BIOLOGY 115 EXAM 1 REVIEW

Austin College
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CHAPTER 1 - INTRODUCTION TO THE SCIENCE OF BIOLOGY

- **Science** is the systematic observation of natural phenomena for the purpose of discovering the laws governing those phenomena.
- Principles of Science:
    - **Natural Causality** - all phenomena can be traced to natural causes, there is no magic.
    - **Uniformity of Space and Time** - The natural laws governing how things work do not change with time or location → allows scientists to compare their results and to build on the work of previous scientists.
    - **Common Perception** - Scientists perceive the natural phenomena through their senses in the same way. If my senses do not work the same way as Pasteur's, then I cannot compare my observations with his.
- Scientific Method:
    - **Observation** - Careful observation is very important to being a good scientist
    - **Choosing a Natural Phenomenon** - wanting to know how and why something is happening. Curiosity is vital to a scientist.
    - **Creating Hypotheses** - Come up with multiple possible explanations for how or why the phenomenon is happening.
    - **Designing an Experiment** - choosing one of the hypotheses, you design and alternate hypothesis that is the exact opposite. Logic only allows us to **disprove** ideas. To prove an idea or concept true logically, one has to test it in all circumstances.
    - **Experimentation** - You run the experiment that tests one hypothesis and one variable. You also need to do statistical analysis on results to see if your observations could be due to random chances.
    - **Conclusions** - Can you disprove your alternate hypothesis? Can you disprove your original hypothesis? Do you need to do another experiment?
    - **Revising Hypotheses** - Hopefully, you were able to disprove something so that you can either revise the current hypothesis or move on to testing another one.
    - **Design Another Experiment** - The scientific method is a continuous loop.
- A **theory** is a scientific explanation (hypothesis) that has undergone many experiments (attempts to disprove) without being disproven. Theories are *always* being refined by experiments. There is no end to science.
- **Life** is a self-sustained chemical system capable of Darwinian evolution. Other signs of life include homeostasis. Darwinian evolution has three properties:
    - The system has to be able to reproduce itself.

    - Mutations must be possible in the reproduction.
    - The process of reproduction and survival of the next generation of system are subject to natural selection.
- Levels of Life:
    - **Cell** - every reproducing chemical system is contained with a cell. More than 99% of life on Earth is unicellular.
    - **Tissue** - In multicellular organisms, cells develop in groups called tissues.
    - **Organ** - In multicellular organisms, tissues work together in structures called organs to perform a homeostatic function. Organs can work together in organ systems.
    - **Organism** - In multicellular organisms the organs work together to form the replicating individual. In unicellular life, this level is synonymous with the cell level.
    - **Population** - Organisms living and exchanging genetic informations for the purpose of creating offspring.
    - **Community** - All the populations in an area that interact with each other are called a community.
    - **Ecosystem** - A community plus the non-living elements make up an ecosystem.
    - **Biome** - Similar ecosystems are grouped together into biomes.
    - **Biosphere** - Everywhere where life is found on Earth makes up the biosphere.
- **Phylogeny** uses evolutionary history to group living things. It is the foundation of **taxonomy**, which is the science of biological classification.
    - **Domain** - the three major evolutionary divisions in cellular bases life with differences in how genetic material is organized.
        - *Archaea* - unicellular; DNA in chromosomes but not in a nucleus; anaerobic metabolism; live in extreme environments.
        - *Bacteria* - unicellular; DNA in chromosomes but not in a nucleus; anaerobic and aerobic metabolism
        - *Eucarya* - unicellular and multicellular organisms; DNA organized in chromosomes inside a nucleus; aerobic metabolism; the four kingdoms are protista, fungi, animalia, and plantae.
    - **Kingdom** - group of organisms with a domain that have common life processes and characteristics.
    - **Phylum** - group of organisms within a kingdom that have a similar body plan.
    - Class - group of species within a phylum that have unique life processes and characteristics.
    - **Order** - group of species within a class that have common characteristics.
    - **Family** - group of species that share a close common ancestor.
    - **Genus** - group of species that share a very close evolutionary history
    - **Species** - a group of potentially interbreeding populations that is reproductively isolated from other such groups.
    - **Subspecies** - a group of populations of the same species in which the individuals are more closely related to individuals within the subspecies populations than to individual in populations outside the subspecies.

