Gene Regulation

HIGHLIGHT or UNDERLINE key information about mutations and gene expression as you read! Make notes out to the side when something "pops" out at you as important or relative to this topic.

[1]Typically, when we think of genetic mutations, we think of DNA-copying errors during cell division, or perhaps the impact of environmental factors.[2]But it turns out that mutations in regulatory mechanisms—not just in genetic code—can also explain how species come to exhibit new traits.

[3]When a cell divides, it makes a copy of its DNA instructions for the new cell.[4]The double helix structure unwinds and the strands separate.[5]The nucleotides (adenine, thymine, guanine, and cytosine) on each strand pair up with free nucleotides in the nucleus, creating two new strands.[6]Every time a cell divides, it must copy about 6,000 million letters of DNA code.[7]Sometimes errors, or mutations, occur so that a single nucleotide base is changed or entire sequences of DNA are accidentally deleted.[8]Mutations can also be caused by environmental agents, including UV rays in sunlight, cigarette smoke, and radiation, which can alter bases so they look like other bases or break the phosphate "backbone" of DNA.[9]Our cells have built-in mechanisms that catch and repair most mutations that occur during replication or from environmental damage.[10]But some mutations inevitably get through and result in new traits being passed on to offspring.

[11]Scientists have recently discovered that regions of DNA once believed to have no particular function can contain molecular mechanisms responsible for regulating gene expression.[12]These mechanisms, called gene switches, determine whether certain traits are expressed as an organism develops.[13]Thus, depending on whether a gene is switched on or left off, a single gene can produce very different traits in a species.[14]When a mutation occurs in a noncoding region and a gene switch is added or deleted, new traits can result.[15]Provided the new traits are not fatal, they may be passed on to offspring and eventually result in new species being formed.

[16]A gene switch mutation explains why some people have blue eyes.[17]Up until about 6,000 to 10,000 years ago, all humans had brown eyes.[18]Then, a mutation in the gene involved in the production of melanin—the pigment that gives eyes their color—resulted in a switch present in some people's genes that controls how much melanin is produced in the iris.[19]This switch does not turn melanin production on or off; rather, it limits how much is produced.[20]Thus, it effectively dilutes brown eyes to blue.

Below, summarize the identified sections in the above reading:

Section #6-#10: _____

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Section #11-#14: _____

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Section #16-#20: _____

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Name: _____

Date: _____ Period: _____

Gene Expression

Reared at 20°C or less

Reared at temperatures above 30°C

How can the environment affect gene expression?

Temperature and Light

Directions: Read the article below and answer the questions that follow.

Every cell in an organism's body contains the exact same DNA as every other cell in the organism's body. Different traits develop depending on which part of an organism's genes are expressed. Sometimes the external environment has an effect on these expressed genes. In addition to drugs and chemicals, temperature and light are external environmental factors that may influence gene expression in certain organisms. For example, Himalayan rabbits carry the C gene, which is required for the development of pigments in the fur, skin, and eyes, and whose expression is regulated by temperature. Specifically, the C gene is inactive (does not work) above 35°C, and it is maximally active from 15°C to 25°C. This temperature regulation of gene expression produces rabbits with a distinctive coat coloring. In the warm, central parts of the rabbit's body, the gene is inactive because the temperature is above 35°C, and no pigments are produced, causing the fur color to be white (see image above). Meanwhile, in the rabbit's extremities (i.e., the ears, tip of the nose, and feet), where the temperature is much lower than 35°C, the C gene actively produces pigment, making these parts of the animal black.

Light can also influence gene expression, as in the case of butterfly wing development and growth. For example, in 1917, biologist Thomas Hunt Morgan conducted studies in which he placed *Vanessa urtica* and *Vanessa io*caterpillars under red, green, or blue light, while other caterpillars were kept in the dark. When the caterpillars developed into butterflies, their wings showed dramatic differences. Exposure to red light resulted in intensely colored wings, while exposure to green light resulted in dusky wings. Blue light and darkness led to paler colored wings. In addition, the *V. urtica* butterflies reared under blue light and *V. io* butterflies reared in the dark were larger than the other butterflies.

Questions:

1. How does DNA compare in every cell in the entire body of an organism?
2. If there is the same copy of DNA in every cell, why are different traits possible?
3. What two environmental factors can affect gene expression in an organism?
4. **Explain** how temperature affects the coloring in rabbits.
5. How did the red light affect butterfly wings?
6. How did blue light or no light affect the size of butterflies?