SM

Living Environment Regents Review

WHAT YOU ABSOLUTELY, POSITIVELY NEED TO KNOW TO ACE THE LE EXAM!

Topic One: Chemistry of Living ~~Things~~

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

A) **Homeostasis:** A balanced state in the body

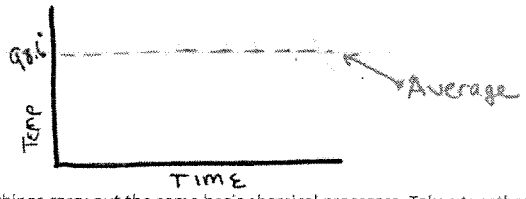
B) Failure to maintain homeostasis results in disease or death

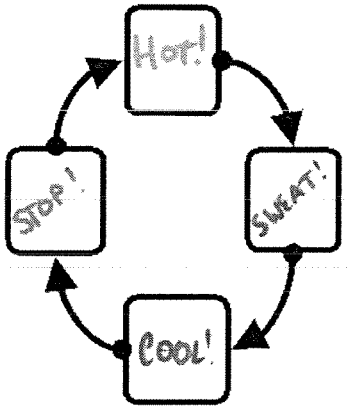
C) Homeostasis is often maintained using feedback mechanisms.

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 process make up an organism's metabolism.

A) **Metabolism:** all chemical processes used to maintain homeostasis

1. Nutrition: Using nutrients for growth, synthesis, repair and energy.
2. Respiration: Converts energy in food into a usable form (ATP).
3. Synthesis: Making complex chemicals from simple substances.
4. Transport: Absorbing and distributing materials throughout the body.
5. Regulation: The control and coordination of life processes.
6. Excretion: Removing of wastes produced by metabolic activities.
7. Reproduction: Passes on genes to offspring.

III. **Inorganic Chemicals**: Simple compounds

A) **Water** (H_2O) : Most common substance in all living things (about 60% of body mass)
- Needed for chemical reactions (won't happen in "dry" conditions)
- Dissolves other molecules into **solution**, allowing them to be **transported** through the body.

B) **Oxygen** (O_2): Needed by **most** (not all) organisms for **cellular respiration**.
- Released by plants and algae as a waste product of photosynthesis.
- **Aerobic respiration:** Process that uses oxygen to extract **energy** from glucose (sugar). Used by most organisms.
- Anaerobic respiration: Process that extracts energy from glucose without using oxygen. Gives less energy, so only used by some simple organisms (some bacteria, yeast). These organisms do not need to breathe in oxygen.

C) **Carbon Dioxide** (CO_2): With water, used by plants to make glucose (**photosynthesis**).
- Waste product of **aerobic respiration**.

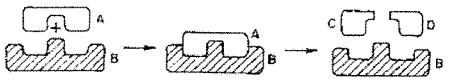
D) **Nitrogen** (N_2): Most common gas in air (70%)
- Needed to make protein.
- Converted into nitrates by soil bacteria. Nitrates are absorbed by plants and then eaten by animals.
- Excreted as waste in ammonia or urea.

E) Acids and Bases: Used for different functions in body (such as digestion).
- Measured by the pH scale
- Very high and very low pHs are usually lethal.
- 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:** Larger, more complex chemicals. Always contain the elements carbon (C)and hydrogen (H). Synthesized from simpler substances (building blocks).

A) **Carbohydrates:** Sugars + starches

1. **Building blocks:** Simple sugars
2. Functions:
   - Provide energy
   - Store energy (starch) ← in plants



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

B) **Lipids:** Fats, oils and waxes

1. Functions:
   - Store energy
   - cell membrane
   - water proofing
   - insulation

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

1. **Building blocks:** Amino acids
2. After water, proteins are the most plentiful substances in the body.
3. Have many different functions as determined by their _____.
4. **Lock and Key Model:** Proteins must have the right shape to "fit" with other molecules.
   - **Changing the shape of a protein will change what it can interact with its function.**
5. Important types of proteins:
   - **Hormones** and **neurotransmitters** – carry messages through the body.
   - Cell receptors – in cell membrane; receive hormones and neurotransmitters.
   - Antibodies – attack foreign **pathogens**
   - **Enzymes**- act as **catalysts**, controlling all chemical reactions in the body.
     - High temperatures will cause enzymes to denature (lose their shape) and stop functioning. This is why high fevers are dangerous.

D) **Nucleic Acids (DNA and RNA):** Make up genes and chromosomes.

1. **Building blocks:** Nucleotides; molecular bases (ATCGU)

Topic Two: The Cell

I. Definition: Basic unit of structure + function in an organism

II. Cell Theory has three parts:

1. All organisms are made of 1 or more cells
   Unicellular – single celled organisms (amoeba, paramecium)
   Multicellular – have more than 1 cell; may be only a few (vorticella), or many *trillions* of cells (humans). Almost all structures in multicelled organisms are made of or by cells.

2. All life functions are the result of cell activities
   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.

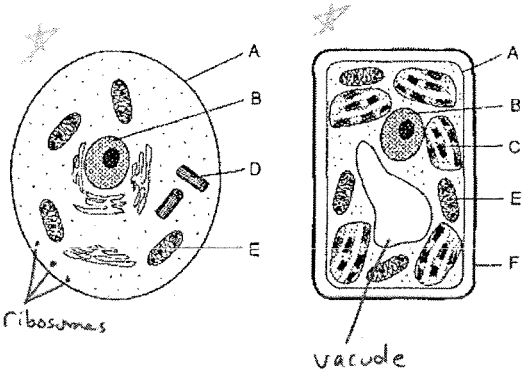
B) Exceptions to the Cell Theory

1. Viruses are not made of cells. However, they also do not carry out all life processes, so many biologists do not consider them true living things.
2. The 1st cell obviously could not come from another cell.

