finches that had the beaks best suited for seed eating survived and reproduced. On another island, the finches best suited for insect eating survived and reproduced. In the end, there were many new finch species, each with slightly different beaks.

Convergent Evolution (Diagram B) - unrelated organisms evolve similar characteristics due to similar environmental pressures.

The word 'converge' means to come together, so two unrelated organisms 'come together' to have similarities due to environmental pressures. Many species have similar traits because they are descendants of a single common ancestor. These traits they share are known as **homologous structures**. Species may have similar traits even though they are not related to each other. This usually results because the species live in similar environments and fill similar ecological roles. The structures in this case are known as **analogous structures**. The process that brings these traits forward is called convergent evolution.

Examples:

An example of a trait derived through convergent evolution is flippers. Animals, such as seals and penguins, both have flippers to help them navigate through their aquatic environments. Because the seal is a mammal and the penguin is a bird, it is clear that the flipper evolved in these very different species because it was the best functional feature for the environment they inhabited instead of from a common ancestor.



Convergent evolution is the process by which unrelated species evolve similar physical characteristics because they have similar lifestyles

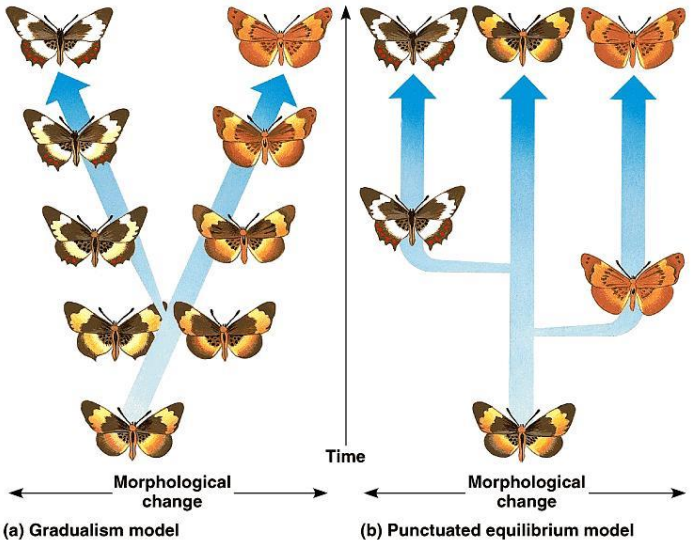
Coevolution (Diagram C) - when one species develops an evolutionary advantage, it triggers a change in a closely associated species. This change may then cause another evolutionary change in the first species.

Coevolution can be mutualistic or competitive. In **mutualistic coevolution**, two species that benefit from each other evolve together. In **competitive coevolution**, prey will evolve traits to prevent being eaten, and predators will then evolve to be able to eat their prey. This type of interaction is also called an **evolutionary arms race**. Competitive coevolution can also take place between hosts and parasites. Hosts evolve to prevent attack from parasites, and parasites evolve to gain something from a host.

Punctuated Equilibrium – hypothesis stating that organisms are in **stasis** (holding pattern of no change) until a major change causes evolutionary pressures, which result in a **rapid burst of speciation** until stasis is again reached.

Species spend most of their generations in stasis - not needing to change because the environment is stable. But every once in a while, a major change comes along, and those life forms affected by that change evolve into something new or die out completely.

This change happens relatively rapidly in terms of geologic time, so we end up seeing a whole bunch of new species within a few thousand years and then millions of years of very little change. Each short burst of change is the 'punctuated' portion, while years of stasis are the 'equilibrium' portion of the hypothesis.



Graduated Equilibrium - selection and variation that happens gradually over long periods of time.

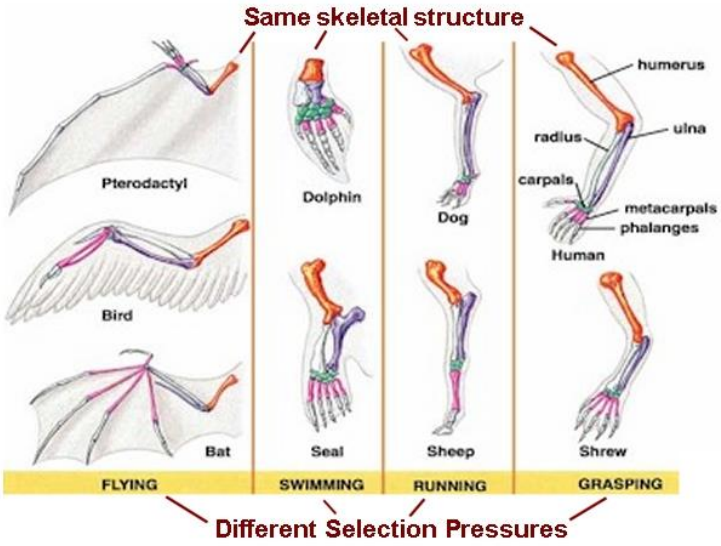
Over a short period of time it is hard to notice. Small variations that fit an organism slightly better to its environment are selected for: a few more individuals with more of the helpful trait survive, and a few more with less of the helpful trait die. Change is slow, constant, and consistent.

Extinctions - To say that an organism is extinct means that it is no longer living anywhere on the planet. There are two types of extinction:

1) **Background Extinction** - the natural rate of extinction
2) **Mass Extinction** - a widespread event that wipes out the majority (over 50%) of living plants and animals. The last mass extinction event was about 65 million years ago, and it was the event that wiped out the dinosaurs.

