Name: _____

LIVING ENVIRONMENT REGENTS EXAM – THE BARE ESSENTIALS

What you absolutely need to know for the Regents Exam!

What is the best way to study?

- Get a good night's sleep
- Eat a healthy breakfast and lunch

What is the format of the exam?

Approximately 80 - 85 questions.

Part A → 30 multiple choice (general biology content)

Part B-1 → 13 multiple choice (general lab skills & general biology content)

Part B-2 → 12 short answer (general lab skills & general biology content)

Part C → 10 short answer (general biology content applied to real world)

Part D → 15 multiple choice & short answer (4 required labs)

What should I bring to the exam?

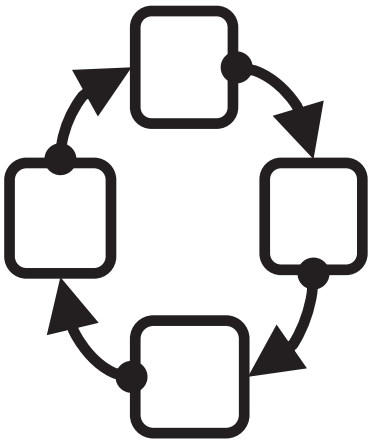
TUESDAY JUNE 11 – arrive no later than 11:45 am. You have 3 full hours for the exam.

- **Pen** –black ink ONLY. All answers must be written in PEN.
  NO WHITE OUT OR ERASERS ALLOWED ON ANSWER SHEET.
- **Pencil** and **eraser** – to complete the graph.
- **Calculator** (optional) – simple 4 function.
  NO GRAPHING CALULATORS ALLOWED.

Are there special instructions?

- Part A and Part B-1 you bubble answers on answer sheet.
- Part B-2 and Part C and Part D you write answers in test booklet.
- To correct mistake - DRAW ONE X through mistake then write new answer
- You must sign the declaration when you have completed the exam.
- Other than calculator NO ELECTRONIC DEVICES ALLOWED.

Original LE Bare Essentials 2010 revision produced and shared on Bioforum Listserve by Mr. Michael Dunleavy, Port Jervis High School. This modification is by Marilou Bebak, Nardin Academy High School 2013.



UNIT ONE – CHEMISTRY & THE CELL / ORGANIC COMPOUNDS

I. All living things must maintain **homeostasis** in order to stay alive.

- **A) Homeostasis**: A balanced state in an organism's body.
- **B)** Failure to maintain homeostasis results in disease or death.
- **C)** Homeostasis is often maintained using feedback mechanisms.
  1. **Feedback** mechanisms are **cycles** in which the product of one reaction causes another to start or stop.
- **D)** While organisms are balanced, they are not unchanging. The term used to describe the balanced state is **dynamic equilibrium.**
  1. **Dynamic Equilibrium:** A balanced state created by many small, opposing changes.

II. Life Processes: All living things carry out the same basic **chemical processes**. Taken together, these processes make up an organism's **metabolism**.

- **A) Metabolism:** All the **chemical processes** that take place in an **organism**.
  1. **Nutrition:** Use nutrients for growth, synthesis, repair and energy.
  2. **Cellular Respiration:** Convert **energy** in food into a usable form (**ATP**).
  3. **Synthesis**: Make complex compounds from simple substances.
  4. **Transport**: Absorb and distribute materials throughout the body or the cell.
  5. **Regulation**: **Control and coordination** of life processes.
  6. **Excretion**: Remove wastes produced by metabolic activities.
  7. **Reproduction**: Pass on genes to offspring.

III. Inorganic Molecules: Simple compounds

- **A) Water** H_2O Most common substance in all living things (about 60% of body mass)
  - Needed for chemical reactions (which won't happen in "dry" conditions)
  - Dissolves molecules into **solution,** allowing them to be **transported** through the body.
- **B) Carbon Dioxide** CO_2
  - With water, used by plants to make glucose during **photosynthesis**.
  - Waste product of **cellular respiration** (**aerobic**).
- **C) Oxygen** O_2 Needed by **most** (not all) organisms for **cellular respiration**.
  - Released by plants and algae as a waste product of **photosynthesis.**
  - **Cellular respiration** (**aerobic**)**:** Process that uses oxygen to release **energy** from glucose (sugar). Used by most organisms.
  - **Fermentation** (**anaerobic**): Process that releases energy from glucose without using oxygen. Provides less energy, so only used by a few simple organisms such as some bacteria and yeast. These organisms do not need to take in oxygen.
- **D) Nitrogen** N_2
  - Most common gas in air (70%).
  - Needed to make protein and nucleic acids.

- Converted into **nitrates** by **decomposers** such as fungi and soil bacteria. Nitrates are absorbed by plants which are then eaten by animals.
- Excreted as waste in **urine**.

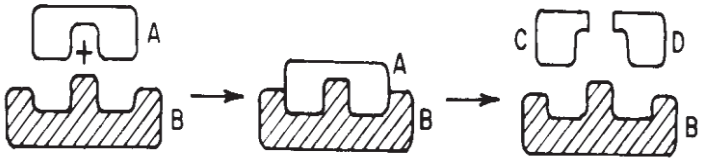
E) Acids and Bases:

- Measured by the **pH scale** (0.0 – 6.9 acid, 7.0 neutral, 7.1 – 14.0 base)
- pH can affect rates of chemical reactions; for example, digestive **enzymes** work fastest in acidic environments, which is why we make stomach acid (hydrochloric acid, or HCl).

IV. Organic Compounds: Large, complex molecules (polymers). Always contain the elements carbon C and hydrogen H. Synthesized from simpler substances called monomers (building blocks).

A) Carbohydrates: sugars and starches

1. Building blocks = simple sugars such as **glucose**
2. Functions:
   - Provide energy
   - Store energy in plants (starch)



Starch (A) is broken down by an enzyme (B) into two simple sugars (C & D). This is a good example of the **lock and key model**.

B) Lipids: fats and oils

1. Building blocks = fatty acids
2. Functions:
   - Store energy (animal fat)
   - Insulation
   - Water proofing (hydrophobic)
   - Make up the cell membrane and steroid hormones.

C) Proteins: Complex compounds that carry out all the body's activities.

1. Building blocks = amino acids
2. Have many different functions which are determined by the protein shape.
3. **Lock and Key Model:** Proteins must have the right shape to "fit" with other molecules.
   - **Changing the shape of a protein changes what it can interact with and its function.**
4. Important types of proteins:
   - **Enzymes** – act as **catalysts**, controlling all chemical reactions in the body.
     - High temperatures cause enzymes to denature (lose their shape) and stop functioning. This is why high fevers are dangerous.
   - **Membrane Proteins** – part of cell membrane; help with transport into and out of the cell, and receive chemical messengers such as neurotransmitters and hormones.
   - **Antibodies** – attack foreign **pathogens**
   - **Neurotransmitters** and **hormones** – carry messages through the body.

D) Nucleic Acids (DNA and RNA):

1. Building blocks = Nucleotides (with nitrogen bases – DNA has ATCG, RNA has AUCG)
2. DNA found in genes and chromosomes. RNA helps to produce proteins (protein synthesis).

UNIT ONE – CHEMISTRY & THE CELL / THE CELL

I. The cell is the basic unit of structure and function in all living things.

A) **Cell Theory** has three parts:

1. **All living things are made of one or more cells.**
   - Unicellular – single celled organisms (amoeba, paramecium)
   - Multicellular – have more than one cell; may be just a few cells, or many *trillions* of cells. Almost all structures in multicelled organisms are either made of or by cells.
2. **Cells carry out all life processes.**
   - Everything you do is the result of the work of your cells – walking, talking, even thinking and feeling. When you get sick, it is because your cells are not working correctly.
3. **All cells come from preexisting cells.**
   This seems obvious now, but at one time people believed in *spontaneous generation*, the idea that living things regularly emerged from nonliving things.

Exceptions to the Cell Theory

- **Viruses** are not made of cells. Viruses do not carry out all life processes, so many biologists do not consider them true living things.
- **The first cell** could not come from another cell. (BIG QUESTION? How did first cell begin?)

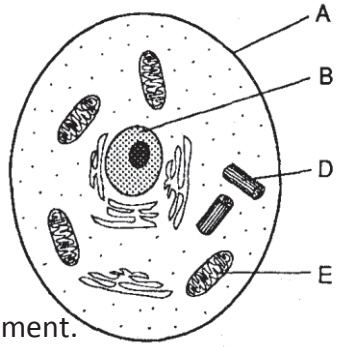
II. **Organization** (smallest to largest)

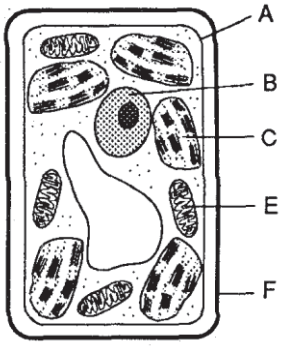
A) **Molecules**
B) **Organelles** – Cell structures
C) **Cells**
D) **Tissues** – Group of cells with the same structure and function.
E) **Organs** – Made of different tissues working together for the same function.
F) **Systems** – Groups of organs that work together for the same function.
G) **Organism** – living thing (species)
H) **Population** – members of the same species living in the same place at the same time.
I) **Community** – Many different populations living in the same place at the same time.

III. **Cell Organelles:** These are the tiny cell parts that make up a cell.

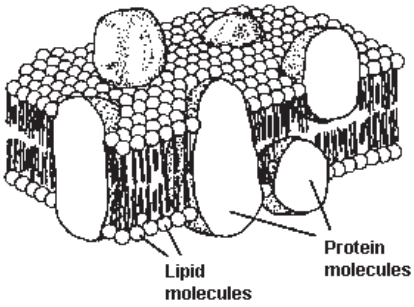
1. **Nucleus**
   - Controls the cell
   - Contains hereditary material (chromosomes, genes, DNA)
2. **Cytoplasm** (technically not an organelle)
   - Fluid/liquid in the cell – mostly water
   - Helps transport material
3. **Mitochondrion**
   - Carries out **cellular respiration**
   - Gives cell usable **energy** in the form of **ATP** (powerhouse of the cell)

4. **Ribosome**
    - Makes **proteins** by joining **amino acids** (protein synthesis)
5. **Vacuole**
    - Stores food, water and waste
    - Food vacuoles with lysosomes may digest large molecules.
    - Waste vacuoles may excrete waste out the cell membrane
    - Plant cells have LARGE water vacuoles.
6. **Chloroplast**
    - Contains chlorophyll and carries out **photosynthesis**.
    - Found ONLY in plant cells and algae cells.
7. **Cell Wall**
    - Gives shape, structure and protection.
    - NEVER found in animal cells.





