The Birth and Death of Genes

Ice Fish

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Period 4
Background

- Icefish dwell in the icy waters near Antarctica. They are able to live in these conditions because they have antifreeze proteins that lower the freezing point of their blood.
- Icefish do not have red blood cells. To compensate, they have developed traits such as scaleless skins, large grills, a large heart, and a large blood volume.
The ice fish was discovered in 1927 by zoologist Ditlef Rustad, on a Norwegian expedition to Bouvet Island of the Antarctic. One of the greatest goals of the expedition was to discover information about all the sea life that inhabited the waters surrounding the Bouvet Islands. Originally called the crocodile fish due to its protruding jaw and teeth.
Summary

- Scientists were first intrigued by the fish’s lack of red blood cells.
- Lack of red blood cells allows the fish to live in cold temperatures.
- Developed at one point when a mutation happened that stopped the gene that produced red blood cells. Since ice fish had no use for this, the mutation was carried on through the generations.
Summary (cont.)

- The antifreeze protein gene evolved 34 million years ago when the Antarctica's water dropped from 10 degrees Celsius to -1.8 degrees Celsius.
- Created when a preexisting gene was altered to create a new protein that had new functions. An ancestral gene was accidentally duplicated while one copy remained the same, the other accumulated mutations that developed into antifreeze genes.
Key Concepts

- Mutations can lead to an appearance and disappearance of a trait.
- Traits are determined by genes.
- Changes in environment can change which traits are favorable.
- The frequency of the allele depends on its usefulness.
- The function of a gene can change when it is duplicated and one copy of the gene accumulates mutation.
- One way a gene can be lost is when one or more mutations accumulate that destroy its functions.
Discussion Points

● Mutation is random. However, selection depends on the environment. When the environments change, so does the selection pressures.

● When Dr. Carroll says “birth and death” of genes, new genes cannot actually be born. There are several mechanisms by which new genes originate. The most common way is through gene duplication. Another source of new genes is gene transfer from a different species. New genes can also originate from noncoding regions of DNA, as well as through gene fusion: two genes fuse and become part of the same transcript.
Discussion Points

- So where did the icefish antifreeze gene originate from? The gene responsible for the production of antifreeze proteins in ice fish evolved from a trypsinogen gene through a series of mutations. A chance duplication resulted in the production of an extra copy of the trypsinogen gene.

- Over time, in addition to the mutation, a piece of the gene that would eventually code for the antifreeze protein became amplified. As the temperature decreased, fish that happened to have the ability to produce antifreeze proteins would have survived and reproduced.
Quiz Questions

1. Explain the relationship between genes and traits.
2. Explain how a change in the environment can result in a change in the frequency of a gene in a population.
3. State two genetic changes these fish have undergone to be able to thrive in this cold environment.
Quiz Answers

1. Genes can encode/influence/determine traits.
2. Genes encode traits or characteristics. Because the environment determines what traits are advantageous to an organism, the prevalence of certain genes in a population can change due to changes in the environment. For example, if the environment becomes warmer, genes that help organisms survive at higher temperatures will increase in frequency in the population.
3. (1) The loss of the hemoglobin gene; (2) the gain of an antifreeze gene