Homologous Structures =

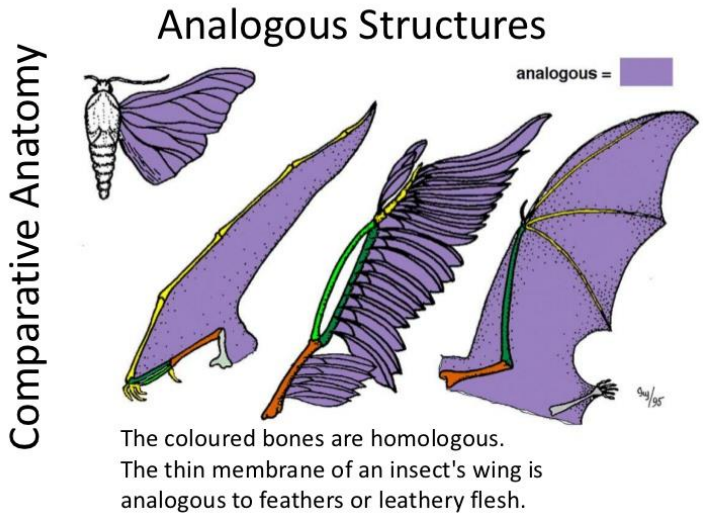
similar structures that develop similarly but serve different functions



Different niches (jobs) develop due to variations in the population that accumulated over time and served as adaptions due to selective pressures.

In this picture, there is a homologous structure in all four individuals most likely because they all have a common ancestor and over time have evolved from their ancestor to carry out different functions.

Plant Examples: Succulent Leaves, Leaves, Colored Leaves, Tendrils, Spines



Analogous Structures =

similar structures that developed differently to serve the same function

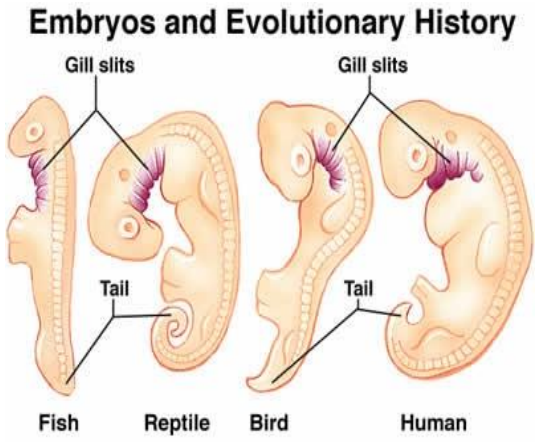
Different niches (jobs) develop due to variations in the population that accumulated

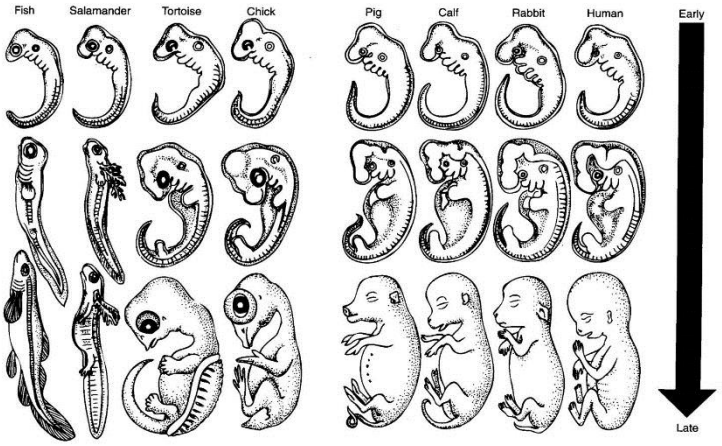
Analogous structures are examples of convergent evolution, where two organisms separately have to solve the same evolutionary problem – such as staying hidden, flying, swimming, or conserving water – in similar ways. The result is similar body structures that developed independently.

In the case of analogous structures, the structures are not the same, and were not inherited from the same ancestor. But they look similar and serve a similar purpose.

Comparative Embryology =

similar development of embryos in closely related species

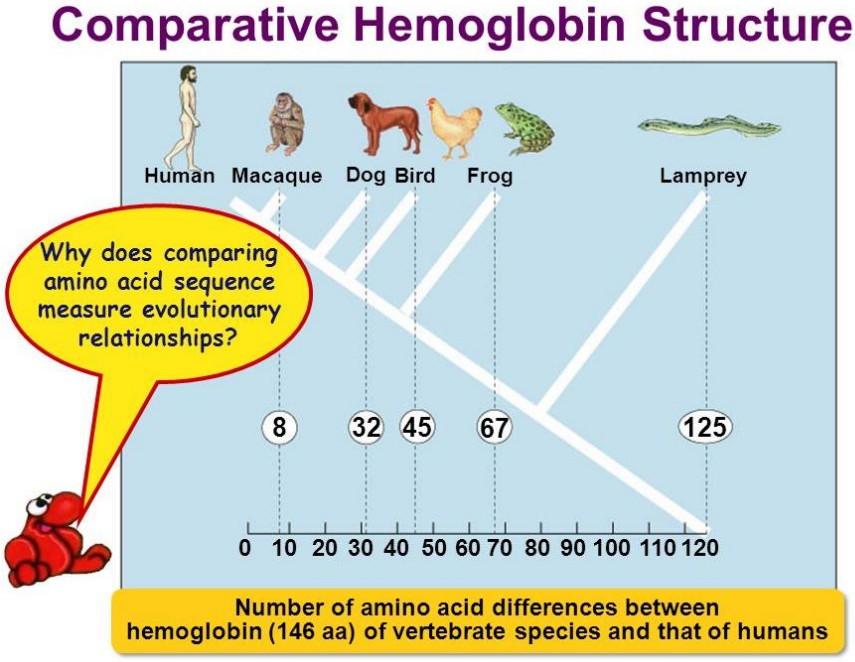




At different stages of development, there are similar structures that exist in vertebrate embryos. In the individuals above, there is a gill pouch present in each vertebrate. However, that does not mean that humans have gills because we don't. It is really thyroid glands, not gills that is in humans. Comparative embryology shows species with similar ancestors.