8. **Cell Membrane**
    - Separates cell interior from outer environment.
    - Made of two layers of lipids plus proteins embedded in the lipid layers.



    - Controls what enters and leaves the cell using **membrane proteins.** This is part of regulation and homeostasis.
    - Has **receptor molecules** (**proteins**) that pick up signals from other cells.
    - Also has protein "tags" that identify the cell (see immune system).
    - **Diffusion** – movement of substances from an area of high concentration to an area of low concentration. A form of passive transport that does NOT require energy.

    - **Osmosis** – diffusion of water. Water moves into or out of the cell from an area of high concentration to an area of low concentration.
    - **Active Transport** – substances move into or out of cells from an area of low concentration to an area of high concentration. Requires the use of energy (ATP).

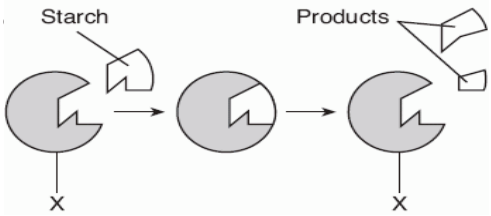
UNIT ONE – CHEMISTRY & THE CELL / NUTRITION AND ENERGY

Reminder – All life processes are **chemical activities** which make up your **metabolism**.

I. **Nutrition**: Taking in nutrients (food) for various activities including:
   1. growth
   2. repair damaged tissue
   3. synthesis (building)
   4. cellular respiration (energy)

   A) **Ingestion:** To take nutrients into the body.

   B) **Digestion**: To break down nutrients (polymers) into smaller molecules (monomers).
      1. Nutrients must be broken down into smaller parts so that they can be absorbed into the blood and cells of organisms.
         - Carbohydrates (such as starches) are digested into monomers called simple sugars.
         - Lipids (such as fats and oils) are digested into monomers called fatty acids.
         - Proteins (such as meat and fish) are digested into monomers called amino acids.



Starch is broken down by enzyme (X) into two simple sugars (Products).
"**Lock and key model**"

   C) **Autotrophic Nutrition:** Organisms take inorganic molecules (CO_2 & H_2O) and convert them into organic nutrients (carbohydrates such as sugars and starches).
      1. Autotroph = makes its own food.
      2. Photosynthesis is most common form of autotrophic nutrition.
      3. Producers such as plants, algae and some bacteria (cyanobacteria) are common autotrophs.

   D) **Heterotrophic Nutrition:** Organisms must consume nutrients from other organisms.
      1. Heterotroph = can't make its own food.
      2. All animals and all fungi and some bacteria are heterotrophs.
      3. Includes:
         - **Carnivores**: eats animals
         - **Herbivores**: eats plants or algae
         - **Omnivores**: eats both plants and animals
         - **Decomposers**: breaks down dead matter and waste
            - Decomposers are important decay organisms for recycling nutrients.

II. **Photosynthesis:** Process in which sun's energy is stored in the chemical bonds of sugar.

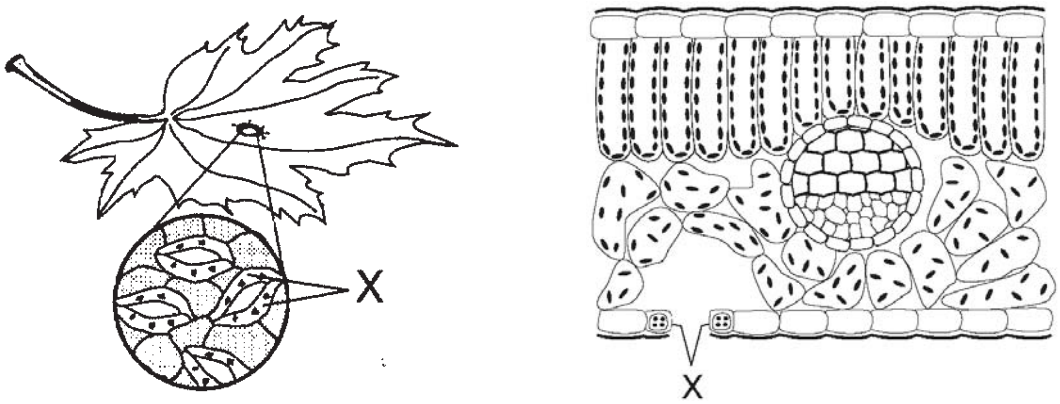
   A) Requires sunlight, water H_2O and carbon dioxide CO_2.

   B) Makes glucose $C_6H_{12}O_6$ as food.

   C) Water H_2O and oxygen O_2 are waste products.

D) Benefits:
   1. Provides food for all plants, animals and other organisms.
   2. Provides O_2 for cellular respiration
   3. Removes CO_2 from atmosphere.

E) Plant adaptations:
   1. **Chloroplast**: Cell organelle (containing chlorophyll) that does photosynthesis.
   2. Gas exchange:
      - **Stomata:** Pores or tiny openings under a leaf; let gases in and out,
      - **Guard cells:** open and close the stomata to prevent plant drying out.
   3. Transport:
      - **Xylem and Phloem:** "tubes" transport food and water throughout the plant.



Two different views of the **stomata (the clear opening)** and their **guard cells** (X) that **control the size of the stomata.**

III. **Cellular Respiration:** Process that takes **energy** from sugar molecules and places it in molecules of **ATP.**

A) ATP is the **molecule** all cells use for **energy**.
   - No organism can get USABLE energy from sunlight or sugar without first putting the energy into ATP.

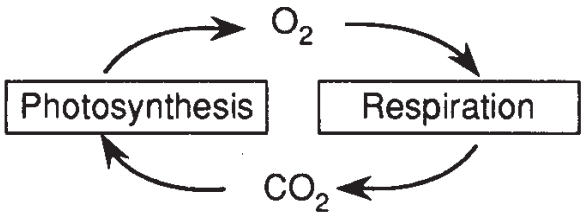
B) Requires **oxygen, glucose** and **water.**

C) **Carbon dioxide** and **water** are waste products.

D) Most organisms carry out **cellular respiration** (**aerobic** = uses oxygen) in the **mitochondria**.

E) **Fermentation** (**anaerobic**) does not require oxygen, and produces less ATP (energy) for each molecule of sugar.
   - When exercise causes human muscles to run out of oxygen, the cells will do **anaerobic respiration**. The waste product, **lactic acid**, causes muscles to "burn" so that you will **stop**.

F) **Photosynthesis and Cellular Respiration are opposite reactions!** They are important in cycling oxygen, carbon, hydrogen and water through the environment.



COMMON MISTAKES!

- "Plants do photosynthesis, animals do cellular respiration."
  <u>All</u> organisms, including plants, use cellular respiration to get their energy as ATP.

- "Respiration is breathing."
  *Breathing is **<u>not</u>** respiration. Breathing exchanges the gases needed for respiration. Inhaling oxygen and exhaling carbon dioxide does not give you ATP.*

- "Oxygen is used to breathe."
  This is backwards. Breathing is used to get oxygen which is used for cellular respiration. Without oxygen, you have no respiration, no ATP, and no energy.

- "All living things need oxygen. All living things need to breathe."
  Anaerobic organisms (such as yeast and some bacteria) do not need oxygen, and do not breathe.

UNIT TWO – EVOLUTION & CLASSIFICATION

I. **Evolution**: gradual change over time.

II. **Modern Theory of Evolution:**

A) **Charles Darwin:**

1. Was not the first to think of evolution, but he did figure out how it works (mostly).
2. Darwin did not know about genes or DNA, so he could not know about mutations.

B) The modern theory (which combines Darwin's ideas with genetics) contains the following ideas:

1. Earth is old (4.5 billion years old) and is constantly changing.
2. As the environment changes, evolution causes species to adapt to their environment.
3. **Natural Selection** is the **mechanism** that causes species to change.
4. **Descent with Modification:** Modern species evolved from earlier species and share a **common ancestor**.
5. Species that can not adapt become extinct.
6. New traits arise in a species from mutations and genetic recombination.

III. **Environment and Evolution**: Species usually evolve when the environment changes.

A) Changes must be long term – species do not evolve because of a change in the season.

B) Changes can include:

1. Change in climate
2. Change in temperature
3. Change in water availability
4. Change in food availability
5. Change in amount of sunlight
6. Introduction of new species (new food, new predator)
7. Species may be moved to a new location (accidentally taken to an island for example)

C) Environmental change **DOES NOT CAUSE** evolution to occur. A temperature or climate change does not itself force a species to change its inherited characteristics.

1. If this were the case, then all species would be able to adapt to the new environment, and extinction would be a very rare event.

IV. **Natural Selection:** The basic steps in natural selection are:

A) Overproduction = Too many offspring are produced than can possibly survive.

B) Competition = Offspring must struggle to survive and reproduce.

C) Variations = Members of a species are different from each other due to sexual reproduction, genetic recombination, and mutations.

1. Without variations there is no evolution or natural selection, since there is nothing to "select." Species with little or no variation are usually the first to die when the environment changes.

D) Survival of the Fittest

1. Offspring who inherit helpful variations are, on average, better able to get resources, escape from predators and find mates.
2. Offspring with harmful traits have more difficulty surviving and finding mates.
3. **Fitness:** A measure of how well a trait helps an organism to survive and reproduce in its environment. There is no absolute rule for fitness – what is fit in one environment may be unfit in another.
4. **Note:** Natural selection is not a conscious act – no one is "choosing" who survives and who doesn't. It is the result of the conditions of the organism's environment.

E) Reproduction

1. More organisms with helpful variations reproduce and pass on their genes to their offspring than those organisms with harmful variations.
2. On average, the next generation has more traits from the "fit" parents than the unfit ones.
3. NOTE: Traits are still inherited randomly. Individuals' offspring of "fit" parents can still inherit "unfit" traits (though it will be unlikely to survive and reproduce). It is only by looking at the ENTIRE population that you will see the "fit" traits become more common. *****POPULATIONS EVOLVE NOT INDIVIDUALS!*****

F) Evolution

1. Does not happen overnight. It takes MANY generations of repetitive selection and reproduction and to remove all unfit traits.

V. Speciation: The process of forming a new species from an existing species.

A) Geographic Isolation: A population is separated into 2 or more different habitats.

B) New variation and adaptation: Each population adapts to its new environment in different ways. This results in physical and genetic differences between the two populations.

C) Add time: The longer two populations are apart, the greater their differences become.

D) Reproductive Isolation: Eventually the populations change so much that they are unable to interbreed, even when brought together.

1. **Once two populations can no longer breed together, they are considered new species.**

VI. Classification: Organisms are classified based on their evolutionary relationship.

A) Domains are largest group of related organisms.