III. Organization

organelle - a cell part
↓
cell
↓
tissue - group of specialized cells
↓
organ - group of tissues that work together
↓
organ system - group of organs that work together
↓
organism

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



1. Nucleus (B)
   - Controls the cell
   - Contains hereditary material (chromosomes, genes, DNA)
2. Cytoplasm
   - Fluid/liquid in the cell – mostly water
   - Helps transport material
3. Mitochondrion (E)
   - Carries out cellular respiration.
   - Gives cell energy (Powerhouse of the cell).
4. Ribosome
   - Makes proteins from amino acids.
5. Vacuole
   - Stores food, water and waste
   - Food vacuoles may digest large molecules.
   - Waste vacuoles may excrete waste out the cell membrane
6. Chloroplast (C)
   - Carries out **photosynthesis**
   - Plant and algae cells only
7. Cell Wall (F)
   - Gives shape, structure and protection.
   - NEVER found in animal cells.
8. Cell Membrane (A)
   - Separates cell interior from environment
   - Controls what enters and leaves the cell using transport proteins.
   - Has receptor proteins that pick up signals from other cells.
   - Has antigens which are proteins that identify the cell; prevent the cell from being attacked by the immune system.

Topic Three: Nutrition, Photosynthesis and Respiration

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

I. **Nutrition:** Taking in nutrients (food) for various activities including:
   1. Respiration (energy)
   2. Growth
   3. Repair
   4. Synthesis

A) **Ingestion:** Taking in nutrients

B) **Digestion:** Breaking down nutrients
   1. Nutrients must be broken down into smaller parts so that they can be absorbed into the blood and cells of organisms.
      - Starches are digested into sugars.
      - Proteins are digested into amino acids.

C) **Autotrophic Nutrition:** Organisms take simple inorganic materials (CO_2, H_2O) and convert them into organic nutrients (glucose).
   1. Auto = self ; troph = feeding so Autotroph = self feeding
   2. Photosynthesis is most common form of autotrophic nutrition
   3. Ex: Plants, algae

D) **Heterotrophic Nutrition:** Organisms must consume nutrients made by other organisms.
   1. Hetero = other, so Heterotroph = feeds on others.
   2. All animals and fungi are heterotrophs.
   3. Includes:
      - Carnivores: consumes animals
      - Herbivores: consumes plants
      - Ominivores: consumes both
      - Decomposers: breaks down dead matter

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

A) Requires sunlight, CO_2 and H_2O.

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

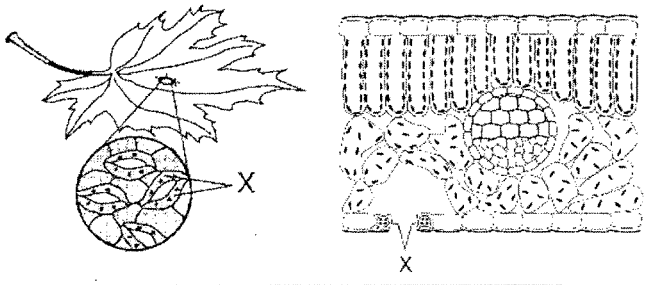
C) O_2 and H_2O are waste products.

D) Benefits:

1. Provides food for all plants, animals and other organisms.
2. Provides oxygen to breathe.
3. Removes CO_2 from atmosphere.

E) Plant adaptations:

1. **Chloroplast:** Cell organelle that does photosynthesis
2. Gas exchange:
   - **Stomates:** Holes under a leaf; let gases in and out
   - **Guard cells:** open and close stomates to prevent dehydration
3. Transport:
   - **Xylem and Phloem:** "tubes" transport food and water throughout the plant.



Two different views of the **stomates** and their **guard cells** (X).

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

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

B) Requires glucose, O_2 and H_2O.

C) CO_2 and H_2O are waste products.

Photosynthesis

Sunlight + CO_2 + H_2O → Glucose + O_2 + H_2O

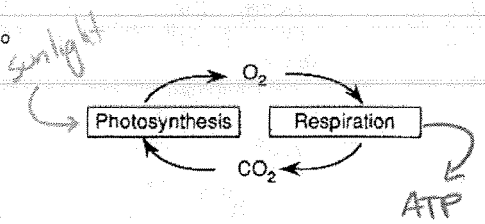
Cellular Respiration

Glucose + O_2 + H_2O → ATP + CO_2 + H_2O

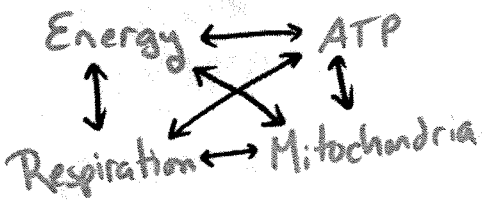
D) Most organisms carry out **aerobic respiration** (uses oxygen) in their **mitochondria**.

E) **Anerobic respiration** does not require oxygen, but gives less ATP (energy) for each molecule of sugar.
- When exercise causes human muscles to run out of oxygen, their 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 also important in cycling oxygen, carbon, hydrogen and water through the environment



G) **Common mistakes:**
- "Plants use photosynthesis, animals use respiration."
  All organisms, including plants, use respiration to get their energy.
- "Respiration is breathing."
  *Breathing is **not** respiration. Breathing exchanges the gases needed for respiration. Inhaling and exhaling does not give you ATP.*
- "Oxygen is used to breathe."
  This is backwards. Breathing is used to get oxygen which is used for respiration. Without oxygen, you have no respiration, no ATP, and no energy.
- "All living things need oxygen/need to breathe."
  Anaerobic organisms do not need oxygen, and do not have to breathe.



