BIOLOGY AIR TEST STUDY GUIDE

ECOLOGY: LEVELS OF ORGANIZATION

1. **Population** – all of the same species living in a particular area
2. **Community** – all of the living things (all species) living in a particular area
3. **Ecosystem** – community of living things plus their non-living surroundings

EVOLUTION BASICS

1. **Natural selection** – organisms that are best adapted for their environment have the highest **fitness** and will therefore survive, reproduce, and pass on their good genes to their offspring
2. **Sexual selection** – Females choose males based on "sexy" or "showy" phenotypes or behaviors (ex: peacock feathers)
3. **Gene flow** – when individuals move into or out of a population, new alleles/genes/traits are added to (or removed from) the mating gene pool
4. **Genetic drift** – random change in gene frequency within a population due to random events (ex: natural disaster). Only the survivors of a disaster can reproduce, so the mating gene pool is drastically reduced, and only the genes of the survivors can be passed on.

IMPORTANT: Small populations will experience more drastic changes than larger populations!

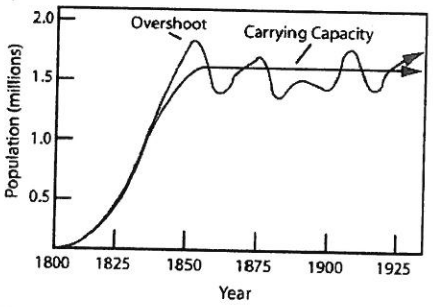
EVIDENCE FOR EVOLUTION

1. **Fossils** and/or **comparative anatomy** – if two species share lots of physical similarities, they are probably related.
2. **Biomolecules** – compare DNA, RNA, or amino acids (proteins). If the molecules have few differences, then they are probably related. More differences = less related.

ECOLOGY: CAUSE AND EFFECT IN ECOSYSTEMS

- **Biomagnification/bioaccumulation** – if pollutant (mercury, DDT, etc.) is taken up by producers (plants, algae), then the relative amount of that pollutant will increase moving up the food chain. Top-level consumers are often most affected by these pollutants.
- **Algal blooms** – extra fertilizer (nutrients) wash into lakes or ponds; algae take up extra nutrients and overpopulate ("bloom"); algae start dying off and decomposers eat them; decomposers increase in number and suck all the oxygen out of the water
- **Carrying capacity** – the number of organisms in a population that the ecosystem can support. Usually hovers around an average number.

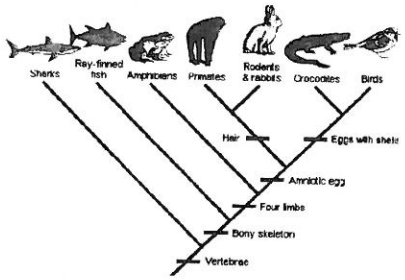
  If population too large → run out of food, population drops. If population small → predators run out of food, population rises.



CLASSIFICATION & EVOLUTION: CLADOGRAMS

Cladograms – diagrams that show evolutionary relationships between organisms

1. Organisms shown before a trait mark DO NOT have that trait. Organisms shown after a trait mark DO have that trait.
2. Organisms who are closer together on a cladogram shared a more recent ancestor and are therefore more closely related.



PROKARYOTES VS. EUKARYOTES

1. **Prokaryotes** have NO nucleus and are very simple. They have DNA, a cell membrane, a cell wall, and ribosomes, but that's it.
2. **Eukaryotes** DO have a nucleus and organelles like mitochondria, chloroplasts, ER, golgi, etc.

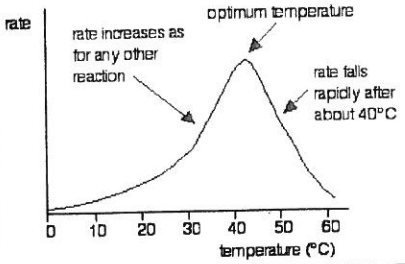
CELL STRUCTURES

1. **Nucleus** - contains DNA in eukaryotes
2. **Cell membrane** – controls what enters and leaves the cell
3. **Cell wall** – extra support/protection around plant and bacteria cells
4. **Ribosomes** – make protein (all cells)
5. **Mitochondria** – break down glucose to release energy for the cell to use (in plants and animals)
6. **Chloroplast** – carries out photosynthesis in plant cells

ENZYMES

Special types of proteins that catalyze (speed up) chemical reactions in living things.

1. Every enzyme helps ONE reaction and binds to ONE **substrate** (starting material).
2. Shape is very important. If the shape changes, enzyme is **denatured** and can't bind to substrate.
3. Work best at certain temperatures and pH. If too hot or too acidic/basic → denaturation (shape changes, reaction slows and then stops).