CHAPTER 2 - THE HISTORY OF THE THEORY OF EVOLUTION

New species arise from older species? Yes or No

- **Anaximander** started a school of philosophy that reached its peak in the writings of a Roman named **Lucretius**. Developed ideas on the origin of new species from old species and on the arrangement of matter into atoms. Also postulated Earth was millions of years old. **Yes**
- **Aristotl**e was a Greek who thought that all life on Earth could be arranged into a hierarchy with humans as the highest form of life on Earth. **No**
- **al-Jahiz** wrote *The Book of Animals* in which he describes 350 types of animals and their struggle for existence. Also states that men are not so different from other animals. Earliest reference to natural selection.**Yes**
- **Carolus Linnaeus** was first naturalist to propose classifying every animal, vegetable, and mineral on the planet using *binomial nomenclature*. **No**
- **Comte de Buffon** proposed that new species could arise through "degeneration" from those species created by god. **Yes**
- **James Hutton** proposed that the Earth was molded not by sudden, violent events but through gradual processes such as erosion. Hutton started the **gradualism** school of thought. **Yes**
- **Eramus Darwin** proposed that animals have historical connections to one another, that they change in response to their environment, and that the changed can be passed on to their offspring. **Yes**
- **William Smith** scientifically described fossils and the layers of rock they were found in. He noted that certain fossils were found only in certain layers of rock. **Yes**
- **Georges Cuvier** founded the sciences of vertebrate paleontology and comparative anatomy, and proposed reconstructions of fossil species from only a few fossil bones. Also developed **catastrophism** school of thought to explain the disappearance of species through time (first to describe mass extinction events) **No**
- **Lamarck** got the mechanisms of evolution all wrong. He proposed that all species, including humans, were descended from other species. His two biggest ideas were:
    - **Acquired Characteristics** - parts of organisms become stronger or weaker depending on how they are used
    - **Universal Creative Principle** - all organisms are unconsciously striving to evolve into a higher, more complex organism. All life on earth was on its way to becoming human. **Yes**
- **Sir Charles Lyell** favored Hutton's gradualism and opposed catastrophism. Noted that processes such as erosion had very little effect over a human lifetime. Therefore, Earth must be very, very old (+1 billion years old) **Yes**
- **Charles Darwin** learned on the Galapagos Islands that each island had its particular kind of lang rotroise. Each tortoise had a different shaped shell that seemed to be related to how it fed. Each species of finch has a modified bill that matches how it feeds. **Yes**
- **Rev. Thomas Malthus** noted that the rising human population were exceeding the food supply. Darwin developed the notion that natural forces could also cause selective

breeding. **Yes**

- **Alfred Russel Wallace** was collecting beetles in Malay. Wallace outlines a hypothesis that was very similar to Darwin's. **Yes**
- **Five Principles of Modern Evolutionary Theory**
    - Organisms beget like organisms
    - Number of individuals in each generation that survive and reproduce is small compared to the number initially produced. (Malthus' theory)
    - In any given population there are mutations among individual organisms and some of the variations are inheritable.
    - Survival and reproduction is determined by how these chance variations interact with the environment. Some variations enable individuals to produce more offspring than other individuals. Other variations reduce the number of offspring produced. Darwin termed the process **natural selection**.

CHAPTER 3 - NATURAL SELECTION: MICROENVIRONMENT IN ACTION

- We test evolution by testing the mechanism by which it works. That mechanism is **natural selection.** Natural selection can be summed in three parts:
    - An individual's personal set of characteristics (**phenotype**) interacts with environment
    - The interaction determined the number of kids that the individual produces in its lifetime
    - The phenotypes that produce the most kids will predominate in the population over time
- Evolution is not interested in the perfect phenotype, only the one that survives to reproduce.
- To test natural selection we have to apply a **selective pressure**. Selective pressures can be any change in the environment or any change in the other organisms the individuals in our test population interact with.
- Resistance and immunity are NOT the same biological concept. To develop immunity, means to have an immune system that attacks cells and particles foreign to the organism. Bacteria *resist* the killing properties of antibiotics. We eukaryotes develop immunity to pathogens *after exposure* via infection or vaccination.
- **Directional selection** is when for example a specific phenotypic (antibiotic resistance) is being selected for.
- **Stabilizing** is when the midpoint on the range of phenotypes in the population is being favored and both extremes are being selected against.
- **Disruptive** selection is when the extreme phenotypes have more kids than the intermediate phenotype.
- Malaria occurs much more frequently in visitors to malarial regions than in the native human populations. People with mutated hemoglobin never had the disease, the two mutations are: sickle-cell disease and thalassemias.