Topic Four: The Human Body

I. **Organization:** The human body is made up 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 special shape and function.
      2. Cells specialize by turning specific genes on or off.
         - Ex: A white blood cell has turned off 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 turned on.
   D) As the body continues to develop, tissues will work together to form organs.
   E) Organs will work together to form organ systems.
   F) Org an systems will work together to help a person **maintain homeostasis.**

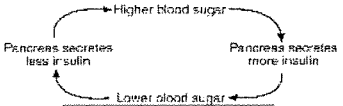
Two **neurons** carry an impulse to a muscle cell. (3) shows where a **neurotransmitter** would carry the signal from one cell to the next.

II. **Nervous System**
   A) The nervous system regulates your body with electrochemical impulses.
      1. The chemical portion of a nerve impules is called a neurotransmitter
      2. Neurotransmitters released by 1 nerve cell are received by receptor proteins 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 also called a neuron.
   C) The main organs of the nervous system are the brain and spinal cord
   D) The **spinal cord** controls reflexes and relays impulses between the brain and body.

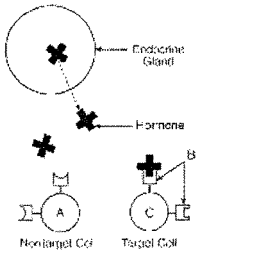
III. Endocrine System

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

1. A hormone is a chemical messenger secreted by endocrine **glands.**
2. Hormones are slower than nerve impulses, but with longer lasting effects.
3. Hormone levels are controlled by **feedback mechanisms.**



A feedback mechanism



4. **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.**

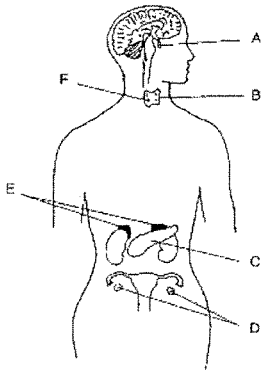
Receptor Molecules in the cell membrane can only accept molecules of the correct shape. This is a good example of the **Lock and Key Model.**

B) The pancreas makes insulin and glucagon which control blood sugar.

- **Common mistake:** "Insulin lowers blood pressure."
  Insulin (and glucagon) directly control blood sugar (or glucose) levels, not blood pressure.

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

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



The brain (nervous system) and some endocrine glands.

IV. Circulatory System

A) Moves material through the body to the organs and cells that need them.

B) Transported material includes:

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. wastes 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.
   - **Ex**: There is a high concentration of oxygen in the lungs, so oxygen will diffuse 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.

E) Red blood cells carry oxygen and carbon dioxide

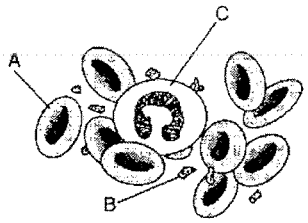
1. Hemoglobin: Protein in red blood cells that carries oxygen.

F) Plasma is the fluid of the blood. It transports everything *except oxygen.*

G) Platelets clot the blood.

H) Common mistakes:

1. "The heart pumps oxygen to the brain."
   Technically true, but the heart pumps blood (which carries the oxygen) everywhere in your body.
2. "Oxygen diffuses into and out of the heart."
   No materials diffuse in or out of the blood when it is in the heart. This only occurs in capillaries.



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

VIII. Immune System

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

B) **Pathogen:** Disease causing organism.

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

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

1. Different w.b.c's have different roles, including:
   - Identify pathogens
   - "Tag" pathogens for destruction by other wbc's.
   - 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" that identify a cell or virus.

1. Your blood type is determined by your antigens (you can have A or B antigens, both or nether (type O).
2. Any cell of virus 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.

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

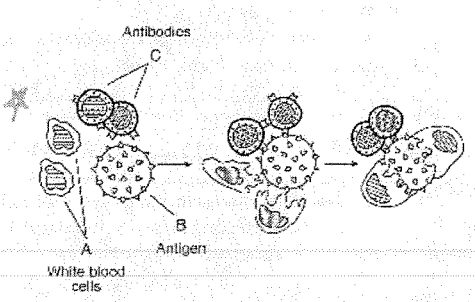
1. Triggers the body to make antibodies against that pathogen.
2. Effective against both viruses and bacteria.
3. Can only prevent disease, not cure it.

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

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

H) **Common mistake:**

1. "Antibodies are cells that attack pathogens." *Antibodies are proteins, not cells.*



An immune response – white blood cells and antibodies attack a virus.

IX. Interactions between body systems

A) The different systems of the body work together to maintain homeostasis. For example:

1. *Nutrients from the* digestive *system are transported to cells by the* circulatory *system.*
2. *Wastes from the* nervous *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* respiratory *system from disease.*

AND MANY MORE!

X. 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 cell reproduces (divides) at an uncontrolled rate, forming a **tumor.**
   - Cancer cells **do not specialize** and take resources from healthy tissue.
   - May be caused by radiation, chemicals (such as asbestos or cigarette smoke), and viruses.
   - Treatments include surgery, radiation therapy, and chemotherapy.
3. **Diabetes**
   - Affects body's ability to control blood sugar.
   - Some diabetics may be treated using 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.