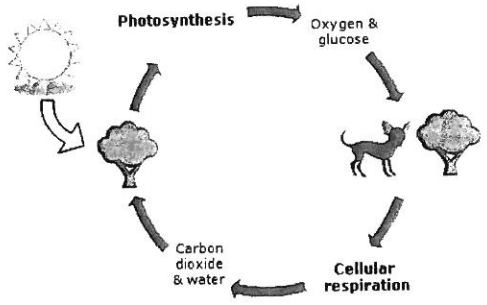
CELL MEMBRANE & CELL TRANSPORT/HOMEOSTASIS

1. **Diffusion** – movement of small uncharged particles from high to low concentration, does NOT need energy, does NOT use a protein channel
2. **Osmosis** – diffusion of water molecules, does NOT need energy (**Proteins and sugars are too big to move through the cell membrane, so water will usually move instead in order to reach equilibrium.)
3. **Facilitated diffusion** – bigger molecules like proteins or sugars (carbohydrates) go through a protein channel
4. **Active transport** – mostly charged particles (like K+ or Na+), get pumped across the membrane; needs energy

IMPORTANT: Size often matters when it comes to movement across the cell membrane. Remember that oxygen (O_2), carbon dioxide (CO_2), and water (H_2O) are *much smaller* molecules than proteins and carbs.

IMPORTANT BIOMOLECULES

1. **Carbohydrates** – energy sources like sugars and starches (ex: glucose, sucrose).
2. **Lipids** – fats and oils. Make up cell membranes and store extra energy.
3. **Proteins** – building blocks of body (make up muscles, hair, bones, etc.) or **enzymes** that speed up reactions in body
4. **Nucleic acids** – carry genetic information. (ex: DNA and RNA)



CELL ENERGY & METABOLISM

Photosynthesis

- Occurs in **chloroplasts** – contain green pigment **chlorophyll**
- $6CO_2 + 6H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2$

Cellular respiration

- Occurs in **mitochondria** – "powerhouse of the cell"
- $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 36\ ATP$

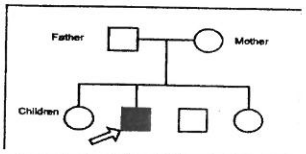
ATP (adenosine triphosphate) – temporarily stores energy for the cell.

CHROMOSOMES

1. Humans have 46 total (44 autosomes and 2 sex chromosomes, X and Y).
2. **XX** = female, **XY** = male
3. Too many or too few chromosomes = genetic disorder (ex: Down syndrome)

HEREDITY: DEFINITIONS

1. **Gene** – segment of DNA that codes for a particular protein (and therefore a particular trait)
2. **Alleles** – different forms of a gene. (ex: dominant allele, recessive allele)
3. **Genotype** – allele combination for a gene/trait (AA, Aa, aa)
4. **Phenotype** – physical trait determined by genotype (white fur, brown eyes)
5. **Punnett square** – diagram used to predict genotype and phenotype ratios of offspring
6. **Pedigree** – family-tree type diagram that shows inheritance of a trait through multiple generations. Females are represented as circles and males are represented as squares.



DIHYBRID CROSSES

Crossing two traits at a time instead of one (using a 4x4 Punnett square, must figure out gametes first).

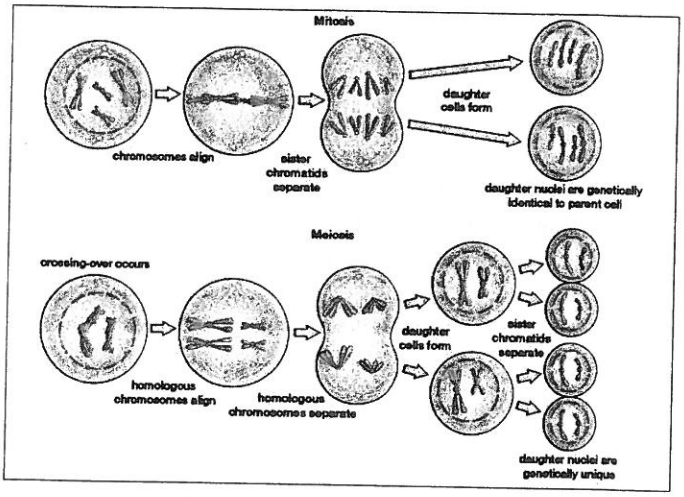
- If both parents are heterozygous, you will get a 9:3:3:1 ratio:
- 9 A_B_; 3 A_bb; 3 aaB_; 1 aabb

Gene linkage – two genes are located close together on the same chromosome.