Molecular Record =

comparing DNA and protein structures



All organisms have DNA and RNA. The genetic code sequences are more similar in species that are closely related than those that are distantly related.

The further apart species are, the more protein structure changes. DNA changes as protein structure changes because of agents such as mutation.

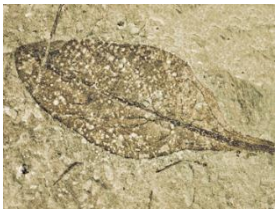
Fossils =
remains and traces of ancient once-living organisms

To qualify as a fossil, a specimen usually must be more than 10,000 years old. Out of all the millions of species that evolved and lived on this planet since life first began 3.5 billion years ago—out of all the billions upon billions of individual organisms—very few have been preserved as fossils.

To become fossilized, plant or animal remains must be rapidly buried. Organisms that lack hard body parts, such as bones, scales, teeth or shells, are rarely preserved. Soft body parts such as skin, muscle tissue and organs decompose rapidly and are often consumed by predators before fossilization can take place.

Replacement
When an entire organic structure decays and ground water minerals replace it, making an exact stone copy of the original.

Permineralization
When ground water seeps into tiny holes or pores of the hard remains of plants or animals leaving behind deposits of minerals such as silica or calcite. The mineral deposits fill the spaces and make the fossil heavier and more resistant to erosion. With this type of fossilization, you can easily see the internal structure of the original material. Most fossils in Dinosaur Provincial Park are preserved in this manner.



Carbonization
When a plant or animal dies and is buried by sediment, hydrogen and oxygen are eliminated and a carbon etching results. Plant leaves are often fossilized in this manner.

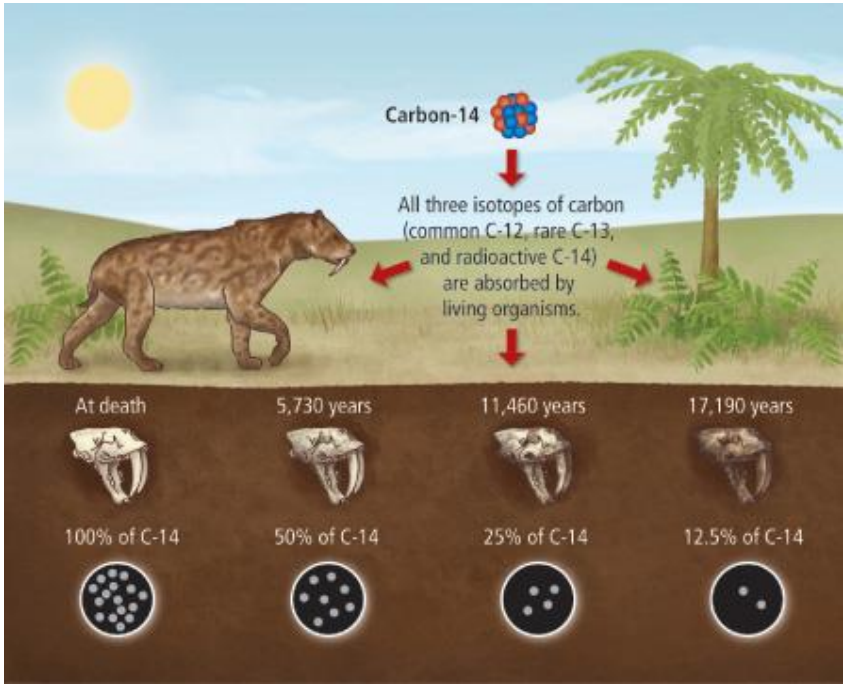
Natural Molds & Casts
Whenever an animal or plant is buried in soft sediment and later disintegrates, the impression it leaves behind is called a natural mold. When mud or other material fills the mold, a natural cast is created.

Trace Fossils
These fossils are not of the actual animal or plant, but rather an indication of its existence or activity. Examples include footprints, skin impressions, coprolites (fossil dung), gastroliths (gizzard stones) and burrows.

Radioactive Dating

Many chemical elements in rock exist in a number of slightly different forms, known as **isotopes**. Certain isotopes are unstable and undergo a process of radioactive decay, slowly and steadily transforming - molecule by molecule - into a different isotope. This rate of decay is constant for a given isotope, and the time it takes for one-half of a particular isotope to decay is its radioactive half-life. For example, about 1.5 percent of a quantity of Uranium 238 will decay to lead every 100 million years. By measuring the ratio of lead to uranium in a rock sample, its age can be determined. Using this technique, called **radiometric dating**, scientists are able to "see" back in time.

Carbon-14 has a half-life of only about 5700 years, but it is continually regenerated by the action of cosmic rays in our upper atmosphere so it is always present in trace amounts.