CHAPTER 4 - POPULATION GENETICS

- **Diploid organism**: organism with two alleles for each gene - one from mom and one from dad
- **Haploid**: contains 1 set of unpaired alleles
- **Gamete**: reproductive cell; germ cell; half a kid; gametes are haploid
- **Alleles**: two or more forms of a gene; all alleles of a particular gene occupy the same position on the chromosome; a diploid organism gets one allele from mom and another from dad
- **Allele frequency**: the relative proportion of a particular allele among the individuals of a population
- **Phenotype**: the observed characteristics of an organism; what traits are expressed
- **Phenotypic frequency**: the relative proportion of a particular phenotype among the individuals of a population
- **Genotype**: the actual genetic composition; the known alleles for one or more genes
- **Austosomes**: all the chromosomes in an organism except the sex chromosomes (those that determine the sex of the organism)
- **Homozygous**: in a diploid organism both alleles for a particular gene are the same
- **Heterozygous**: in a diploid organism the alleles for a particular gene are different
- **Dominant**: an allele that will be expressed in the phenotype if the organism is either homozygous or heterozygous
- **Recessive**: an allele that will be expressed in the phenotype only if the organism is homozygous
- **Incomplete dominance**: in heterozygous individuals one allele does not mask the other completely; the resulting phenotype is an intermediate mix of both alleles
- **Codominance**: in heterozygous individuals both alleles are expressed equally
- **Polygenetic inheritance**: the observed phenotype is a combination of several genes
- **Gene pool**: all the alleles of all the individuals in a population of organisms
- **Gene flow**: movement of alleles in and out of a population; the increase or decrease in an allele's frequency of occurrence in the population
- **Gene drift**:change in allele frequencies owing to chance processes, esp, in small populations
- Just because a trait has a dominant inheritance pattern does NOT mean that the majority of the population will express that phenotype. If a recessive trait provides better immune response to a disease or condition then over time that recessive trait will be selected for and the number of individuals expressing that trait will increase in the population.
- Alleles *flow* into and out of populations. Alleles do not drift. Gene pools *drift* when they get small. Large gene pools are too big to drift.
- If one mag of M&Ms becomes isolated from the others, it can represent a small population of the species. The population founded by one small bag will have color allele frequencies unlike the wider M&M species. This is **genetic drift**. Whatever the color frequencies in the founding small bag will determine the frequencies of subsequent generations, as long as there is no **gene flow**. The huge effect of the founders' original

gene pool is called the **founder effect**. The small population also has limited mate choice. The founder effect leads to **inbreeding**. Inbreeding can lead to:
    - Poorly adapted phenotypes caused by deleterious mutations
    - The loss of **genetic diversity**. Without genetic diversity a population may not have the mutations in its gene pool to handle changes in the environment.
- When a population has a significant loss of genetic diversity, is is said to be going through a **genetic bottleneck**. The population had diversity but is now passing through a restriction.

CHAPTER 5 - SPECIATION: MACROEVOLUTION IN ACTION

- Definitions of what is a species
    - **Typological** - classification based on appearance
    - **Biological** - classification by reproduction, a group of actual or potentially interbreeding populations that are reproductively isolated from other such groups.
    - **Evolutionary**: classification by phylogeny, a lineage of ancestral descendant populations that maintains its identity from other such lineages and has its own evolutionary tendencies and historical fate.
- The driving force behind speciation is **reproductive isolation**. One gene flow stops between two populations, then the fifth principle of modern evolutionary theory kicks in: given sufficient time, natural selection leads to the accumulation of changes that differentiates populations of organisms from one another. These difference cause the two populations to not reproduce with each other when they encounter each other.
- If a barrier to gene flow is removed soon after two populations were isolated, then the populations will go back to being the same species.
- If species A interbreeds with species B, the result is NOT a new species C. The result of this interbreeding is the return of species b into the original species A.
- Reproductive Isolation:
    - **Prezygotic Isolation Mechanisms**: these prevent gametes from coming together to form a zygote (fertilized egg). There is geographical, ecological, or temporal separation. Individuals are physically *not* in the same place at the same time. If they are, there is a behavioral or anatomical separation.
    - **Postzygotic Isolation Mechanisms**: these prevent a fertilized egg from developing into a reproductively viable offspring. Chromosomal mismatch or other genetic problem will cause early embryo death. A fertilized egg that does not develop into a reproductively viable offspring represents a waste of energy and gametes.
- Two closely related species (used to be interbreeding populations) are called **sister** or **sibling** species. The sister species are similar enough for the two sister species to fill the same **niche** (way of life).
- **Gause's Principle of Competitive Exclusion** is when two species that have identical ecological requirements cannot exist in the same area at the same time.
- Sister species will need to specialize to avoid direct competition. This specialization leads to **resource** or **niche partitioning**.

- In an area with very little interspecific (between species) competition and many open niches, then rapid speciation will occur in response to intraspecific (within species) competition. This phenomenon of rapid speciation is called **adaptive radiation**. The founder species radiates out into the open niches via any new mutations that lead to the adaptations to fill the niches.
- Punctuated equilibria is when fossils don't have intermediate forms. Eldredge and Gould proposed that the missing intermediate forms were truly missing because they never evolved. Without some new selective pressure there was little need to change form. If a species has to rapidly evolve to meet a new challenge this will be a punctuation point between the equilibria.

CHAPTER 6 - PHYLOGENY: MACROEVOLUTION IN ACTION

- Phylogenic trees hypothesize what organisms are related to other organisms. An advantage to fossils is that we can date fossils using radioactive isotope decay. The disadvantages to fossils are that they are rarely complete specimens. **Convergent evolution**-just because two organisms have the same adaptations does not mean they share a common ancestor. If similar selective pressures have been applied to two species, then they will have similar adaptations.
- Genetics gives us a way to avoid convergent evolution, but fossils give us our best timelines. The oldest ancestor organism is at the base of the tree. The next oldest, direct descendent species are branches off this base. All species at the same time are drawn at the same height of the tree.
- Time considerations are always of prime concern: a descendent species cannot be older than its ancestor species. Also, evolution rarely goes backwards. If a species does evolve backwards it is called a yo-yo.
- Cladograms don't have a time scale.