

Natural selection, in a nutshell:

Yum! Green beetles! Our favorite!

Evolution and Biodiversity

5.2- Natural Selection

Essential idea:

- The diversity of life has evolved and continues to evolve by natural selection.

Natural selection, in a nutshell:

Yum! Green beetles! Our favorite!

...generations later...

Green beetles have been selected against, and brown beetles have flourished.

Nature of science:

- Use theories to explain natural phenomena
 - the theory of evolution by natural selection can explain the development of antibiotic resistance in bacteria. (2.1)

Before selection

After selection

Final population

Resistance level
Low High

Applications

- Application: Evolution of antibiotic resistance in bacteria.
 - 1928: Penicillin, the first true antibiotic, was discovered by Alexander Fleming.
 - 1940s: Mass production leads to widespread use.
 - Present Day: these drugs have been used so widely and for so long that the infectious organisms the antibiotics are designed to kill have adapted to them, making the drugs less effective.
 - Each year in the United States, at least 2 million people become infected with bacteria that are resistant to antibiotics and at least 23,000 people die each year as a direct result of these infections.

A bunch of bacteria, including a resistant variety...

...get bathed in antibiotics. Most of the normal bacteria die.

The resistant bacteria multiply and become more common.

Eventually, the entire infection evolves into a resistant strain.

Legend: normal bacterium, dead bacterium, resistant bacterium

Theory of knowledge:

- Natural Selection is a theory.
 - How much evidence is required to support a theory and what sort of counter evidence is required to refute it?

Darwin's Finches
ADAPTIVE RADIATION

Leaves, Seeds, Insects, Grubs, Buds / Fruit, Tool Using Finch

Variation is a feature of natural populations and every population produces more progeny than its environment can manage. The consequences of this overproduction is that those individuals with the best genetic fitness for the environment will produce offspring that can more successfully compete in that environment. Thus the subsequent generation will have a higher representation of these offspring and the population will have evolved. -Charles Darwin "The Origin of Species" (1859)

Charles Darwin (1809-1882)

- Sailed on the Beagle (1831-22 years old)
- Made observations in the Galapagos
- Begins writing *The Origin of Species* (1844)
- Publishes *The Origin of Species* (1859)
 - Descent with Modification
 - Natural Selection is mechanism (survival of fittest)

THE ORIGIN OF SPECIES BY MEANS OF NATURAL SELECTION

Understandings

- Natural selection can only occur if there is variation among members of the same species.



Problems with Darwin's Theory

- Doesn't explain how chance variations arise
- Doesn't explain how variations are precisely transmitted from parents to offspring.
- Doesn't explain variation in a continuum.



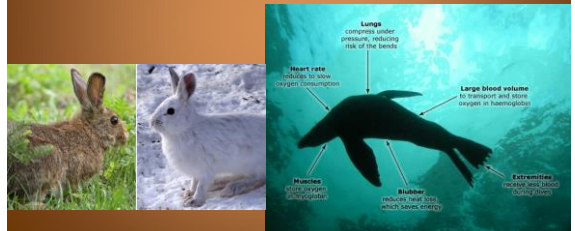
Understandings

- Mutation, meiosis** and **sexual reproduction** cause variation between individuals in a species.
 - Population Genetics (1930s)
 - Emphasizes genetic variation in populations
 - Due to changes in allele frequencies.



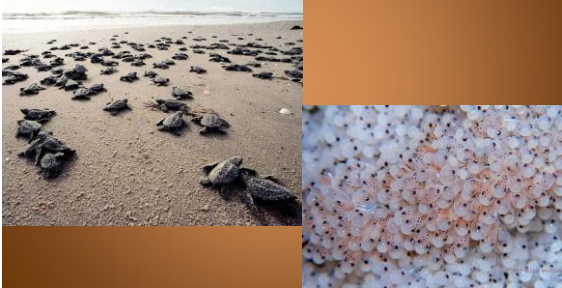
Understandings

- Adaptations are characteristics that make an individual suited to its environment and way of life.
 - If environment changes, then characteristic may not be an adaptation anymore.



Understandings

- Species tend to produce more offspring than the environment can support.



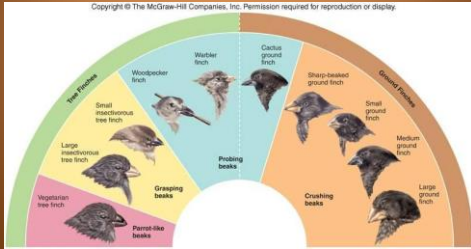
Understandings

- Individuals that are better adapted tend to survive and produce more offspring while the less well adapted tend to die or produce fewer offspring.



Applications

- Application: Changes in beaks of finches on Daphne Major.
 - Associated with eating different foods
 - Survival & reproduction of beneficial adaptations to foods available on each island.



Understandings

- Individuals that reproduce pass on characteristics to their offspring.
 - Characteristics acquired during a lifetime are not passed on.



Lamarck's Ideas

- Lamarck also suggested that a bird that acquired a trait, like longer legs, during its lifetime could pass that trait on to its offspring, a principle referred to as inheritance of acquired characteristics.