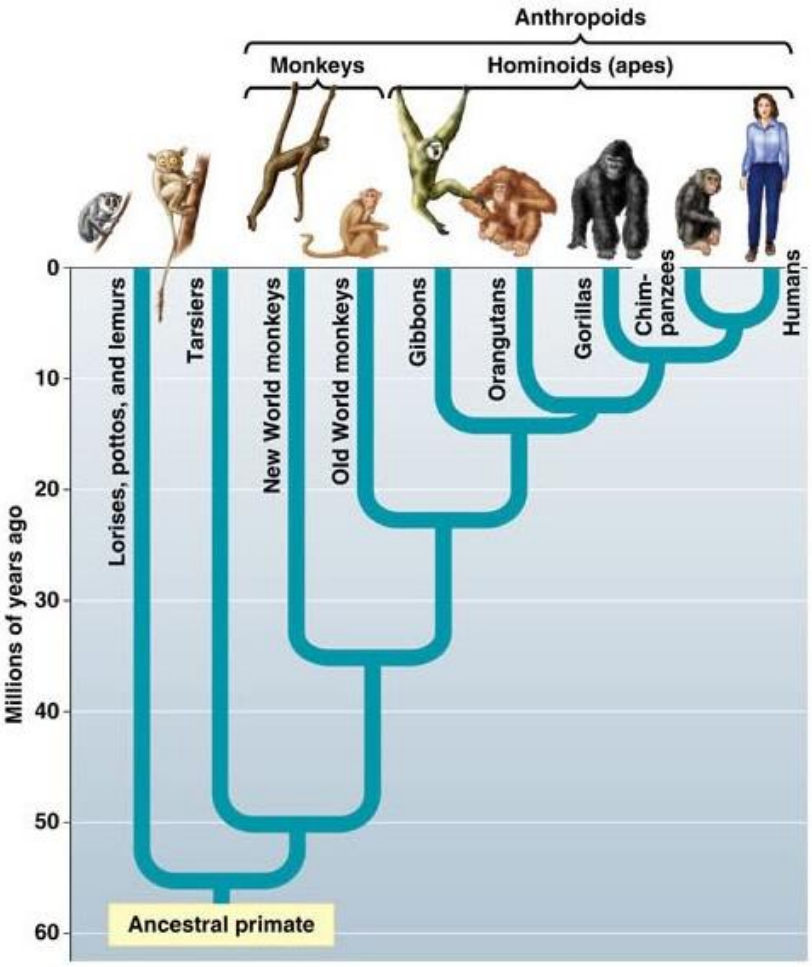
The carbon-14 cycles down to the surface of the Earth relatively quickly, then organisms ingest it along with other carbon. The balance between ingesting fresh material with the radioactive decay of carbon-14 keeps the carbon-14 concentration at a more or less steady value.

But when the organism dies (or when part of the organic material is cut away, as in picking an apple from a tree), no more material comes in and the carbon-14 concentration in the organic matter decreases with radioactive decay.

Scientists can then measure the decrease in carbon-14 an organism has experienced. If the organic matter is observed to have half the expected steady-state value of carbon-14, then (we estimate) one half-life (about 5700 years) has passed since the organism was alive. If one-eighth (1/2 times 1/2 times 1/2) of the steady-state value is found, then three half-lives or about 17,000 years have elapsed.

Carbon-14 or radiocarbon dating, as the technique is called, is accurate up to 50,000 years, or with special sample preparation methods the range can be extended up to 75,000 years.

Primate Comparisons



Many cognitive scientists believe that humans' ability to innovate by varying syntax engenders much of the richness and complexity of our thoughts and ideas. This gulf between humans and our nearest primate relatives is but one of many.

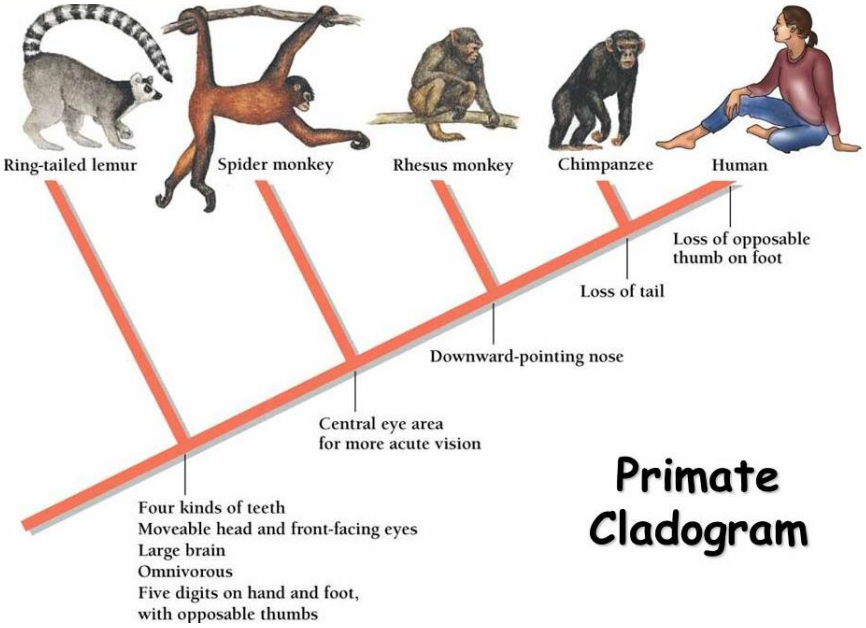
Stance

Humans are bipedal, and except for short bouts of uprightness, great apes walk on all fours. It's a profound disparity.