1. Eukarya Domain has organisms with **eukaryotic** cells (cells WITH a nucleus). Includes single-celled and many-celled organisms.

2. Archea and Bacteria Domains have organisms with **prokaryotic** cells (cells WITHOUT a nucleus). Includes single-celled organisms only.

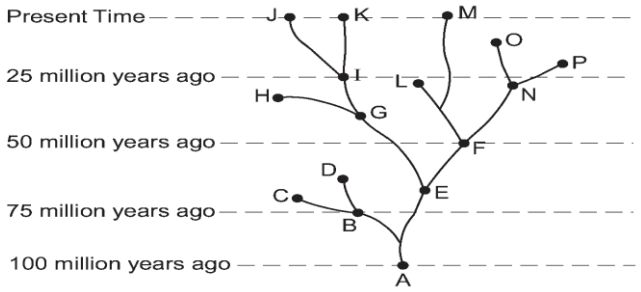
B) Kingdoms are large groups of related organisms (Protists, Fungi, Plants, Animals).

C) A **species** is able to successfully reproduce with its members and produce fertile offspring.

1. Note that this is not a perfect definition. Horses and donkeys can breed together, as can dogs and wolves. Single-celled organism do not breed. Evolution is a constantly ongoing and gradual process, so there are examples in which the lines between species are blurry.

D) The scientific name of an organism is the **genus** plus the **species** name. The genus name comes first but is like the last name of a person. The same genus indicates closely related organisms.
- Example: *Panthera leo* (lion) and *Panthera tigris* (tiger) are closely related. But *Ursus actos* (brown bear) and *Phascolarcto**s** cinereus* (koala bear) are NOT closely related**.**

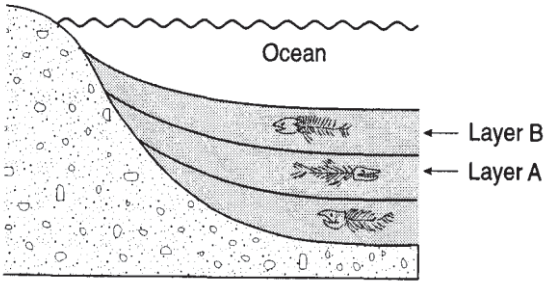
E) Branching tree diagrams (phylogenetic trees and cladograms) are often used to show evolutionary relationships.



Evolutionary trees show the relationship between living species and extinct species.

VII. Evidence: Evidence in support of evolution comes from many fields:

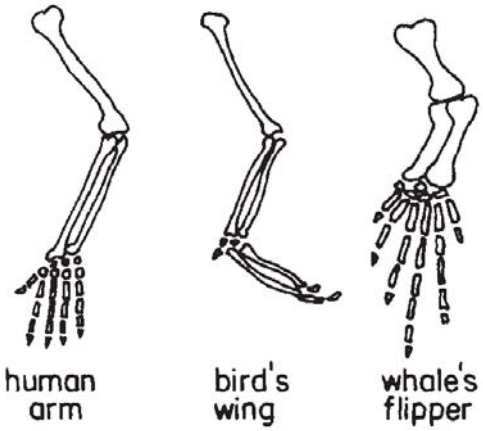
A) **Fossil record** preserves extinct species as well as transitional forms between different types of organisms.



Deeper fossils are typically older than those above them.

B) **Dating** of rocks and rock layers confirm the age of the Earth and fossils. Generally, the bottom layers contain the oldest fossils and simpler organisms. Top layers contain the younger fossils and more complex organisms.

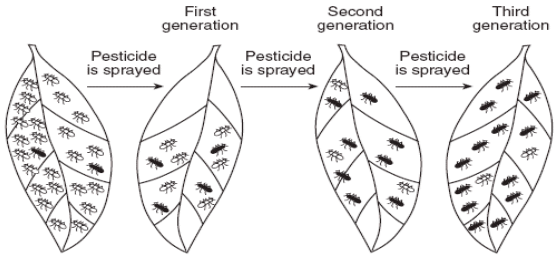
C) Comparisons of the anatomy (physical structures), embryology (development), chemistry (proteins) and genes (DNA) of species confirm expected relationships.



Homologous Structures are similar body parts modified to perform different functions. Homologous structures indicate a common ancestor.

D) Direct observation: Humans see evolution happening in nature and in the lab. Examples include

1. **Bacteria** evolve resistance to antibiotics. **DO NOT SAY** "become **immune** to the antibiotic"
2. **Insects** evolve resistance to pesticides. **DO NOT SAY** "become **immune** to the pesticide"



Over time, the number of insects resistant to the pesticide increases.

3. Artificial selection / Selective breeding alters a species' traits. This models natural selection but with humans choosing the best traits instead of nature.
4. Observed examples of speciation.

COMMON MISTAKES!

• "Stronger organisms are more fit than weak ones."
Evolutionary fitness is not physical fitness. Fitness is determined by who is better adapted to survive in a particular environment and who can pass on their genes. Stronger is not always better. There are many examples of species for whom it is better to be slow, weak, or stupid, than fast, strong or smart. It all depends on the environment you are in.

• "The organism evolved to live in its environment."
Individual organisms do not evolve. Only populations can evolve.

• "The organism could not adapt and it went extinct."
Individual organisms die; they cannot go extinct. Only species can become extinct.

• "The bacteria became resistant to antibiotics when they were exposed to them"
To evolve, variations must exist in a species BEFORE the environment changes (pre-adaptation). Bacteria that did not already have a resistance to antibiotics would die when exposed to them, a Chihuahua who is left out in the cold will not grow long, warm fur and a squirrel who plays in traffic will not evolve automobile resistance.

• "Giraffes got long necks because they <u>needed</u> them to eat leaves at the tops of trees." *Species do not evolve traits because they need them. Short-necked giraffes were never given long necks any more than slower antelopes are given speed when confronted by a predator. The reason there are no short-necked giraffes (or slow antelope) is that they were out competed by members of their species with more helpful traits. Better answers are*

- "Giraffes evolved long necks because the ones with longer necks were better able to get food than short neck giraffes."
- "Giraffes evolved long necks because more short necked giraffes died, and more long neck giraffes lived and reproduced."

UNIT THREE – HUMAN ANATOMY & PHYSIOLOGY

I. Organization: The human body is made of **cells.**

A) All humans (and most other organisms) begin life as a **single** cell.
   1. This single cell is called a **zygote**.
   2. The nucleus of this cell has **all** the genes needed to become a complete organism.

B) Humans grow as a result of **mitosis** (cell division).
   1. This quickly increases the number of cells in the body until there many trillions of cells.
   2. Since all new cells come from the same single cell, they all share the same **genes**

C) As cells divide, they begin to develop into specialized **tissues**.
   1. **Specialization** or **Differentiation:** Process in which a cell changes to have a specific shape and function.
   2. Cells specialize by turning specific genes on or off.
      - Ex: A white blood cell has turned <u>off</u> all genes needed to make skin, bone, or nerves. It still has those genes, but only the genes needed to be a white blood cell remain active.

D) As the body continues to develop, different tissues work together to form **organs**.

E) Organs work together to form organ **systems**.

F) Organ systems work together to help a person **maintain homeostasis**.

II. Digestive System:

A) Food is broken down so that it is small enough to enter the body tissues and cells.
   1. Food is broken down mechanically (chewing) and chemically (using enzymes).
   2. Nutrients and water are absorbed into the body in the small and large intestines.

B) The digestive system is a one way passage through the body that includes the **mouth**, **esophagus, stomach** and **intestines**.

C) Food is moved through the digestive system by smooth muscular contractions called **peristalsis**.

D) Undigested food is eliminated as solid waste (**feces**).

COMMON MISTAKES !

"The digestive system excretes waste."
The digestive system does not excrete waste. Feces are undigested food. (see excretory system).
"The digestive system gives you energy."
Digestive system provides nutrients, including glucose. Energy is gained by cellular respiration.

III. Circulatory System

A) Moves materials through the body to the organs, tissues and cells that need them.

B) Transported materials include:
   1. **Nutrients** and **water** from **intestines** to all cells of body.
   2. **Oxygen** from lungs to all cells of the body.
   3. **Hormones** from glands to **target cells.**
   4. **Waste** from all cells to the **excretory organs.**

C) Materials usually enter and leave the blood through **diffusion.**
   1. **Diffusion**: Process in which material moves from a high concentration to a low concentration.

- Example: There is a high concentration of oxygen O_2 in the lungs, so oxygen diffuses from the lungs into the blood, which has less oxygen.

2. **Capillaries:** Microscopic blood vessels where diffusion occurs.

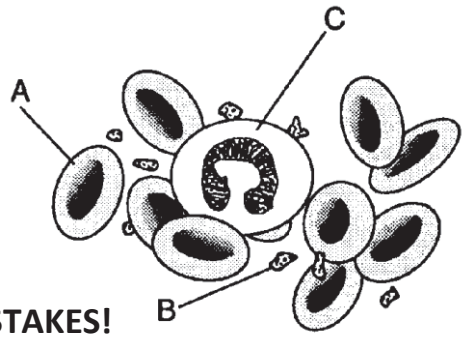
D) The **heart** is the pump that drives the circulatory system. Blood vessels called veins carry blood to the heart while arteries carry blood away from the heart.

E) **Red blood cells** carry oxygen**. White blood cells** defend against disease.

1. Hemoglobin: Protein in red blood cells that carries oxygen O_2.

F) **Plasma** is the fluid of the blood. Transports all blood cells, nutrients and hormones.

G) **Platelets** clot the blood by making a protein called fibrin.



Red blood cells (A), platelets (B) and white blood cells (C).

COMMON MISTAKES!

"The heart pumps oxygen to the body."

Technically true, but the heart pumps blood (which carries the oxygen) everywhere in your body.

"The heart gives you oxygen."

No materials diffuse in or out of the blood when it is in the heart. This only occurs in capillaries.

IV. Respiratory System:

A) Breathing (inhale and exhale) provides **oxygen** O_2 needed for **cellular respiration** (which uses energy from sugar to make **ATP**).

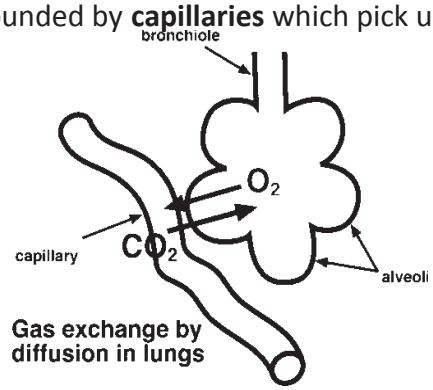
B) Excretes the waste carbon dioxide CO_2 which is produced from cellular respiration.