Topic Five: Reproduction

I. Asexual reproduction:
   A) Advantages: Faster, easier, safer
   B) Disadvantage: No variety

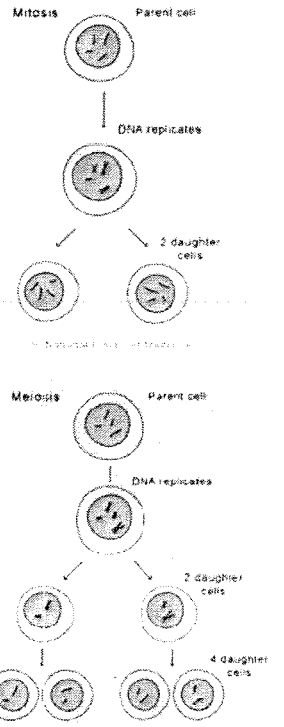
II. Sexual reproduction:
   A) Advantage: variety
   B) Disadvantage: slower, harder, riskier

III. 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) Large organisms use mitosis for growth and healing. Simple organisms use it to reproduce.
   D) One division of a cell → two identical, diploid (2n) cells.
      1. Diploid: Cell with a two sets of chromosomes. (in pairs)

IV. Meiosis
   A) Makes gametes used in sexual reproduction.
      1. Gamete: Sex cells; egg and sperm
   B) One cell divides *twice* → four DIFFERENT haploid (1n) cells.
      1. Haploid: Cell with one set of chromosomes (½ normal)
   C) Separates pairs of chromosomes so that offspring get one chromosome of each pair from that parent.
   D) Each daughter cell (gamete) gets only one half of the chromosomes of the "parent" cell.

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 males life
      3. Sperm are smaller than the egg and mobile
      4. Sperm only provide 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.

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



VI. Female Reproductive System

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

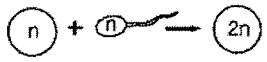
C) The fallopian tube carries the egg to the uterus.

D) The uterus is the womb where the baby will develop.

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

VII. Development

A) Fertilization occurs in the 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).



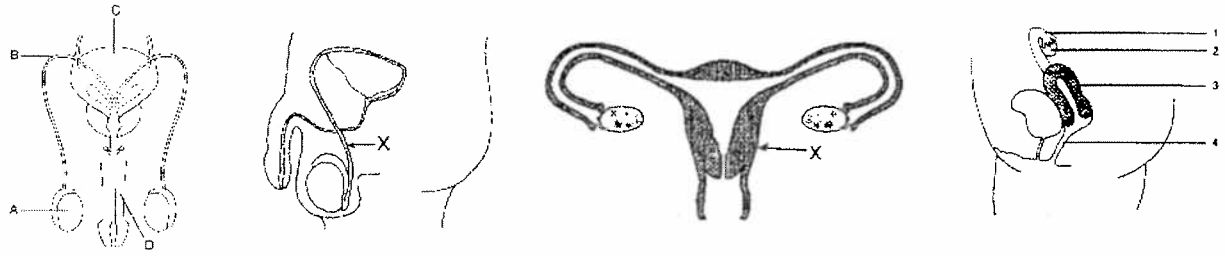
Fertilization retores the correct number of chromosomes.

B) A zygote develops in the following order:
   1. Cleavage – A form of mitosis; cells divide but do not differentiate
   2. Differentiation – Cells begin to form into tissues and organs
   3. Embryo – up to 8 weeks
   4. Fetus – most major organs are formed (but not completed) - after 8 weeks
      - Continues to grow through cell division (mitosis)

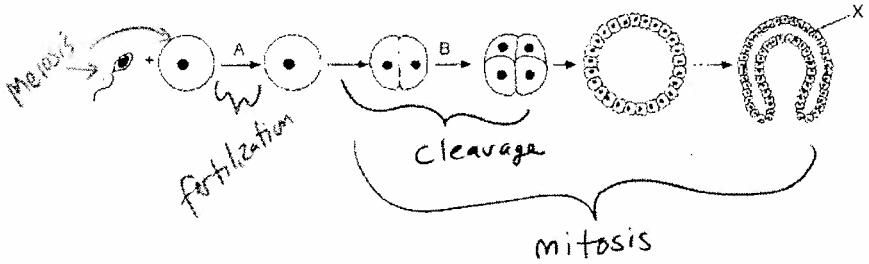
C) The placenta transfers nutrients and oxygen from the mother's blood into the blood of the fetus through the process of diffusion.
   1. The blood of the mother and fetus do not mix.
   2. The fetus is attached to the placenta by the umbilical cord.
   3. Waste produced by the fetus is also removed 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, etc because organs and systems are still developing.

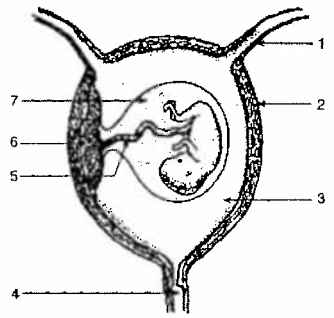
Front and side views of the male and female reproductive systems



Early development – Fertilization (A) forms a single celled zygote which then begins the process of cleavage (B) which will eventually create a layered ball of cells that will form the embryo.



Late Development – The fetus pictured here is nearly ready to be born. Note the umbilical cord, placenta and amniotic sac.



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Topic Six: Genetics

I. **Chromosomes:**
   A) Humans have 46 chromosomes, or 23 homologous pairs.
      1. **Homologous:** Chromosomes w/ same genes, size + shape
   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.
   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 missing many 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.**
   D) **Common mistake:** "Humans have 23 chromosomes (or 46 pairs of chromosomes, or some other incorrect number)."
      These numbers are often confused. You must memorize them correctly.

II. **Chromosomes and Genes**
   A) Each chromosome has hundreds or thousands of genes.
   B) **Each gene codes for a particular protein.**
      1. **Common mistake:** "Genes/DNA are made from protein."
         Genes carry the instructions to make protein. The genes themselves are made from nucleic acids.
      2. While genes determine our traits, **the environment can affect expression of genes.**

III. DNA

A) DNA is the chemical that makes up your genes and chromosomes.