Kevin Hunt, director of the Human Origins and Primate Evolution Lab at Indiana University, thinks humans' ancestors stood upright in order to reach vegetation in low-hanging tree branches. "When Africa started getting drier about 6.5 million years ago, our ancestors were stuck in the east part, where the habitat became driest," Hunt told Life's Little Mysteries. "Trees in dry habitats are shorter and different than trees in forests: In those dry habitats, if you stand up next to a 6-foot-tall tree, you can reach food. In the forest if you stand up, you're 2 feet closer to a tree that's 100 feet tall and it doesn't do you the least bit of good."

Thus, our ancestors stood up in the scrubby, dry areas of Africa. Chimps in the forests did not.

Charles Darwin was the first to figure it out why the simple act of standing up made all the difference in separating man from ape. One word: tools. "Once we became bipedal, we had hands to carry tools around. We started doing that only 1.5 million years a
fter we became bipedal," Hunt explained. Give it a couple million years and we turned those chipped stones into iPads.



Strength

According to Hunt, if you shave a chimp and take a photo of its body from the neck to the waist, "at first glance you wouldn't really notice that it isn't human." The two species' musculature is extremely similar, but somehow, pound-for-pound, chimps are between two and three times stronger than humans. "Even if we worked out for 12 hours a day like they do, we wouldn't be nearly as strong," Hunt said.

Once, in an African forest, Hunt watched an 85-pound female chimp snap branches off an aptly-named ironwood tree with her fingertips. It took Hunt two hands and all the strength he could muster to snap an equally thick branch.

No one knows where chimps get all that extra power. "Some of their muscle arrangement is different — the attachment points of their muscles are arranged for power rather than speed," Hunt said. "It may be that that's all there is to it, but those who study chimp anatomy are shocked that they can get that much more power out of subtle changes in muscle attachment points."

Alternatively, their muscle fibers may be denser, or there may be physiochemical advantages in the way they contract. Whatever the case may be, the outcome is clear: "If a chimp throws a big rock and you go over and try to throw it, you just can't," Hunt said.

Conversation

Herb Terrace, the primate cognition scientist who led Project Nim, thinks chimps lack a "theory of mind": They cannot infer the mental state of another individual, whether they are happy, sad, angry, interested in some goal, in love, jealous or otherwise. Though chimps are very proficient at reading body language, Terrace explained, they cannot contemplate another being's state of mind when there is no body language. "I believe that a theory of mind was the big breakthrough by our ancestors," he wrote in an email.

Why does he think that? It goes back to Nim the signing chimp's linguistic skills. Like an infant human, Nim spoke in "imperative mode," demanding things he wanted. But infantile demands aren't really the hallmark of language. As humans grow older, unlike chimps, we develop a much richer form of communication: "declarative mode."

"Declarative language is based on conversational exchanges between a speaker and a listener for the purpose of exchanging information," Terrace wrote. "It is maintained by secondary rewards such as 'thank you,' 'that's very interesting,' 'glad you mentioned that.' In the case of declarative language, a theory of mind is clearly necessary. If the speaker and the listener could not assume that their conversational partners had a theory of mind there would be no reason for them to talk to each other. Why bother if there is no expectation that your audience would understand what you said?"

He added, "I know of no example of a conversation by non-human animals." This limitation, perhaps more than any other, prevents a series of events like that in the new film "Rise of the Planet of the Apes." In the film, chimps learn sign language — a realistic scenario. But it's a stretch to imagine them using their new skill to discuss and plan a world takeover.

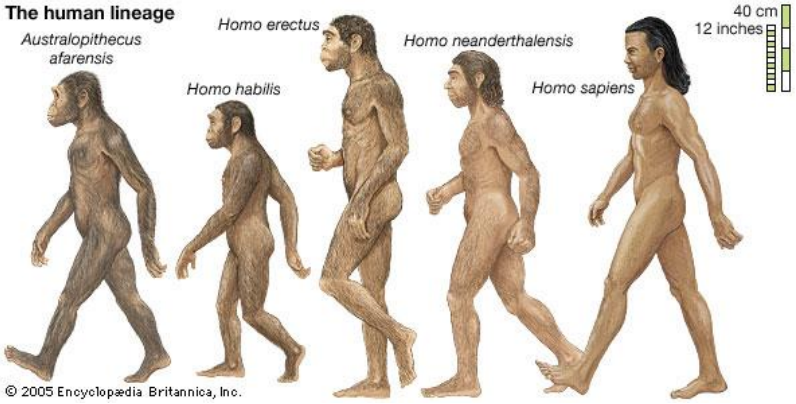
Genes

The chimpanzee genome was sequenced for the first time in 2005. It was found to differ from the human genome with which it was compared, nucleotide-for-nucleotide, by about 1.23 percent. This amounts to about 40 million differences in our DNA, half of which likely resulted from mutations in the human ancestral line and half in the chimp line since the two species diverged.

From those mutations come the dramatic differences in the species that we see today — differences in intelligence, anatomy, lifestyle and, not least, success at colonizing the planet.

Source: http://www.livescience.com/15297-chimps-humans.html

Out of Africa Hypothesis

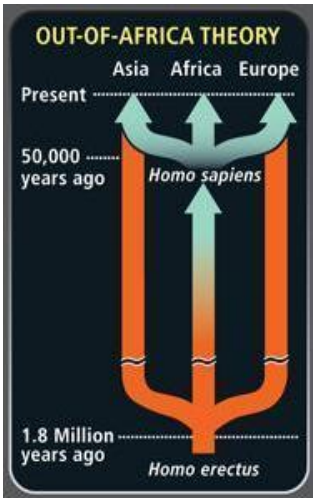


Lucy is the common name of an Australopithecus afarensis specimen discovered in 1974 in Ethiopia. Lucy is estimated to have lived 3.2 million years ago.