C) The **diaphragm** is the muscle that allows breathing to occur.

D) You breathe faster when CO_2 builds up in the blood because your cells are doing more cellular respiration (not when you need oxygen).

E) The **alveoli a**re microscopic sacs inside the lungs where oxygen O_2 enters the blood and CO_2 leaves the blood and enters the air sacs.

1. The alveoli are surrounded by **capillaries** which pick up oxygen O_2 and drop off CO_2.



V. Immune System

A) The job of the immune system is to protect the body against **pathogens**.

B) **Pathogen:** An organism that causes a disease.

1. Types of pathogens include viruses, bacteria, and parasites.

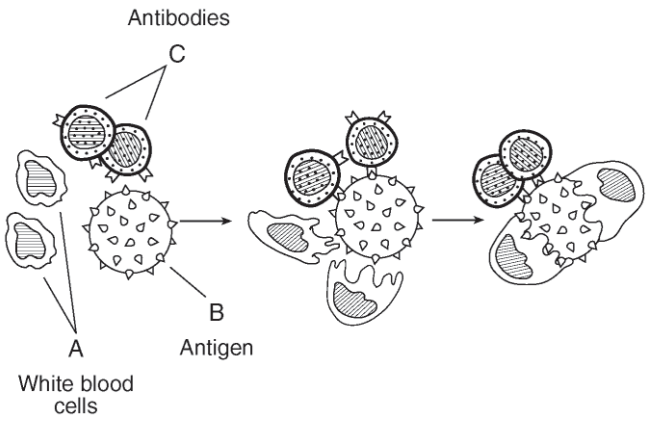
C) **White Blood Cells** are the main components of the immune system.

1. Different white blood cells have different roles, including:
   - Identify pathogens
   - "Tag" pathogens for destruction by other white blood cells.
   - Destroy pathogen by eating it.
   - Destroy pathogen using chemicals
   - Make **antibodies**

D) **Antibodies** are **proteins** made by white blood cells to attack pathogens.

1. Every antibody is specific in its action – it can attack one and only one type of pathogen. As with all proteins, this is because the shape of the antibody must fit its target (lock and key model).

E) **Antigens** are protein "tags" on pathogens that identify a bacteria or virus.

1. Any pathogen with the wrong antigen will be seen as foreign by your immune system, attacked, and destroyed. This is why you must match blood types before receiving blood or an organ transplant.
2. 

An immune response – white blood cells (A) and antibodies (C) attack a virus (B).

F) **A vaccine is an injection of a dead or weakened pathogen.**

1. Triggers the body to make antibodies against that pathogen.
2. Effective against both viruses and bacteria.
3. Can only prevent disease by providing immunity, not cure it.

G) **Antibiotics** are drugs used to stop infections by **bacteria only**.

1. Antibiotics will not work against viruses.
2. Unlike vaccines, antibiotics can cure diseases.

H) COMMON MISTAKES!

"Antibodies are cells that attack pathogens."
Antibodies are proteins made by white blood cells, they are not cells.

"A vaccine contains a little bit or a tiny part of a pathogen."
A vaccine contains a dead, weekend or altered pathogen.

VI. Diseases and Disorders

A) Typically the exam asks you to name a disease, what causes it, its effect on the body, and how to prevent/treat/cure it. The most important diseases and disorders for you to know are:

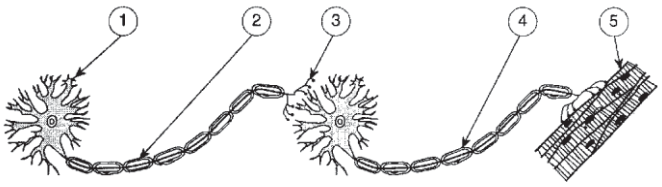
1. **AIDS**
   - Caused by HIV virus (a pathogen)
   - Weakens human immune system, leaving body vulnerable to other diseases.
   - Spread through bodily fluids, usually sexual contact, intravenous (IV) drug use (sharing needles), or blood transfusions.
   - Can't be cured, but spread may be prevented by sexual abstinence, "safe" sex (using condoms), not sharing needles, or testing blood before using it for a transfusion.
2. **Cancer**
   - Caused when a body cell divides at an uncontrolled rate, forming a **tumor**.
   - Cancer cells **do not specialize** and take resources away from healthy tissue.
   - May be caused by exposure to UV or X-ray radiation, chemicals (such as asbestos or cigarette smoke), and some viruses.
   - Treatments include surgery, chemotherapy, radiation therapy.
3. **Diabetes**
   - Affects body's ability to control the amount of sugar in the blood.
   - Some diabetics are treated with injections of **insulin** made by genetically engineered bacteria.
4. **Allergies**
   - Occur when immune system reacts to a harmless substance (such as pollen).
   - **Asthma** is a form of allergy caused by a reaction to dust particles in the air.

VII. Nervous System

A) The nervous system **regulates** your body with **impulses** that are electrical and chemical.

1. The chemical portion of a nerve impulse is a protein called a **neurotransmitter**.
2. Neurotransmitters released by 1 nerve cell are received by **receptor molecules** in the cell membrane of the next nerve cell.
3. The shape of the receptor molecule determines which neurotransmitter it can receive.

B) A nerve cell is called a **neuron**.



Two neurons carry an impulse to a muscle cell (5). **Neurotransmitters** carry the impulse from one cell to the next cell at number (3).

C) The main organs of the nervous system are the **brain** and **spinal cord** and are made of interneurons.

D) The **spinal cord** controls **reflexes** and relays impulses between the brain and body.

E) Sensory neurons carry impulses to the brain and spinal cord while motor neurons carry impulses to the muscles or glands.

VIII. Excretory System:

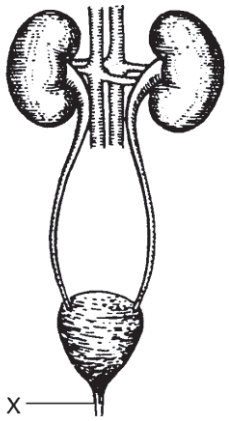
A) Removes waste produced by the cells of your body.
   1. These wastes include **urea**, **water**, **salt**, **carbon dioxide** and **heat**.

B) **Lungs** excrete **carbon dioxide** and **water vapor**.

C) The **skin** excretes water and salt as sweat.

D) The **kidneys filter** wastes out of the blood and then excrete water and urea and other substances as urine.
   1. Kidneys also control the amount of water in your body.

E) **The liver** makes urea, filters toxins and dead red blood cells from the blood.



The Urinary System - kidneys, ureters, bladder and urethra (X).

F) **COMMON MISTAKES!**

"The body excretes feces."

Feces never enter cells of the body, so technically it is not excreted. The correct term is "eliminated."

"The kidneys make urea.

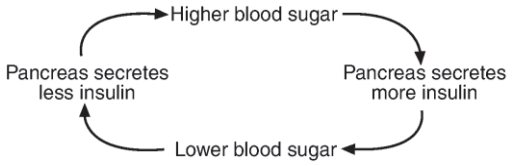
The liver changes ammonia to urea. Urea is then transported by the blood to the kidneys. The kidneys filter wastes from the blood to make urine.

Endocrine System

A) Uses **hormones** to **regulate** the body.

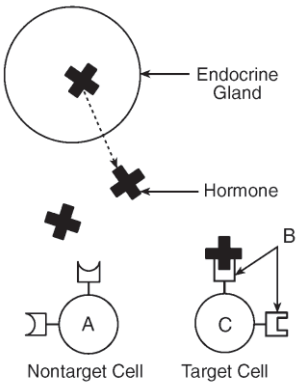
1. A hormone is a chemical **message** (usually a protein) secreted by endocrine **glands.**
2. Hormones are carried from the glands to the target tissue by the blood.

3. Hormones are slower than nerve impulses, but with longer lasting effects.
4. Hormone levels are controlled by **feedback mechanisms**.



A feedback mechanism

5. **Receptor molecules** on the surface of the cell membrane receive hormones. **As with all proteins, it is the shape of the receptor molecule that determines which hormone it can receive.**



Receptor Molecules in the cell membrane can only accept molecules of the correct shape. This is a good example of the **Lock and Key Model**.

G) The **pancreas** makes **insulin** and glucagon which control the level of sugar in the blood.

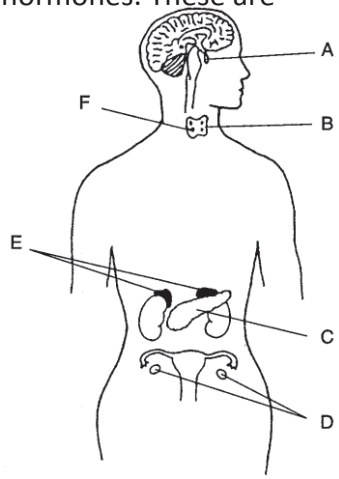
H) Adrenal glands make **adrenaline** when the body is under stress.

I) **Testosterone** (male), **estrogen** and **progesterone** (female) are the sex hormones. These are made in the gonads (testes for males, ovaries for females)

J) **COMMON MISTAKES!**

"Insulin provides sugar."

Insulin (and glucagon) directly control blood sugar (or glucose) levels, Insulin lovers blood sugar levels by causing sugar to be taken in by the body cells.



Some endocrine glands.
Pituitary (A)
Pancreas (C)
Ovaries (D)

Interactions between body systems

A) The different systems of the body work together to maintain homeostasis. Some examples:

1. *Nutrients from the digestive system are transported to cells by the circulatory system.*
2. *Wastes from the muscular system are removed by the excretory system.*
3. *The nervous and endocrine systems work together to control the body.*
4. *The immune system protects the all body systems from disease.*

UNIT FOUR – REPRODUCTION

I. Asexual reproduction:

A) Advantages: One parent. Quickly provides large numbers of offspring

B) Disadvantage: No variations.

II. Sexual reproduction:

A) Advantage: Two parents provide variations.

B) Disadvantage: Need to find mate, happens more slowly.

III. Mitotic Cell Division (Mitosis)

A) Used in all forms of asexual reproduction.

B) The number and types of chromosomes in the daughter cells are the same as in the parent cell.

C) Multicellular organisms use mitosis for growth and repair of damaged tissue.

D) Unicellular and some simple organisms use it to reproduce.

E) One division of a cell makes two identical, diploid (2n) cells.

1. Diploid: Cell with sets of chromosomes in **pairs**.

IV. Meiotic Cell Division (Meiosis)

A) Makes **gametes** used in sexual reproduction.