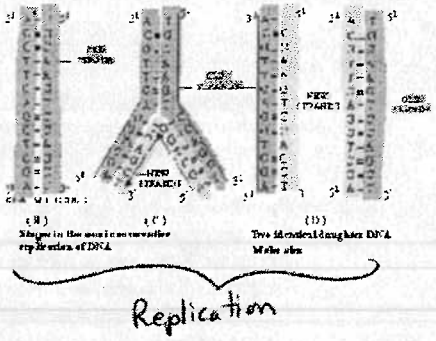
1. Analogy: If your genes and chromosomes are the "instruction manual" for your body, DNA would be the paper it is printed on.

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, G.

1. Base pairs: A-T and C-G
   - in RNA the pairs are A-U and C-G



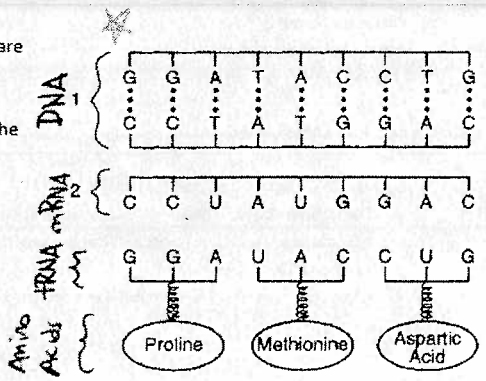
Replication

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 will 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 will determine the function of all the proteins in the body.
- The proteins build and run the body.

B) RNA carries the genetic code to ribosomes.



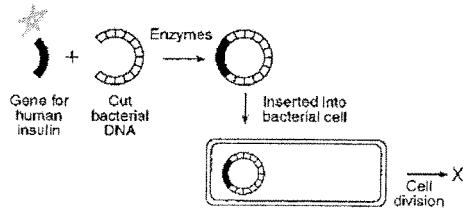
The order of DNA bases in your genes determines the order of amino acids in your proteins, which determines the protein's shape and function.

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

V. Mutations: Any change in an organisms genetic material
- A) Can only be passed on if they occur in reproductive cells (sperm or egg).
- B) Common **mutagenic agents** include Radiation, Chemicals, viruses.
  1. Mutagenic agent: Any environmental factor that causes mutations
- 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 changed.
- 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
  2. **Down's Syndrome:** Non lethal mutation, caused by inheritance of an extra copy of chromosome 21. (Note – only chromosome 21 can cause Down Syndrome).

VI. Genetic technology:
- A) Selective breeding: Controls the breeding of animals or plants to produce offspring w/ desirable traits
  Ex:

- B) Genetic engineering: "Cuts" a gene from one organism and "pastes" it into the DNA of a new organism.
  1. Restriction enzymes are used to cut and paste the DNA segments.
  2. Organism that receives the new gene will begin to make the protein, enzyme or hormone coded for by that gene.
  3. The new protein/enzyme/hormone will be exactly the same as the one produced by the original organism.
  4. Bacteria are often used because they are simple and reproduce quickly.
  5. The example of gene splicing you MUST know:
     - **Bacteria have been engineered to make** insulin **fo r diabetics.**
     - **Bacteria have been engineered to make** growth hormone.
     - In both cases the engineered hormones are safe to use because they are identical to normal human hormones.



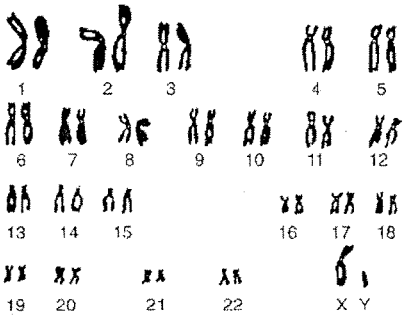
C) New technologies (**karyotyping, DNA fingerprinting**) are making it easier to diagnose and treat genetic disease, though we cannot yet cure them.

1. **Karyotype:** A photograph of an organism's chromosomes.
   - Can determine if a person has a chromosome disorder such as Down Syndrome.
2. **DNA finerprinting**, or gel electrophoresis, creates banded patterns based on 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 (ie right and wrong) that science alone cannot answer.

1. Ethics: Study of what is morally right or wrong

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



Topic Seven: Evolution

I. Evolution: Progressive 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 didn't know about genes, so he couldn't know about mutations.

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

1. Earth is old (4.55 billion years) 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. **Common Descent:** Modern species evolved from earlier, different species and share a common ancestor.
5. Species that can not adapt become extinct.
6. New traits arise in a species from mutations and gene recombination (sexual reproduction)

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

A) Changes need to be long term – species do not evolve because of changes in the season.

B) Changes can include:

1. Climate change
2. Change in temp
3. Change in water availability
4. Change in food availability
5. Introduction of new species (new food, new predator)
6. 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) Variation: Members of a species are different from each other due to mutations and sexual reproduction.

1. No variation = no evolution or natural selection, as there is nothing to "select."
   - Species with no variation are usually the first to die when the environment changes.

B) Overproduction: Too many offspring are produced.

C) Competition: Offspring must struggle to survive and reproduce.

D) Survival of the fittest:

1. Offspring who inherited "fit" traits are, on average, better able to get resources, escape from predators and find mates.
2. Offspring with "unfit" traits will 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. Note that there is no absolute rule for fitness – what is fit in one environment may be unfit in another.
4. **Note:** This "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 fit organisms reproduce and pass on their genes than unfit organisms.
2. On average, the next generation will have 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.

F) Repetition: Evolution does not happen overnight. It takes many generations of repetitive selection to weed out the unfit traits.

V. **Speciation:** The process of making a new species from an existing one.
   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 will 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) Kingdoms are large groups of related organisms (fungi, bacteria, protists, animals, plants).
   B) A species is able to successfully reproduce amongst its members.
      1. Note that this is not a perfect definition – Lions and tigers can breed together, as can dogs and wolves. Because evolution is a constantly ongoing and gradual process, there are many, many examples in which the lines between species are blurry (see Ring Species)
   C) Branching tree diagrams (cladograms) are often used to show evolutionary relationships.