Around 30,000 years ago humans were anatomically and behaviorally similar throughout the world. One of the most hotly debated issues in paleoanthropology (the study of human origins) focuses on the origins of modern humans, *Homo sapiens*. 100,000 years ago, the Old World was occupied by a morphologically diverse group of hominids. In Africa and the Middle East there was *Homo sapiens*; in Asia, *Homo erectus*; and in Europe, *Homo neanderthalensis*. However, by 30,000 years ago this taxonomic diversity vanished and humans everywhere had evolved into the anatomically and behaviorally modern form. The nature of this transformation is the focus of great deliberation between two schools of thought: one that stresses multiregional continuity and the other that suggests a single origin for modern humans.

Multiregional Theory = *Homo erectus* left Africa 2 mya to become *Homo sapiens* in different parts of the world.

- The Multiregional Continuity Model contends that after *Homo erectus* left Africa and dispersed into other portions of the Old World, regional populations slowly evolved into modern humans. This model contains the following components:
- some level of gene flow between geographically separated populations prevented speciation, after the dispersal all living humans derive from the species *Homo erectus* that left Africa nearly two million-years-ago
- natural selection in regional populations, ever since their original dispersal, is responsible for the regional variants (sometimes called races) we see today
- the emergence of *Homo sapiens* was not restricted to any one area, but was a phenomenon that occurred throughout the entire geographic range where humans lived.
- In contrast, the Out of Africa Model asserts that modern humans evolved relatively recently in Africa, migrated into Eurasia and replaced all populations which had descended from *Homo erectus*.



Out of Africa Theory = *Homo sapiens* arose in Africa and migrated to other parts of the world to replace other hominid species, including *Homo erectus*.

- after *Homo erectus* migrated out of Africa the different populations became reproductively isolated, evolving independently, and in some cases like the Neanderthals, into separate species
- *Homo sapiens* arose in one place, probably Africa (geographically this includes the Middle East)
- *Homo sapiens* ultimately migrated out of Africa and replaced all other human populations, without interbreeding modern human variation is a relatively recent phenomenon

The multiregional view posits that genes from all human populations of the Old World flowed between different regions and by mixing together, contributed to what we see today as fully modern humans. The Out of Africa hypothesis suggests that the genes in fully modern humans all came out of Africa. As these peoples migrated they replaced all other human populations with little or no interbreeding.

Out of Africa Hypothesis: Did All Humans Evolve in Africa?

What Do the Discoveries of Neanderthal and Denisovan DNA in Us Mean?

By K. Kris Hirst - Archaeology Expert *Updated April 22, 2016*

The **Out of Africa** or **African Replacement Hypothesis** is a well-supported theory that argues that every living human being is descended from a small group in Africa, who then dispersed into the wider world displacing earlier forms such as Neanderthal and Denisovans. Early major proponents of this theory were led by Chris Stringer. The Out-of-Africa theory was bolstered in the early 1990s by research on mitochondrial DNA studies by Allan Wilson and Rebecca Cann which suggested that all humans ultimately descended from one female: the Mitochondrial Eve.

Today, the vast majority of scholars have accepted that human beings evolved in Africa and migrated out; recent evidence has shown that happened in multiple waves. The number and timing of the waves is still being debated.

Leaving Africa

Scholars largely agree that our modern species (*Homo sapiens*) originated in east Africa by 195-160,000 years ago. The earliest known pathway Out of Africa probably occurred between Marine Isotope Stage 5e, or between 130,000-115,000 years ago, along the Nile Corridor and into the Levant, evidenced by Middle Paleolithic sites at Qazfeh and Skhul. That migration (sometimes confusingly called "Out of Africa 2" because it was discovered more recently than the next) is generally regarded as a "failed dispersal", because only a handful of Homo sapiens sites have been identified as being this old outside of Africa. However, fossil evidence of any kind this old is pretty rare and it may be too early to completely rule that out.

A later pulse from northern Africa, which was recognized at least thirty years ago, occurred from about 65-40,000 years ago [MIS 4 or early 3], through Arabia: that one, scholars believe, eventually led to the human colonization of Europe and Asia, and the eventual replacement of Neanderthals in Europe.

The fact that these two pulses occurred in the past are largely undebated today. A third, and increasingly convincing, human migration is the southern dispersal hypothesis, which argues that an additional wave of colonization occurred between those two better-known pulses. Growing archaeological and genetic evidence supports the existence of this earlier southern route into South Asia.

Denisovans, Neanderthals and Us

Over the past decade or so, evidence has been piling up that although pretty much all paleontologists agree that humans did evolve in Africa and move out from there, we did meet other human species--specifically Denisovans and Neanderthals--as we moved out into the world. All living humans are still one species--but it is now undeniable that we share differing levels of admixture of species which developed and died out in Eurasia. Those species are no longer with us--except as tiny pieces of DNA.

The paleontological community is still somewhat divided on what that means to this ancient debate: John Hawks (2010) argues "we are all multiregionalists now"; but Chris Stringer recently (2014) disagreed: "we are all out-of-Africanists who accept some multi-regional contributions".