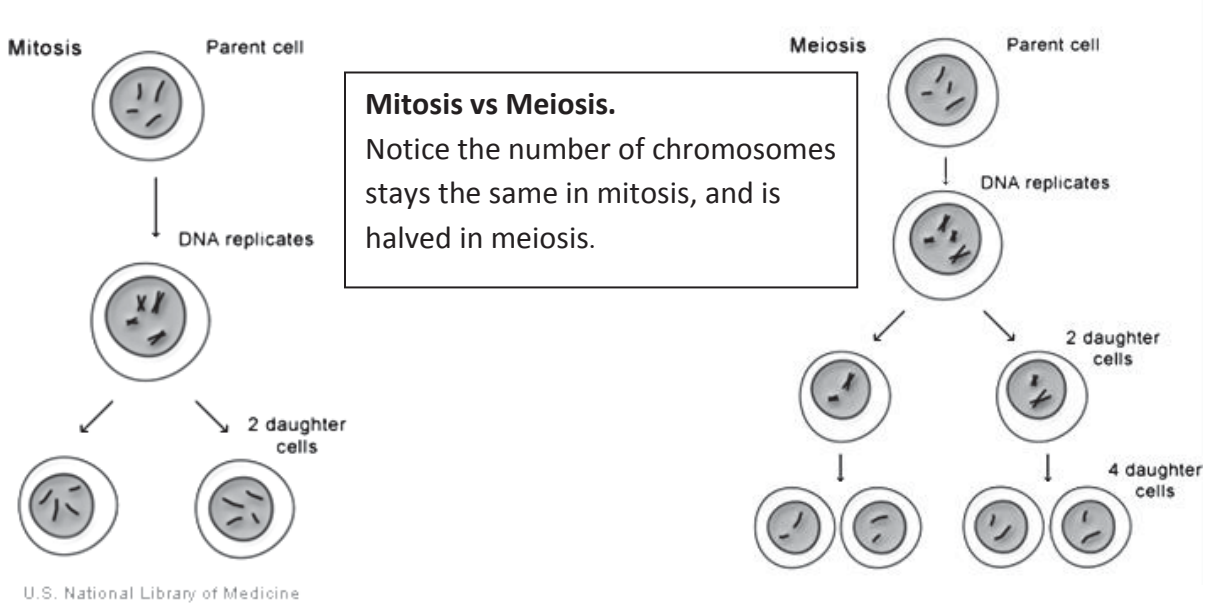
1. Gamete are the Sex cells; sperm and egg in animals, pollen and ovules in plants.

B) One cell divides *twice* producing 4 DIFFERENT haploid (n) cells.

1. Haploid: Cell with **half the normal number** chromosomes and **no pairs**.

C) Separates pairs of chromosomes so that offspring get **one chromosome of each pai**r from that parent.

D) Each daughter cell (gamete) gets only one half of the chromosomes of the "parent" cell.



Mitosis vs Meiosis.
Notice the number of chromosomes stays the same in mitosis, and is halved in meiosis.

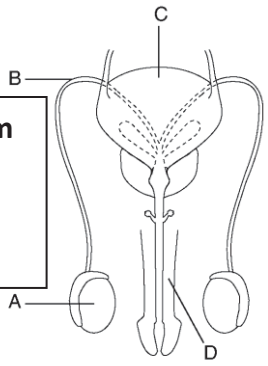
V. Male Reproductive System

A) Testes produce and store sperm.
   1. Sperm are haploid cells made by meiosis.
   2. Sperm are produced in large numbers throughout a male's life
   3. Sperm are smaller than the egg and are mobile (swim using flagella).
   4. Sperm provide human offspring with 23 chromosomes – everything else is in the egg.

B) Testosterone is the male sex hormone, and is made in the testes.

C) Penis transfers sperm into the female reproductive system.

D) Semen is the fluid that carries sperm.
   1. Semen contains sugar to give sperm energy.



Male Reproductive System
Testis (A)
Vas Deferens (B)
Penis/Urethra) (D)

VI. Female Reproductive System

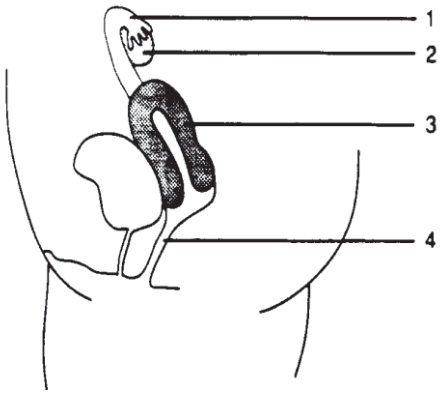
A) Ovaries produce eggs.
   1. Eggs are haploid cells made by ovaries.
   2. Females are born with all eggs they will ever have.
      - An egg is not fully developed until ovulation.
      - Females are born with millions of eggs, enough for several lifetimes.
   3. Eggs are the largest cells in the body..
   4. Eggs do not move on their own.
   5. Contain 23 chromosomes and all cell parts (mitochondria, ribosomes, cytoplasm) that the offspring will need to grow and develop.

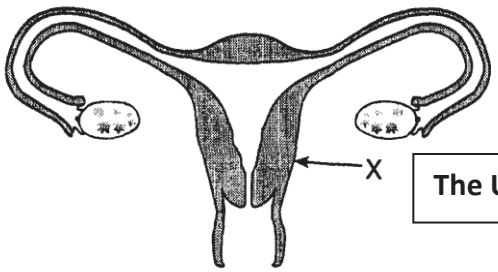
B) The menstrual cycle lasts 28 days (on average)
   1. Ovulation – release of an egg (typically 1 per cycle)
   2. Menstruation – shedding of the uterine wall if fertilization doesn't occur
   3. If pregnancy occurs, the menstrual cycle will temporarily stop.

C) The oviduct / Fallopian tube carries the egg to the uterus.

D) The uterus is the womb where the baby develops.

E) The vagina is the birth canal where the baby leaves the body.





The Uterus (X)

Female Reproductive System
Ovary (1)
Oviduct (2)
Uterus (3)
Vagina (4)

VII. Development

A) Fertilization occurs in the oviduct / Fallopian tube.

1. A fertilized egg is called a **zygote**.
2. Fertilization restores the complete set of chromosomes, so the zygote is diploid (23 from the egg + 23 from the sperm = 46).

B) A zygote develops in the following order:

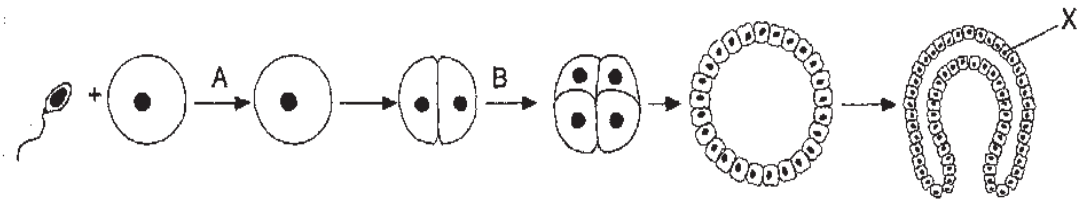
1. Cleavage – A form of **mitosis** when cells divide rapidly but do not differentiate. Forms the **embryo**.
2. Differentiation – Cells specialize to form tissues and organs.
3. **Implantation** in the wall of the **uterus**.
4. **Fetus** - most major organs are formed (but not completed)
   - Continues to grow through cell division (mitosis)

Fertilization restores the diploid of chromosomes (2n = homologous pairs)

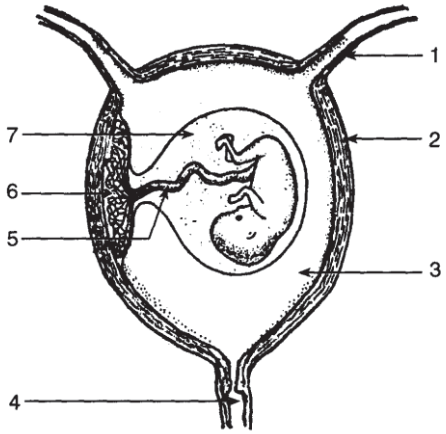
C) The **placenta** transfers nutrients and oxygen from the mother's blood into the blood of the fetus through the process of **diffusion**.

1. The blood of the mother and fetus do not mix.
2. The fetus is attached to the placenta by the **umbilical cord**.
3. Waste produced by the fetus is also removed by the placenta.
   - Waste (CO_2, urea, salts) *diffuse* from placenta into mother's blood.
   - Since the fetus does not eat solid food, it does not have to eliminate feces.

D) The child is vulnerable to alcohol, drugs, whatever the mother takes in because organs and systems are still developing.



arly development – Fertilization (A) forms a single-celled **zygote** which begins the process of **mitosis (B)** which eventually creates a layered ball of cells that forms the embryo.



Later Development – The fetus pictured here is nearly ready to be born. Note the umbilical cord (5), placenta (6), and amniotic sac (7).

COMMON MISTAKES!

"The egg is fertilized in in the uterus."
The sperm fertilizes the egg in the oviduct /Fallopian tube.

"The baby grows in the mother's stomach."
The baby develops inside the mother's uterus. It has nothing to do with the stomach.

UNIT FIVE – GENETICS

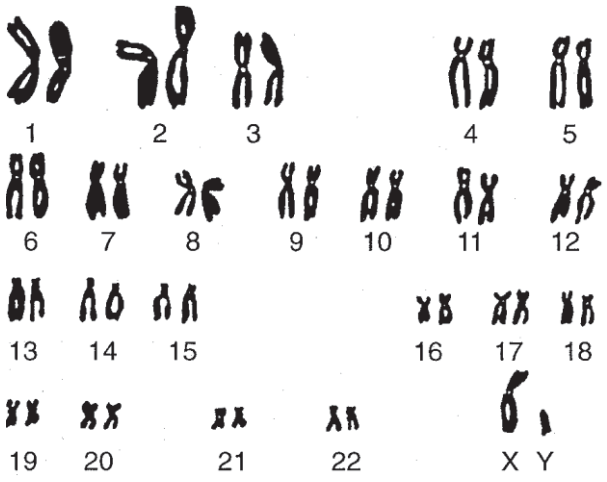
I. Chromosomes:

A) Humans have **46** chromosomes, or **23** homologous pairs.
   1. **Homologous:** chromosomes with the same size, shape and types of genes.

B) **Chromosome pairs** carry genes for the same traits.
   1. Most organisms have two genes for each trait - 1 from each parent, 1 on each member of the homologous pair.
   2. **Alleles** are the option for the gene/trait. For example: the gene is for the trait of coat color in cats while the alleles (options for that gene) are black or gray.