VII. **Evidence:** Evidence in support of evolution comes from many fields:
   A) **Fossil record** preserves extinct speices as well as transitional forms between different types of organisms.
   B) **Radiometric Dating** of rocks consistently confirm the age of the Earth and fossils
   C) Comparisons of the anatomy (physical structures), embryology (development), chemistry and genes of species confirm expected relationships.
   D) **Direct observation:** Humans have seen evolution occur both in nature and in the lab. Examples include:
      1. **Bacteria** evolving resistance to antibiotics.
      2. **Insects** evolving resistance to pesticides.
      3. Modeling natural selection with selective breeding to alter a species' traits.
      4. Observed examples of speciation

VIII. Common Mistakes

A) "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.

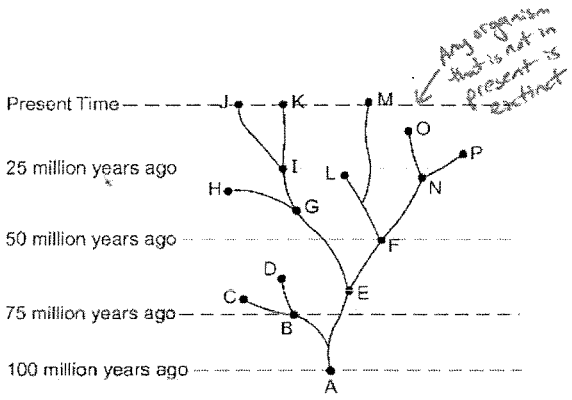
B) "The organism evolved to live in its environment."
Individual organisms do not evolve. Only populations can evolve.

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

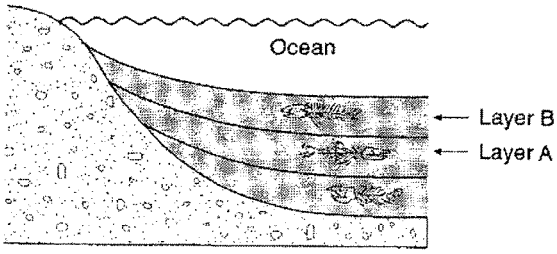
D) "The bacteria became resistant to antibiotics when they were exposed to them"
To evolve, variations must exist in a species BEFORE the environment changes (pre-adaptation). Bacteria who did not already have a resistance to antibiotics would die when exposed to them, a Chihuahua who is left out in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

E) "Giraffes got long necks because they needed them to eat leaves at the tops of trees."
Species do not evolve traits because they need them - Life would be much better if we could! 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 fit traits. Better answers are

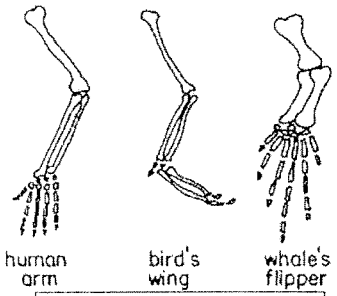
- "Giraffes evolved long necks because the ones with longer necks were better adapted to get food than short neck giraffes."
- "Giraffes evolved long necks because more short necked giraffes died, and more long neck giraffes lived and reproduced."



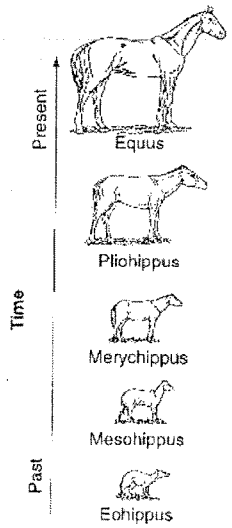
Evolutionary trees can show the relationship between living and extinct species.



Deeper fossils are typically older than those above them.



Homologous Structures reveal that the same body parts can be modified to perform different functions.



Transitional forms for many species can be found in the fossil record. This diagram shows the evolution of the modern horse from a small, many-toed ancestor.

Topic Eight: Ecology

I. Ecology: Study of organisms and their environment
   A) Habitat: Where organism lives
   B) Niche: What organism does (esp. how it gets nutrients)
      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: occurs when 2 or more organisms need same resource
         Ex: A squirrel and a chipmunk compete for food.
      2. Feeding: One organism feeds on another.
         - Producer – An autotroph; organisms that makes its own nutrients from simple substances.
         - Consumer – A heterotroph; may be an herbivore, carnivore, omnivore or decomposer.
      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 things
   B) Biotic Factors: Living things
   C) Levels of organization:

population – 1 species in an area
↓
community – all species in an area
↓
ecosystem – all species + abiotic factors in an area
↓
biome – similar ecosystems (deserts, rain forests)
↓
biosphere – all of Earth's ecosystems

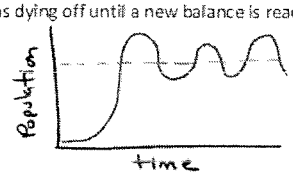
III. **Populations:** A given area can only supply enough resources for a limited number of organisms.

A) Carrying capacity: largest population that an ecosystem can support

B) Limiting factors: Anything which limits the size of a population, including:

food, water, sunlight, soil, predators, disease

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



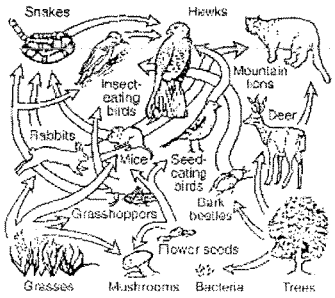
NOTE - This fluctuation in population size is an example of dynamic equilibrium!

IV. **Energy in an Ecosystem**

A) Sunlight provides all energy for life on Earth.