- You'll know that two genes are linked if you cross two heterozygous parents and you do NOT get a 9:3:3:1 ratio.

CELL DIVISION

1. **Mitosis** – how body cells make identical copies of themselves. Produces 2 identical daughter cells, necessary for growth, healing, and repair.
2. **Meiosis** – how gametes (sex cells) are made. Reduces the chromosome number to half so that full number of chromosomes is accomplished at fertilization. Produces 4 slightly different daughter cells, necessary for production of sperm and eggs for sexual reproduction.



TYPES OF INHERITANCE

1. **Mendelian inheritance** or **complete dominance** – normal dominant/recessive; dominant masks recessive
2. **Sex-linked trait** – trait carried on a sex chromosome; X-linked recessive most common
   - Males are more likely to have X-linked recessive traits because they only have one X chromosome
   - Females are less likely to have X-linked recessive traits because they have two X chromosomes and can therefore be carriers
   - Males will always inherit an X-linked trait from their mother's side of the family. Fathers pass their Y chromosomes to their sons and therefore have no influence on their sons' X-linked traits.
3. **Incomplete dominance** – three phenotypes instead of two (heterozygote has mixed/blended phenotype)
4. **Polygenic trait** – trait determined by more than one gene (ex: skin color, height)
5. **Epistasis** – one gene changes or masks the result of another gene (ex: coat/nose color in labs)
6. **Pleiotropy** – one gene affects more than one phenotype/part of the body (ex: sickle cell anemia)

DNA & RNA

1. **DNA** = deoxyribonucleic acid. Two strands, uses bases GCAT, stays in nucleus.
   - Replication is **semi-conservative**: every new molecule has 1 old strand and 1 new strand
2. **RNA** = ribonucleic acid. One strand, uses bases GCAU, starts in nucleus and leaves.
   - **mRNA** – messenger RNA. Carries instructions from DNA to ribosomes. Made during transcription in the nucleus.
   - **tRNA** – transfer RNA. Brings amino acids to ribosome during translation.
   - **rRNA** – ribosomal RNA. Makes up ribosomes.

GENE REGULATION & EXPRESSION

1. ***ALL cells in the same organism have ALL of that organism's DNA and ALL of that organism's genes!*** Not all of the genes are turned on, though.
2. Genes are turned on (**expressed**) in cells that need those genes to do their jobs.
3. **Cell differentiation** – different types of cells have different genes expressed because they have different jobs/functions within the body
4. **Stem cells** – not yet differentiated, have many possible pathways of differentiation

PROTEIN SYNTHESIS

1. **Transcription** – rewriting DNA into an mRNA messenger. Takes place in nucleus.
2. **Translation** – mRNA travels to ribosome and amino acids are strung together to create a protein.

MUTATIONS – changes in DNA or RNA structure/sequence

1. **Point mutation** – one base substituted for another.
   - No change in protein if codon still codes for same amino acid.
   - Protein shortened if codon now codes for a "STOP"
   - Protein changed/misshapen if codon now codes for different amino acid.
2. **Frameshift** – base(s) added or deleted; disrupts entire protein downstream from mutation

GENE TECHNOLOGY

1. **Cloning** – make an identical copy of an organism
   - Take egg from donor mother, remove DNA
   - Harvest body cell from organism you want to clone, remove DNA
   - Place DNA from cloning subject's body cell into empty egg. Stimulate egg to divide
   - Place dividing embryo into surrogate mother's uterus to (hopefully) carry to term
2. **Restriction enzymes** – cut DNA at specific base sequences
3. **Gel electrophoresis** – create a DNA fingerprint
   - Cut DNA samples with restriction enzymes, place DNA samples in a gel
   - Run electricity through the gel. DNA is negatively charged and will move away from negative end of gel towards the positive end. Smaller pieces of DNA will move further and larger pieces will be stuck towards the beginning.
   - Visualize DNA banding pattern using radioactive probes/X-rays
   - Any samples with *identical* banding patterns are identical and must belong to the *same* organism.
4. **Genetic engineering** – purposefully changing DNA within an organism, or adding/removing genes to an organism's genome
   - **Gene therapy** – introduce a gene into a patient's cells if the patient's own gene is not functioning. Gene that's added will produce protein that has been missing since patient's own gene is malfunctioning.
   - Cloning (see above)
   - **DNA vaccines** – expose immune system to DNA of a germ without actually causing illness; immune system creates antibodies that will recognize the real germ if you come into contact with it
   - Agricultural application – create livestock that make more milk or have leaner meat; create crops that grow faster, produce more fruit per plant, or are resistant to pests or drought