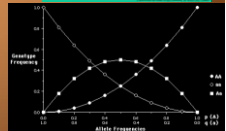
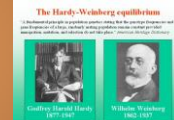
Understandings

- Natural selection increases the frequency of characteristics that make individuals better adapted and decreases the frequency of other characteristics leading to changes within the species.
 - Remember!!! Populations Evolve, not individuals.



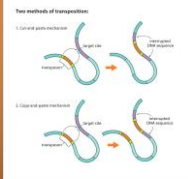
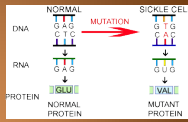
Hardy-Weinberg Theorem

- Allows us to measure changes in allele frequency in a gene pool
- Describes a non-evolving population.
 - $p^2 + 2pq + q^2 = 1$
 - p^2 = frequency of alleles AA
 - $2pq$ = frequency of alleles Aa
 - q^2 = frequency of alleles aa
 - For only two alleles:
 - $1 - p = q$ or $1 - q = p$
- Five conditions must be met:
 - Very large population.
 - Isolation from other populations.
 - No mutations
 - Random mating
 - No natural selection



Mutations

- Permanent change in an allele
- Only source of new alleles
- Causes of mutation
 - Radiation
 - Chemicals
 - Infectious Agents
 - Transposons



Radiation

- UV Radiation: from sunlight and tanning beds
- X Rays: medical X-rays, cancer therapy, tanning

Chemicals

- Cigarette Smoke: causes lung cancer, respiratory irritation
- Nitrate & Nitrite: causes cancer, food preservatives
- Asbestos: causes lung cancer, respiratory irritation
- Herbicides: causes cancer, environmental damage
- Antibiotic resistance: kills other drugs

Infectious Agents

- Hepatitis B: causes liver cancer
- Mutagenic virus: causes cancer

Mutations

- Do not arise out of need

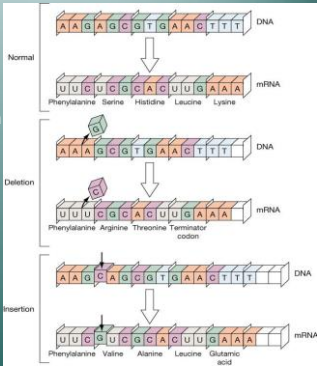


Natural selection does not grant organisms what they "need".

Remember Notes 3.1- Genes

Gene Mutations

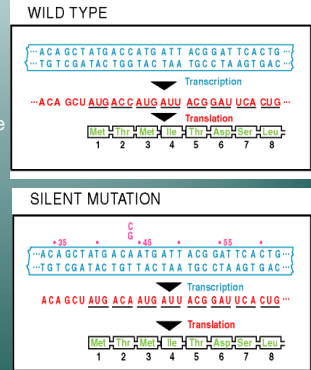
- Changes in DNA nucleotides
- Point Mutations
 - Frameshift Mutations
 - Base-pair insertion or deletion
 - The result is frequently a nonfunctional protein.



Remember Notes 3.1- Genes

Gene Mutations

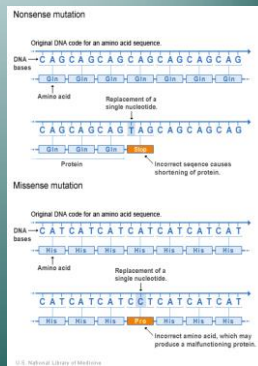
- Base-pair substitutions
 - Silent mutations
 - ❖ Changes to codons that have same effect
 - ❖ ACC to ACA both code threonine.



Remember Notes 3.1- Genes

Gene Mutations

- Nonsense mutation (sickle cell)
 - ❖ A change that terminates the protein
 - ❖ CAG to TAG (a stop codon)
- Missense mutation (cystic fibrosis)
 - ❖ A change that changes the amino acid
 - ❖ CAT to CCT incorporates proline instead of histidine

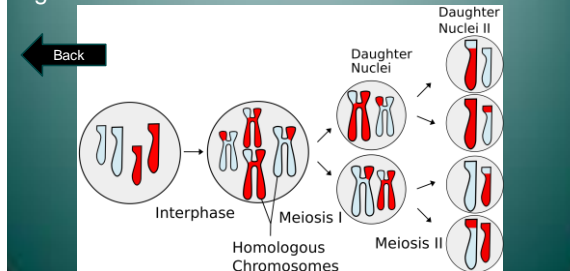


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Remember Notes 3.3- Meiosis

Essential idea:

- Alleles segregate during meiosis allowing new combinations to be formed by the fusion of gametes.



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Remember Notes 3.3- Meiosis

Fertilization

- Involves the fusion of two gametes
- Increases genetic variation in populations by providing for new combinations of genetic information in the zygote
- Restores the diploid number of chromosomes.



| Organism | Body Cell (2n) | Gamete (n) |
|--------------|----------------|------------|
| Human | 46 | 23 |
| Garden pea | 14 | 7 |
| Fruit fly | 8 | 4 |
| Tomato | 24 | 12 |
| Dog | 78 | 39 |
| Chimpanzee | 48 | 24 |
| Leopard frog | 26 | 13 |
| Corn | 20 | 10 |

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