Source: http://archaeology.about.com/od/oterms/g/outofafrica.htm

New Research Reveals Effects Of The Agricultural Revolution On Human Evolution

By Philip Guelpa 15 January 2016

Humans are "**artificial apes**," as one modern anthropologist put it, highlighting the role of technology in the development of human society. From the earliest beginnings of humanity, technological innovation and biological evolution have been dialectically linked in an intricate web of reciprocal determination.

Selective pressures triggered by the development of tools and other aspects of culture have prompted biological changes, not only in obvious features such as the hand and the brain, but in many other human physical characteristics. At the same time, biological changes, such as the elaboration of brain architecture (permitting increasingly sophisticated abstract thought) and increased manual dexterity (e.g., the fully opposable thumb and other changes in wrist and hand bones) have facilitated and promoted cultural innovation. Several recently published scientific articles elucidate this complex process.

The development of agriculture (the domestication of select plants and animals) was the most profound cultural innovation that humans have accomplished since the initial development of tools. Evidence of domestication begins to appear in the archeological record following the end of the last Ice Age (the end of the Pleistocene, roughly 10,000-12,000 years ago), though the process may have begun earlier, at least in some areas.

During the great majority of human existence, even if we only count the span of modern humans (dating back 200,000 years at most), people lived off naturally occurring resources, by hunting animals and gathering plant foods. This economic system is generally known as hunting and gathering or foraging. The independent development of agriculture more or less simultaneously (compared to the time frame of human existence) in a number of regions of the world, was a truly revolutionary change, and strongly suggests that some global process was at work. While much remains to be learned about the mechanisms that accomplished this change, the consequences were many and varied.

Stages in the domestication of maize (corn), wild precursor at top, fully domesticated on bottom.

The most significant among these was the ability to produce a surplus of food beyond the immediate needs of daily subsistence. Some hunter-gatherer groups, such as those harvesting large annual fish runs on the northwest coast of North America, could amass and store food surpluses, but the quantities were limited by the natural abundance, timing, and geographic location of the resource, which could not be manipulated. By contrast, plant and animal husbandry, the care and controlled breeding of selected species, led to genetic changes that allowed greater yields and increased the geographic ranges across which the domesticated species could be grown, among other changes, thus greatly expanding the potential food resources available to humans.

These developments produced a revolution in human life. Most notably, the increase in abundance and reliability of food allowed human groups increased sedentism. Communities that had hitherto been relatively small in size and forced to make seasonal moves across the landscape to follow the shifting availability of naturally occurring resources could now stay in

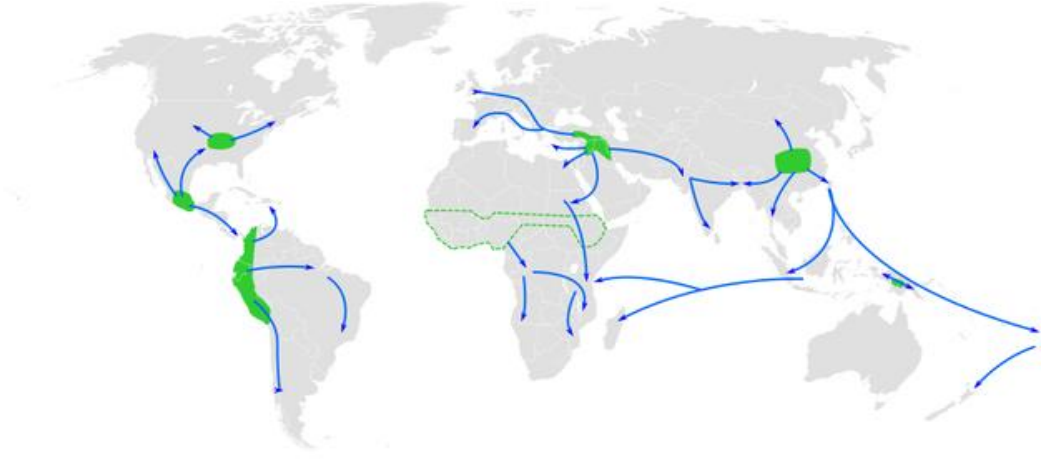
one place for long periods and grow in population size. In turn, this permitted the elaboration of the division of labor. Specialization further promoted technological innovation. And, while some limited social stratification existed among certain hunter-gatherers (like the native peoples of the northwest coast referenced above), the development of agriculture greatly amplified such tendencies and, ultimately, led to the formation of full-fledged class divisions.

These changes also had consequences for human biology. Alterations in diet leading to nutritional deficiencies, increases in tooth decay, and other problems; shifts in the patterns of labor; increased exposure to diseases (due to living in larger settlements); and the effects of living in new climates, among others, resulted in evolutionary changes, in reaction to, but also in some ways enhancing human's ability to live under the new conditions brought about by agriculture.

Several studies published over the past year highlight increases in the understanding of this complex process.

Research published in the *Proceedings of the National Academy of Sciences* (Timothy M. Ryan and Colin N. Shaw, "Gracility of the modern Homo sapiens skeleton is the result of decreased biomechanical loading," *PNAS* vol. 112 no. 2, 13 Jan 2015) examined the relative massiveness (gracility vs. robusticity) of the human skeleton before and after the advent of agriculture and contrasted these with a variety of living primates. The study compared bone density in the hip joints of specimens from 31 extant primate taxa with human remains from four separate archaeological populations including both hunter-gatherers and sedentary agriculturalists. All the human populations whose remains were examined were from Native American sites in eastern North America.