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

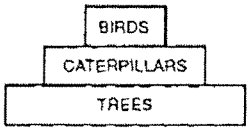
C) Food chain – Shows 1 way that energy can "flow" through an ecosystem.



D) Food web – Shows many energy pathways.

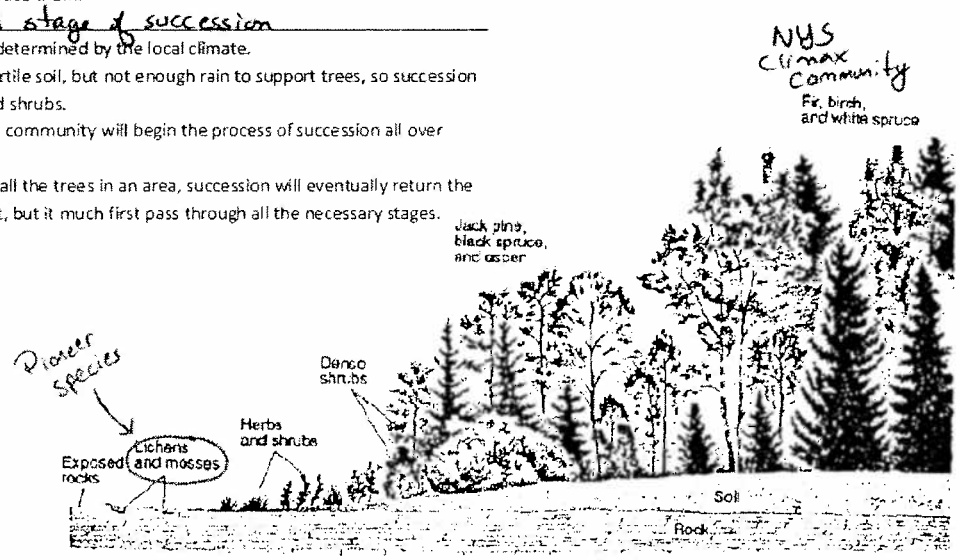
E) Energy pyramid: Shows that energy gets lost with each step in a food chain

1. Energy is lost because every organism uses some of the energy for it's own life processes. Only about 10% of energy is passed from one step to the next.
2. This is why populations of predators are typically less than the populations of their prey.



V. **Biodiversity** refers to the variety of life on earth.
   A) **Diverse ecosystems** (those with many types of species) are more stable than ones that are not diverse.
   B) As habitats are lost and species become extinct, biodiversity is reduced. This is considered to be 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.

VI. Ecological Succession: Process in which existing communities are gradually replaced by a series of new communities
   A) The organisms in each stage of succession change the environment, and allow new organisms to move in and replace them.
   B) Climax Community: 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.
   C) Any temporary disruption of a community will begin the process of succession all over again.
      - Ex: 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.



VII. **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
3. Farming
4. Overhunting,/overgrazing
5. Clear cutting/deforestation
6. Introduction of foreign species

D) **Actions being 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 over fossil fuels)
4. Protection of habitats and endangered species
5. Use of biological controls instead of pesticides and herbicides
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, fishing, etc.

VIII. Specific Environmental Problems:

A) Acid rain
1. Cause: Burning fossil fuels - emits NO_2 + SO_2 which react w/ water to form acid.
2. Negative effect: Acidification of soil + water
   - kills plants + wild life
3. What can be done: Reduce use of fossil fuels
   Use air scrubbers to reduce emissions
   Use buffers to neutralize acid

Remember!

B) Depletion of ozone layer
1. Cause: Using CFC's in coolants + aerosol sprays
2. Negative effect: Increases skin cancer
3. What can be done: Stop using CFC's

C) Industrialization
1. Cause: Change from agriculture to factory/industry
2. Negative effect: Increased pollution
   Uses more land + resources
3. What can be done:
   Laws to regulate pollution, recycling
   Set aside land for preserves, parks

D) Loss of habitat (ex: deforestation)
1. Cause: Industrialization, farming, housing
2. Negative effect: Species lose habitat - loss of biodiversity, extinction
   May disrupt food chain/ecosystems
3. What can be done: Regulate development
   Preserve land

E) Loss of biodiversity
1. Cause: habitat loss, overhunting/harvesting, pollution, climate change, introduced species
2. Negative effect: Extinction
Ecosystems become less stable
Potential loss of valuable resources
3. What can be done:
Regulate hunting/fishing/collecting
Endangered Species Act protects endangered species
Breeding programs to increase population

F) Global warming
1. Cause: Greenhouse gas emissions (CO_2) from fossil fuels
2. Negative effect: May lead to habitat loss, loss of biodiversity, extinction
Climate change
3. What can be done: Reduce emissions
Use cleaner fuels / Alternative energy
Conserve energy
Plant trees
New technology

G) Introduced species
1. Cause: Foreign species brought to new ecosystem by human travel/trade
2. Negative effect: Alien species can outcompete native species (sometimes)
Reduces biodiversity
3. What can be done: Use biological controls to remove species or limit population
Control trade/sale of exotic plants + animals
Screen cargo ships, planes, etc for "hitch hikers"

Topic Nine: Experiments and Labs

I. Terms:
   A) **Observation:** What is seen or measured.
   B) **Inference:** A conclusion based on observation or evidence.
   C) **Hypothesis:** A prediction 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: If I give patients this pill, then they will not get sick.)
   D) **Theory:** An explanation 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 not a simple guess or conjecture, and is 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 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.
      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.

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.

Experimental Group
Group that chews gum.

Control Group
Doesn't chew gum (remember – the control group never receives the new treatment)

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.

III. Graphs and Data Tables

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 in the table must be arranged in ascending or descending order.