C) **Sex chromosomes –** In humans, females are XX and males are XY
   1. The Y chromosome is much smaller than the X, so it is does not have the same genes. This means many genes on the X chromosome do not have a "partner" so:
      - If a male has a recessive trait on the X chromosome, the Y chromosome will not be able to "hide" it with a dominant gene, so...
      - This makes males more likely to have some traits (like color blindness). These are called **sex linked traits.**

A karyotype shows all 23 pairs of human chromosomes. Note the last pair identifies this as a male.



II. Chromosomes and Genes

A) Each chromosome has hundreds or thousands of genes.

B) **Each gene codes for a particular protein**.
   1. While genes determine our traits, **the environment can affect expression of genes.** for example, temperature can effect how are certain trait appears.

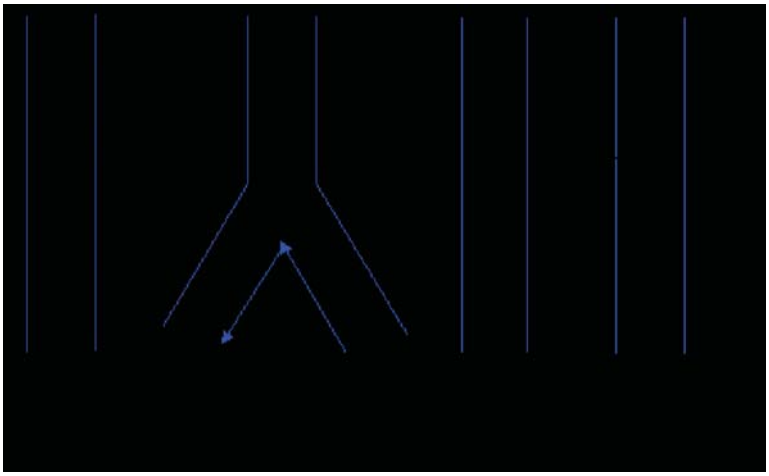
III. DNA

A) DNA is the molecule that makes up your genes and chromosomes.
   1. Analogy: If your genes and chromosomes are the "instruction manual" for your body, DNA would be the paper it is printed on.

B) The shape of a DNA molecule is a **double helix**, which resembles a twisted ladder.

C) The shape of DNA allows it to **replicate** (copy) itself almost perfectly.

D) DNA is made of 4 bases: **A, T, C and G**
   1. Base pairs: A - T and C- G
      - RNA pairs are A - U and C- G



DNA replicating using the base pair rule A-T C-G. DNA replication happens during Interphase, BEFORE mitosis occurs.

IV. Protein Synthesis: This is how genes control your body:

A) A **codon** is a sequence of **three bases** in DNA**.**
   - Each codon represents a specific **amino acid**.
   - Ribosomes assemble amino acids in the same order that they are listed in the DNA codons.
   - The amino acids join together make a **protein**.
   - The order of the amino acids (determined by the DNA sequence) determines the **shape** of the protein.
   - The shape of a protein determines its **function**.
   - Therefore: The sequence of bases in DNA determines the functions of all proteins.
   - The proteins build cells and the body and control cells and the body.

The order of DNA bases in your genes determines the order of amino acids in your proteins, which determines the proteins' shape, which determines the proteins' function.

Therefore: How your body functions depends on the order of the bases in your genes!

B) **RNA** carries the genetic code to **ribosomes**.

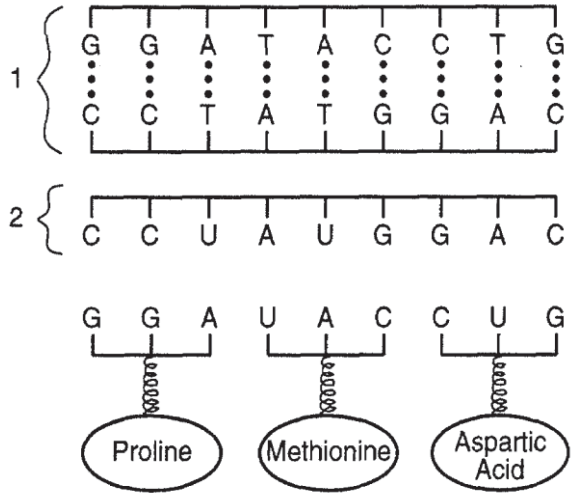
1. mRNA (messenger RNA) copies the DNA code for the gene in the nucleus. mRNA then goes the ribosomes.

2. tRNA (transfer RNA) then brings the correct amino acids to the ribosomes by matching bases with mRNA.

ROW 1 DNA

ROW 2 mRNA copies one strand of DNA

tRNA brings correct amino acids by



V. Mutations: Any change in the genetic material of an organism.

A) Can only be passed on if mutations happens in reproductive cells (sperm or egg).

B) Common **mutagenic agents** include **radiation, chemicals and viruses**.

1. Mutagenic agent: Any environmental factor that causes a mutation.

C) **Gene mutations** may cause a change in a gene which can change the shape of a protein. This will have an effect on the way the protein works (if it still works at all).

1. Gene mutations are caused when DNA bases are in some way altered such as a missing base, added base or changed base.

D) **Chromosome mutations** are usually caused when a person inherits too many or too few chromosomes.

1. Chromosome mutations affect many genes at once. Most are lethal (cause death).
2. **Down's syndrome**: Non-lethal mutation, caused by inheriting an extra chromosome 21. (Note – only extra chromosome 21 causes Down syndrome).

VI. Genetic technology:

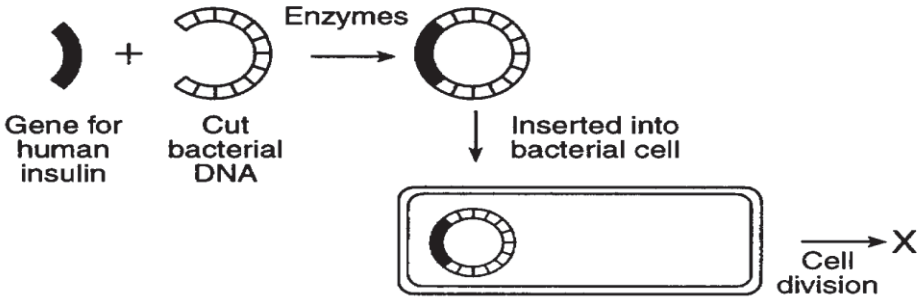
A) **Selective breeding**: also called **artificial selection**. Humans breed organisms to produce offspring with desired traits.

1. Used with breeds of dogs, horses. Also plant breeders for specific flower colors or food quality (juicy strawberries, red tomatoes)
2. Cannot be used to breed completely unrelated species (dog with alligator).

B) **Genetic engineering:** Inserts a gene from one organism into the DNA of a different organism.

1. **Restriction enzymes** are used to cut the DNA segments at specific DNA base sequences.
2. Organism that receives the new gene will begin to make the protein coded for by that gene.
3. The new protein (could be an enzyme or a hormone) will be exactly the same as the one produced by the original organism.
4. Bacteria are often used because they are cheap, simple, and reproduce quickly.
5. The example of gene splicing you MUST know:
   - **Bacteria have been genetically engineered to make insulin for diabetics.**

- **Bacteria have been engineered to make human growth hormone.**
- In both cases the engineered hormones are safe to use because they are identical to normal human hormones.



C) New technologies (**karyotyping, DNA fingerprinting**) are making it easier to diagnose and treat genetic disease, though we cannot yet cure them.
   1. **Karyotype:** A photograph of an organism's chromosomes.
      - Can determine if a person has a chromosome disorder such as Down syndrome.
   2. **Gel electrophoresis** also called **DNA fingerprinting**, creates banded patterns based on the length of a person's DNA base sequence.
      - Each fingerprint is unique, so it can be used to identify people.
      - Fingerprints of relatives are similar to each other, so can be used to determine genetic relationships between two people, or even two groups of organisms.

D) Genetic research has posed many **ethical** problems (what is right and wrong) that science alone cannot answer.
   1. Ethics: Study of what is morally right or wrong.

E) COMMON MISTAKES!

"Humans have 23 chromosomes (or 46 pairs of chromosomes) or some other incorrect
Humans have 23 PAIRS of chromosomes = 46 total chromosomes.

"Genes/DNA are made of protein."
Genes carry the instructions to make protein. The genes are made of DNA (a nucleic acid).

"Amino acids and nucleic acids are the same thing.
Amino acids are the building blocks (monomers) of proteins.

UNIT SIX - ECOLOGY

I. **Ecology:** The study of the interaction between organisms and their environment.

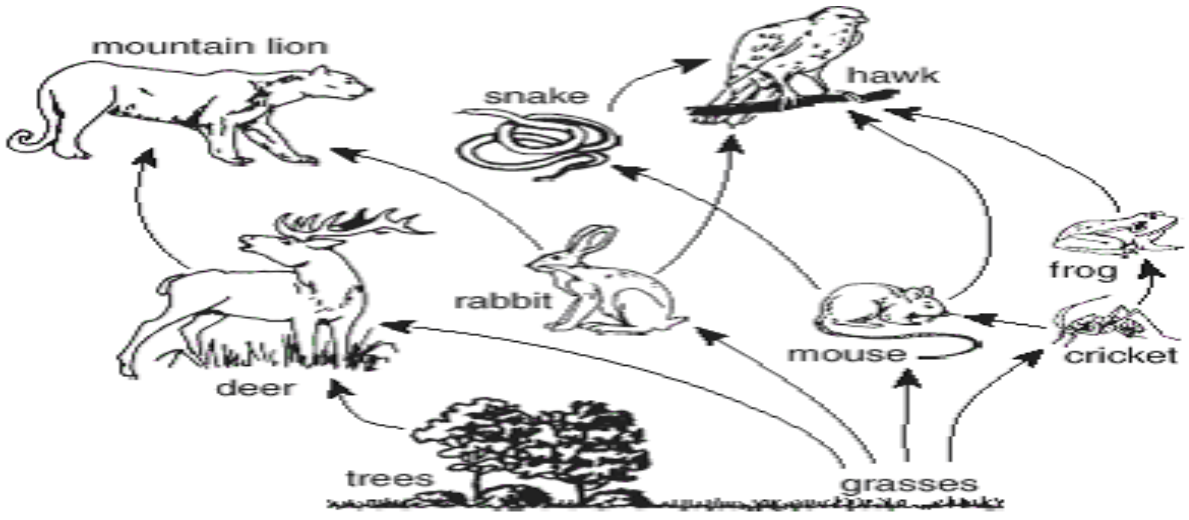
A) **Habitat:** Where an organism lives.

B) **Niche:** What an organism does, primarily determined by when, where, and how it obtains food.

1. **Two species in an ecosystem trying to fill the same niche will create competition**, which usually results in only one species occupying a niche at any one time. Organisms with similar needs will often divide resources to reduce competition (ex: birds eat insects during the day, bats eat them at night).