The study showed that hunter-gatherers, living about 7,000 years ago, had bone strength (the ability to withstand breakage) proportionally similar to that seen in the sample of modern primates. By contrast, agriculturalists, living 6,000 years later, had significantly lighter and weaker bones, more susceptible to breakage. Their bone mass was 20 percent less than that of their predecessors. These findings suggest that the decreased skeletal robusticity in recent humans is not the result of bipedality (walking on two limbs rather than four, which occurred millions of years ago), but rather has to do with the development of agriculture.



Early centers of domestication (of various plants and animals) and routes of dispersal.

The researchers reviewed data to examine whether changes in diet, like reduced calcium intake, between hunter-gatherers and agriculturalists may be the primary reason for differences in bone density. They conclude, however, that it is principally changes in the pattern of physical activity, from highly mobile foragers to relatively sedentary agriculturalists that explain these differences.

These findings do not imply that farmers work less than foragers. Indeed, anthropological research has shown that at least some foragers have more free time than agriculturalists. One distinction may be the necessity for frequent movement from one settlement to another by the former. This is supported by the results of another study, published in the same issue of *PNAS* (Habiba Chirchir, et al., "Recent origin of low trabecular bone density in modern humans," *PNAS* vol. 112 no. 2, 13 Jan 2015), which demonstrates that changes in bone density were more marked in the lower limbs than in the upper. It reviewed hominin fossils from a number of extinct species, stretching back to *Australopithecus africanus* , demonstrating that high bone densities were maintained throughout the span of human evolution until the development of agriculture. This raises the question of whether changes in anatomy aside from bone density may be identifiable as resulting from activities characteristic of an agricultural existence.

The results are important in understanding the evolutionary context of such diseases as osteoporosis and geriatric bone loss in contemporary populations.

Another study, this one published in the journal *Nature* (Iain Mathieson et al., "Genome-wide patterns of selection in 230 ancient Eurasians," *Nature*, 16152, 23 November 2015), uses ancient DNA to trace the arrival of the first farmers from the Near East into Europe and examine a number of genetic changes experienced by the immigrants. The adaptations include changes in height, digestion, the immune system, and skin color.

DNA recovered from samples of ancient human bone provides a new source of data, supplementing archaeological artifacts, anatomical studies of human skeletons, and studies of DNA from contemporary human populations, to examine the introduction of agriculture into Europe. In particular, ancient DNA provides a more direct view of the evolutionary changes that humans underwent as they and their recently developed agricultural technology adapted to a new environment.

Modern humans moved into Europe from the Near East sometime between 40,000 and 50,000 years ago, absorbing and/or displacing the existing Neanderthal inhabitants. Both populations had hunting and gathering economies. Then, about 8,500 years ago, new immigrants, also from the Near East, began spreading into Europe. This time, however, they brought with them a revolutionary new economic system—agriculture. Another wave of agriculturalists moved into Europe from the Russian steppes, about 2,300 years ago.

The study reported in *Nature* compared ancient DNA from Europe, Turkey, and Russia with that from modern populations.

Foragers, who rely on naturally occurring foods, tend to have a varied diet in order to cover their nutritional needs. Agriculturalists, on the other hand, focus on a relatively narrow range of plant and/or animal species, perhaps supplemented by some wild food resources. This more limited diet may not meet all dietary requirements or may predominantly rely on foods that, while conducive to domestication, may not be easily digested. Dairy products and wheat are examples.

The consumption of milk and milk products is not natural for adult mammals. The capacity to digest lactose, a milk sugar, exists in infant mammals, but is usually lost once they are weaned. The domestication of a number of larger mammals, including sheep, goats, and cattle, presented the possibility of using their milk as a food source, converting grass, an abundant resource, but indigestible to humans, into a new food source. However, since hunter-gatherers do not typically consume milk, the widespread lactose-intolerance in adult humans was a major problem for early farmers who sought to employ this food source.

One of the results of the *Nature* study indicates that a gene that allows lactose digestion to continue into adulthood appears to have taken thousands of years to become widespread in European populations, despite its apparent selective advantage, only beginning to appear about 4,000 years ago. This raises the question of whether technological adaptations, such as

the production of aged cheese, which has less lactose, may have allowed for the use of milk products in earlier times.

Another gene was identified that enhances the ability to absorb an important amino acid, ergothioneine, which exists in low amounts in wheat and other domesticated grains. The spread of such a gene would represent a distinct advantage for diets that focused on grains as a food source. However, the effects of genes are often complex, and sometimes have unexpected consequences. This same gene appears to raise the risk of digestive disorders, such as irritable bowel syndrome. Evolutionary adaptations often represent a dynamic balance between positive and negative effects.

The researchers also found evidence regarding an evolutionary change in skin color. The predominance of lightly colored skin among Europeans appears to be a relatively recent phenomenon, possibly related to the need to produce more Vitamin D, which can occur in a reaction caused by sunlight absorbed in the skin. Lighter colored skin is thought to facilitate this process.

The study concludes that modern Europeans have significant genetic differences with early Neolithic populations of the region, despite having a largely common ancestry. The authors propose that these differences reflect evolutionary adaptations to the adoption of an agricultural lifestyle in a new environment as well as successive waves of immigration.

These findings are valuable in that they reinforce our understanding that human physical evolution is a complex and dynamic process of dialectical interaction with the natural and cultural environment. In a very real sense, the development of agriculture involved not only the domestication of a range of plants and animals by humans, but, as part of that process, the transformation of the humans themselves.

Source: https://www.wsws.org/en/articles/2016/01/15/agri-j15.html

☺ Course Closed ☺