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

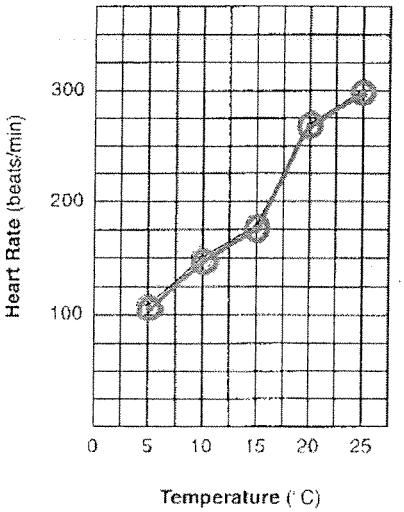
C) The x and y axis must be numbered.
   1. **These numbers must increase by a uniform increment** (that is you must count by 1's, 2's, 5's, 10's, etc).
   2. **Your numerical scales should take up most of the axes.** Squeezing it all into the bottom corner makes the graph impossible to read and no credit will be given.
   3. The **numbers must line up with the grid lines** of the graph, not with spaces between them.
   4. **You do not need to start numbering your axis with 0.**

D) To date, all graphs drawn on the LE Regents have been **line graphs.** Any student who draws a bar graph instead of a line graph will be denied credit for this part of the test.

E) All points plotted on your graph must be **surrounded by a circle** (or sometimes a square or triangle, depending on the directions).

Data Table

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



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.

Topic Ten: The State Labs (Part D)

I. Making Connections (aka The Clothespin Lab)

A) Part A

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

B) Part A2

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

C) Part B

1. **What you did:** Designed an experiment to test how exercise affects squeezing a clothespin.
2. **What you learned:** How to design an experiment (see pages 3-5).

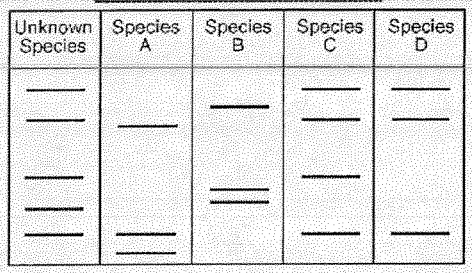
II. **Relationships and Biodiversity (*Botana curus* lab)**

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.

Results of Gel Electrophoresis of DNA from Five Plant Species



Key
——= Band in the gel

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.

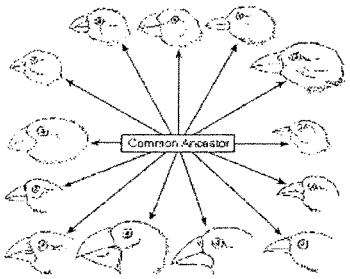
An **electric current** carries the DNA fragments through the gel, separating them according to size (smaller pieces of DNA are carried farther from the well than larger pieces). **This creates a pattern of bands which is unique for every organism.**

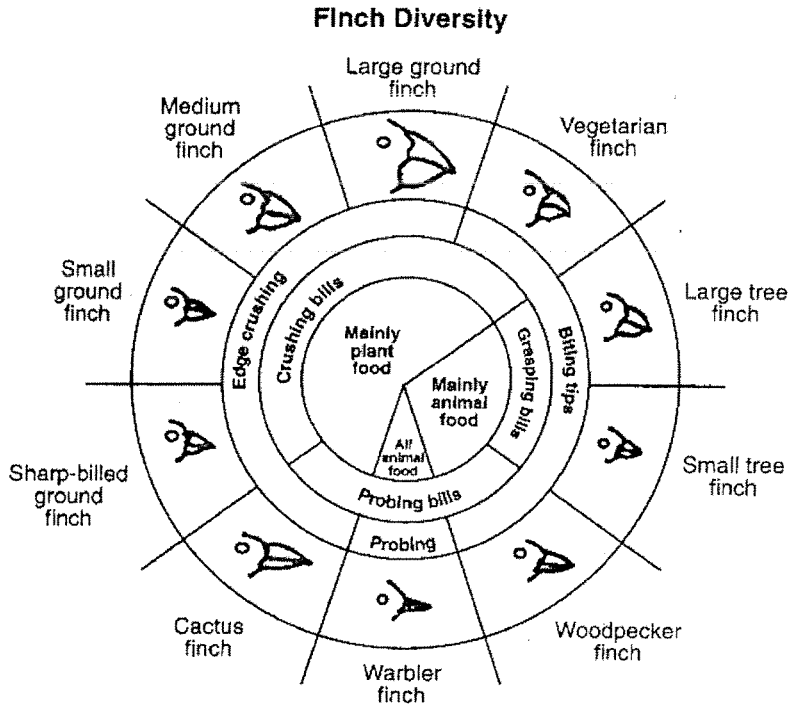
Related organisms will show similar banding patterns because their DNA have similar base sequences.

III. Beaks of Finches

A) What you did: Played 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.





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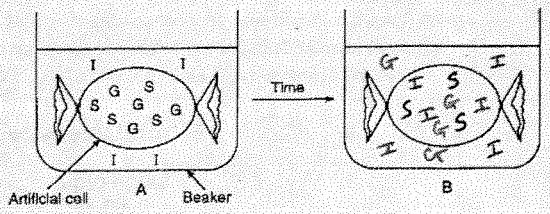
IV. Diffusion Through A Membrane

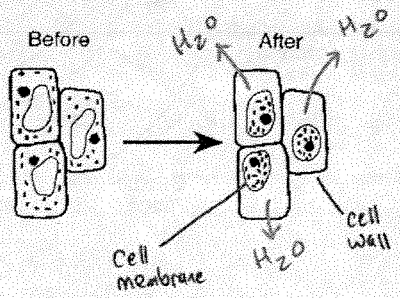
A) Part A

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 cause 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.**



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