C) **How organisms interact with each other:**

1. **Competition**: Two organisms need the same resource at the same time.
   Ex: A squirrel and a chipmunk compete for acorns.
2. Feeding: One organism feeds on another.
   - **Producer** – An **autotroph**; organisms that makes its own nutrients from simple molecules (carbon dioxide and water).
   - **Consumer** – A **heterotroph**; may be an herbivore, carnivore, omnivore or decomposer.
   - **Decomposer** – A **heterotroph** that **decays** dead organisms and returns (recycles) nutrients to the environment.



Notice that the arrows follow the path of nutrients through the food web.

3. **Symbiosis**: A close relationship between two organisms in which at least one benefits.
   - Can include 2 organisms working together for mutual benefit (bee and flower) or 1 organism harming another (parasite-host).

II. Organization

A) **Abiotic** Factors: Non-living

B) **Biotic** Factors: Living

C) Levels of organization (from small to large)

1. **Population:** All members of <u>one</u> species in an area. (Gray squirrels)
2. **Community:** All the different species in an area. (Gray squirrels, robins, earthworms, carpenter ants, maple trees, oak trees,)
3. **Ecosystem:** All species in an area <u>and</u> the abiotic factors.
4. **Biosphere:** Portion of Earth where all life is found.

III. **Populations**: A given area can only supply enough resources for a limited number of organisms.

D) **Carrying capacity**: The largest population an ecosystem can support.

E) **Limiting factors**: Anything which limits the size of a population, including sunlight, water, temperature, climate, soil type, territory, food, predators, disease, competition,

F) **Overpopulation**: When a population exceeds the carrying capacity. Usually results in a large number of organisms dying off until a new balance is reached.

III. Energy in an Ecosystem

A) The sun provides all energy for the majority of life on Earth.

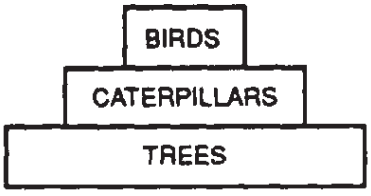
B) Sun's energy is stored in the chemical bonds of food through the process of photosynthesis.

C) **Food chain –** Shows 1 way that energy can "flow" through an ecosystem.

D) **Food web** – Shows many energy pathways through an ecosystem.

E) **Energy pyramid**: Shows that energy is lost with each step in a food chain.

1. Energy is lost because every organism uses some of the energy for its own life processes. **ENERGY CANNOT BE RECYCLED!**
2. **Only about 10% of energy is passed from one step to the next**. This is why populations of predators are typically less than the populations of their prey.



IV. Biodiversity refers to the variety of life on earth.

F) **Diverse ecosystems** (with many different species) are more stable than those that are not diverse.

G) As habitats are lost and species become extinct, biodiversity is reduced. This is considered bad because:

1. **Ecosystems with low diversity are less stable than ecosystems with more diversity,**
2. **Ecosystems with low diversity take longer to recover from environmental changes.**

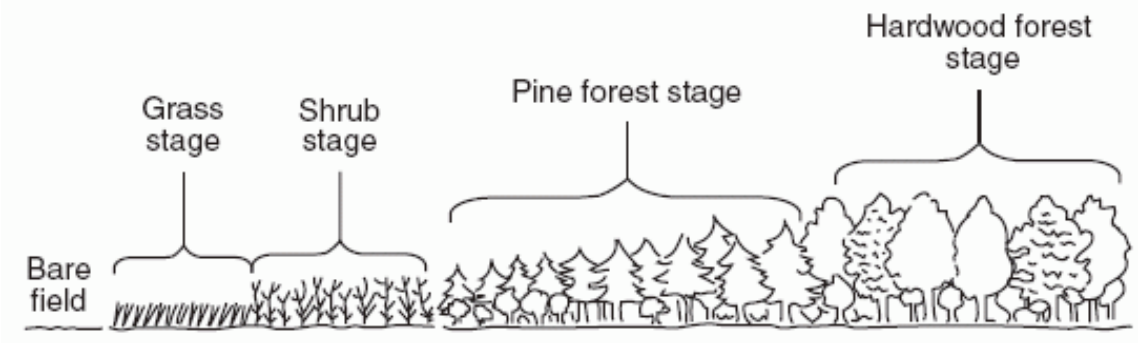
3. **Humans use organisms for many things such as food and medicine; by reducing biodiversity we are losing potentially valuable resources.**

V. Ecological Succession: Process in which one community is gradually replaced by another, until a **climax community** is established.

H) The organisms in each stage of succession change the environment, and allow new organisms to move in and replace them.

I) **Climax Community**: The final stage of succession.
   1. The climax community is determined by the local climate.
      - Ex: Kansas has very fertile soil, but not enough rain to support trees, so succession stops with grasses and shrubs.

J) Any temporary disruption of a community will begin the process of succession all over again.
   - Example: If a forest fire kills all the trees in an area, succession will eventually return the area back into a forest, but it much first pass through all the necessary stages.
   - The type of ecosystem will be the same as the original community. A deciduous forest will replace a deciduous forest destroyed by fire.



IV. Human Impact: Human actions can have both a negative or positive impact on the environment.

A) **The primary reason humans have a negative impact on the environment is because the human population is growing, which places a greater demand on resources such as food, water and space.**

B) **There are no easy solutions to any ecological problem. Every solution can have negative consequences. Choosing the "right" actions requires weighing the benefits with the risks.**

C) Human actions that generally have a negative impact on the environment include:
   1. Development/industrialization
   2. Pollution of air, water, and land.
   3. Farming
   4. Overhunting/overgrazing
   5. Clear cutting/deforestation
   6. Introduction of foreign species

D) **Actions taken by humans to reduce or repair damage to the environment include:**
   1. Recycling wastes
   2. Conserving available resources
   3. Using cleaner resources (ex: solar or wind energy over fossil fuels)
   4. Protection of habitats and endangered species
   5. Use of biological controls instead of pesticides
   6. Farming native plants (ex: cocoa in the rainforest)
   7. Planting trees to replace those cut down.
   8. Rotating crops or planting cover crops to reduce soil loss.
   9. Passing laws to control pollution, land management, hunting and fishing

Specific Environmental Problems:

E) Industrialization
   1. Cause: Development of factories and cities
   2. Negative effect: Increases use of resources, increases human population, increases pollution, acid rain, global warming, habitat loss
   3. What can be done: Plan carefully, use cleaner technology, pass laws to regulate development

F) Acid rain
   1. Cause: Burning fossil fuels, releasing sulphur and nitrogen in the air, which react with rain water to form acid.
   2. Negative effect: Acidification of lakes and soil, damages wildlife and plants, increases erosion of buildings
   3. What can be done: Use filters on smokestacks from factories. Use buffers to neutralize acids in lakes and rivers, reduce use of fossil fuels

G) Depletion of ozone layer – **NOT related to global warming!**
   1. Cause: Use of CFC's (chlorofluorocarbons) in aerosol sprays and refrigeration coolants
   2. Negative effect: allows more UV radiation into atmosphere. Increases skin cancer rates
   3. What can be done: Don't use CFCs – use safer chemicals.

H) Loss of habitat (example – deforestation)
   1. Cause: Industrialization, farming, increasing human population
   2. Negative effect: Loss of **biodiversity**
   3. What can be done: Pass laws to protect natural areas (national parks, wildlife sanctuaries), control population growth

I) Loss of Biodiversity
   1. Cause: habitat loss, over hunting/fishing/harvesting, pollution, introduced species
   2. Negative effect: ecosystems are less stable, humans lose potential resources
   3. What can be done: pass laws to protect species, regulate hunting

J) Global warming
   1. Cause: increased emissions of greenhouse gases from fossil fuels (especially CO_2)
   2. Negative effect: Climate change can lead to loss of habitat and species
   3. What can be done: Cleaner technologies, alternative energy, reduce CO_2 emissions.

K) Introduced species (also known as INVASIVE or ALIEN species)
   1. Cause: humans moving around planet (tourism, business, etc.)
   2. Negative effect: new species may outcompete native wild life
   3. What can be done: control importation of new species, use **biological controls** (natural predators and disease) to control population

COMMON MISTAKES!

"Energy is recycled in ecosystems."
Energy can NEVER be recycled. Carbon, water and nitrogen are elements that ARE recycled.

"Decomposers are autotrophs because they grow in the soil."
Decomposers are a type of heterotroph. They obtain food by decaying dead organisms.

LAB SKILLS

I. Terms:

A) **Observation:** What is seen or measured.

B) **Inference:** A conclusion based on observation or evidence.

C) **Hypothesis:** A <u>prediction</u> based on available evidence. A good hypothesis states both cause and effect.
   1. A correct hypothesis can be **tested** and **falsified** (proven incorrect) using an **experiment**.
   2. The easiest way to write a correct hypothesis is as an **"if-then"** statement. (Ex: <u>If</u> I give patients this pill, then they will not get sick.)

D) **Theory:** An <u>explanation</u> of natural events that is supported by strong evidence.
   1. Theories tie together many scientific facts, hypotheses and laws.
   2. **Common Mistake:** "Theories are things that are opinions, or are not proven."
      *This is an incorrect use of the word "theory" in a scientific context. A scientific theory is **<u>not</u>** a simple guess or conjecture, and **<u>is</u>** strongly supported by evidence.*

II. Controlled Experiments: Compares the results of an experiment between one or more experimental groups with a "normal" group.

A) **Experimental group:** Group being tested or receiving a special treatment.

B) **Control group:** "Normal" group. Should be identical to experimental group in every way except *one*: it does not receive the new treatment.

C) **Placebo:** A sugar pill or other "fake" treatment given to the control group. Usually only needed when using human subjects.

D) **Independent Variable:** Variable that is being tested (ex: new drug, new fertilizer).
   1. The "If" part of an "If-then" hypothesis. This is the "treatment."
   2. The independent variable is always plotted on the X axis.

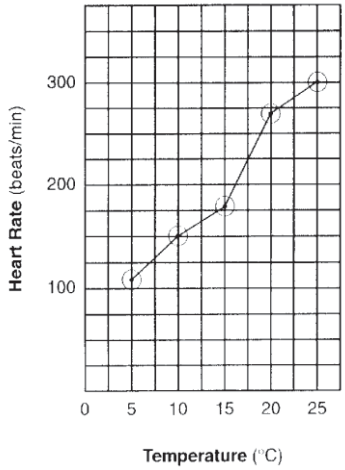
E) **Dependent Variable:** Variable that is measured at the end of an experiment; the results.
   1. The "then" part of an "If-then" hypothesis.
   2. The dependent variable is always plotted on the Y axis.

III. Data Tables and Graphs

A) **Data tables** are used to organize data which will be plotted in a graph.
   1. First column in the table is for the **independent variable**.
   2. Second column is another for the **dependent variable.**
   3. Each column should be titled, and include units of measurement.
   4. Data (independent variable) must be arranged in either ascending or descending order.

Data Table

Temperature (°C)	Heart Rate (beats/min)
5	108
10	150
15	180
20	270
25	300



B) Both the x and y axis of the graph must be labeled. These labels are typically the same ones used in the data table. Once again units of measurement must be written with the label.
   1. The **independent variable** is always plotted on the **x-axis**.
   2. The **dependent variable** is always plotted on the **y-axis**.

C) The x and y axis must be numbered.
   1. **These numbers must increase by uniform spacing** (that is you must count by 2's, 5's, etc.).
   2. **Your numerical scales should take up most of the axes**. Squeezing it all into the bottom corner makes the graph impossible to read and no credit may be given.
   3. Graphs are often line graphs, but bar graphs may be used. Check test directions carefully.
   4. **DO NOT USE ARROWS. DO NOT USE "BREAK" SYMBOL.**

Example of a Controlled Experiment:

Hypothesis:
If people chew gum it will improve their memory.

Independent variable:
Chewing gum – some people will chew gum, some will not.
Dependent variable
Memory – all groups should have their memory checked both before and after the experiment to see if it was improved.

Control Group
Doesn't chew gum (remember – the control group never receives the new treatment)
Experimental Group (INDEPENDENT VARIABLE)
Group that chews gum.

Constants
Should be the same for both groups:
People in each group should be of similar health with similar memory, with similar mixes of sexes, ages, and ethnicities. Each group should also be tested in the same way.

Data Collected
You should test people's memories both before and after the experiment.

IV. Characteristics of a good experiment:

A) **Can be repeated the same way and get the same results.**
B) **Have large sample size/many test subjects.**
C) **Are performed over longer periods of time.**
D) **Test only one independent variable.** All other characteristics of the tested groups should be the same.
E) **Are peer reviewed –** examined by other scientists to determine its accuracy.
F) **Must test the hypothesis and show whether it is wrong or right**.
G) **Is objective –** the experiment and conclusion are fair and **unbiased**. Fact and opinion are not mixed.
H) The experiment follows established **ethical** and **legal** standards.

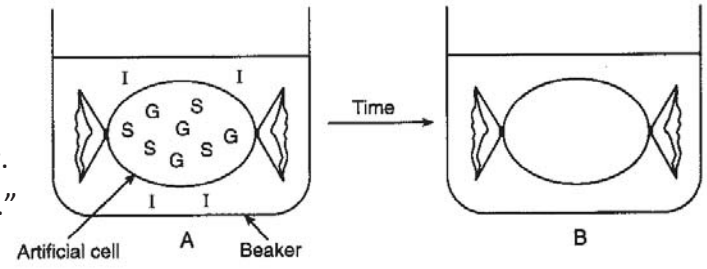
4 REQUIRED REGENTS LABS

I. Diffusion Through A Membrane

A) **Part A**

1. What you did:

- Made a model cell using **dialysis tubing**.
- Put glucose and starch inside your "cell."

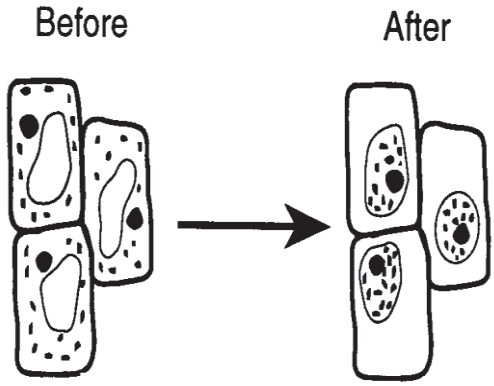


- Put starch indicator (iodine) outside cell

2. **What you saw:**
   - Inside of cell turned black because iodine diffused *into* the cell
   - Because outside of the cell was not black, you know the starch did not diffuse through the membrane.
   - Used blue glucose indicator (Benedict's solution) to see that glucose did diffuse through the membrane.
3. **What you learned**
   - Small molecules (glucose, iodine) can **diffuse** through a membrane on their own.
   - Large molecule (starch) cannot diffuse through a membrane on their own.
   - You can use indicators to identify the presence of specific substances.

B) **Part B**

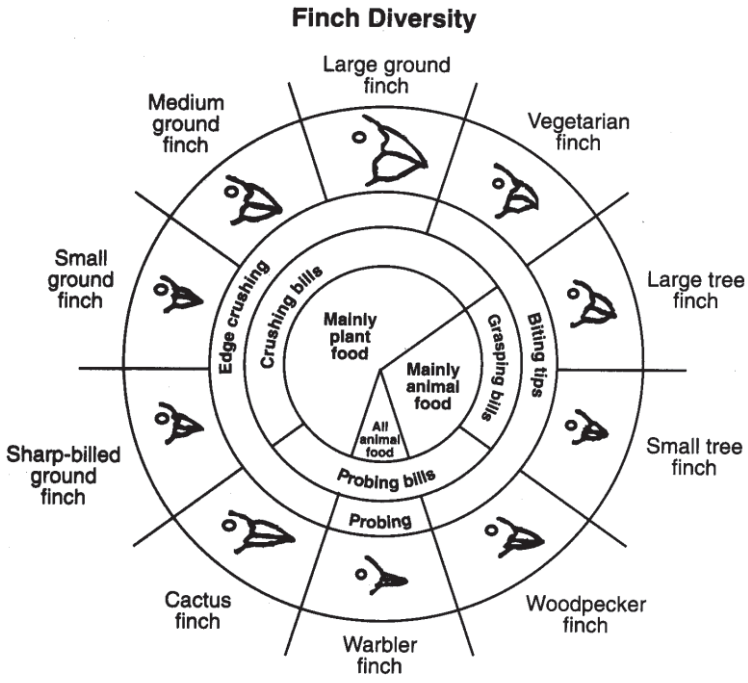
1. **What you did:**
   - Looked at red onion cells under the microscope.
   - Added salt water to the onion cells.
   - Added distilled (pure) water to the onion cells.
2. **What you saw:**
   - Salt water caused the onion cells to shrivel.
   - Distilled water because the cells to swell back to normal.
3. **What you learned:**
   - **Salt water causes water to diffuse out of a cell.**
   - **In pure water, water will diffuse into a cell.**

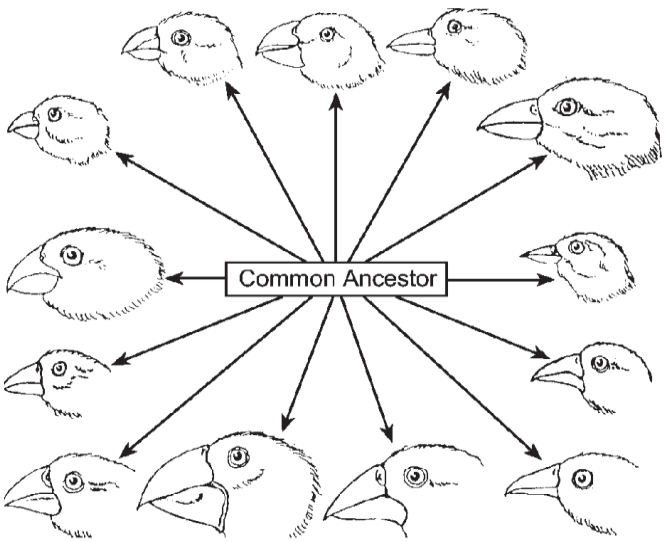


II. Beaks of Finches

A) **What you did:** Used different tools to represent different finch species competing for food.

B) **What you learned:** Different environmental conditions (food) favored different species of finch, allowing some to survive and reproduce, but not others.





III. Making Connections - The Clothespin Lab

A) **Part A**

1. **What you did:** measured how exercise (jumping jacks) affected pulse rate.
2. **What you learned:** exercise increases pulse rate

B) **Part B**

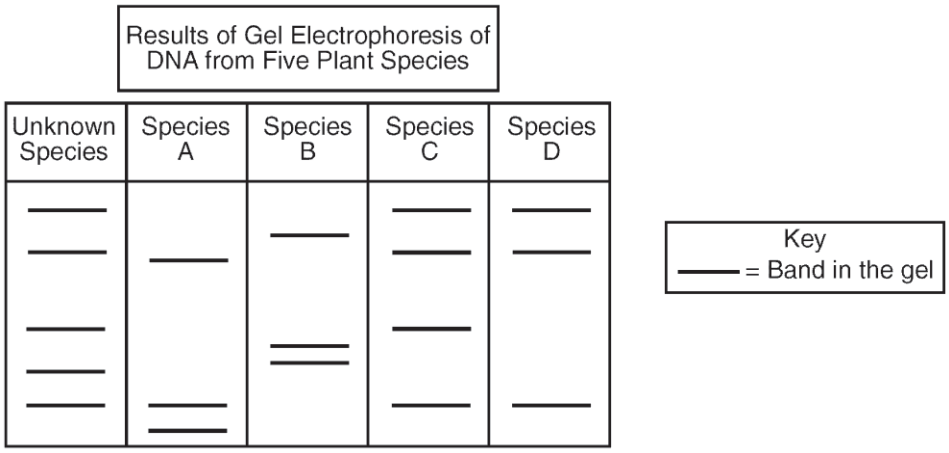
1. **What you did:** Squeezed a clothespin for 1 minute, then squeezed it again for another minute.
2. **What you learned:**
   - If you squeezed less the second round, it may have been because your finger muscles were fatigued because of lactic acid build up (waste product of fermentation).
   - If you squeezed more the second round, it may have been because your finger muscles were "warmed up" from increased circulation.

IV. Relationships and Biodiversity - (*Botana curus* lab)

A) **What you did:** Compared 4 species of plants, based on structural (physical) and molecular (chemical and genetic) traits.

B) **What you learned:**

1. Species that are related share similar traits.
2. Different techniques (such as **gel electrophoresis** and **paper chromatography**) can be used to determine relationships between organisms.
3. Endangered species should be protected because they may offer benefits to humans.



Gel Electrophoresis – A technique used to show how species are related to one another.

Restriction enzymes cut DNA into fragments, which are placed into a well in a gel plate.

An **electric current** carries the DNA fragments through the gel, from the negative pole (next to the labeled well) to the positive pole. The DNA fragments separate according to size (smaller pieces of DNA are carried farther from the well than larger pieces). **This creates a pattern of bands which is unique for every organism.**

Related organisms show similar banding patterns because their DNA has similar length base sequences.