Part One: DNA Error in Replication

In your *Modern Biology* textbook, turn to page 202. After reading this page, complete the following.

1. A mutation is a change in _____.

2. Since genes (sections of DNA) code for ________________, a change in the DNA base code is likely to also change the _______________ that the gene codes for.

3. DNA replication usually occurs with great accuracy. Only about _____ error occurs for every _______________ paired nucleotides added.

4. Even more errors might occur if not for the enzyme ________________, which “proofreads” and corrects mistakes as replication takes place.

Some environmental factors can increase the chances of mistakes occurring in your DNA. These factors are called “mutagens”.

5. Certain _______________ in food or drinking water, or _______________ radiation from the sun are examples of mutagens.

6. Some mutations can lead to ______________ (as shown in the photograph on the page).

Last paragraph, pg 202:

7. Sometimes DNA changes turn out to be beneficial, and may allow individuals to ______________ and _______________ better, so these variations usually increase in the population over many generations. This is known as “natural selection”.

Read page 203 to answer below.

8. Cancer can occur if mutations happen within genes that control cell ___________ and cell ___________.

9. What type of cancer is the most common in the US? _______________

10. What waves of light energy are most damaging to cells? _______________

11. What is a “thymine-thymine dimer” and how do they form?

12. Some organisms do not get skin cancer because they have evolved genes for a DNA repair enzyme, called ______________. Humans do not have this gene so cannot make this enzyme in their skin cells. However, scientists are experimenting with “gene therapy”.

13. What is gene therapy and what is its goal?
GENE MUTATIONS

Name: ___________________ Date: __________ Perio]: ___________________

Part Two: WEBQUEST

Go to http://evolution.berkeley.edu/evolibrary/article/0_0_0/mutations_01

Slide 1: DNA and Mutations

• Read the information on the page. You can click on any highlighted term to view its definition.

• Complete the items below.

1. Mutations are essential to evolution; they are the raw material of ________________ ________________ .

<click “next”, in bottom corner>

Slide 2: DNA and Mutations

1. The genetic code of your DNA is “written” in varying sequences of 4 nitrogen bases, known by the letters: ___ ___ ___ & ___.

2. The sequence of these bases encodes instructions. Some parts of your DNA are control centers for turning other ________ on and off, some parts have no function (“junk”), and some parts have a function that we don’t understand yet. Other parts of your DNA are genes that carry the instructions for making ____________—which are long chains of___________ __________. These proteins help build an organism.

3. Protein-coding DNA can be divided into ___________ (sets of three bases) that specify an amino acid or signal the end of the protein.

4. For example, GCA codes for what amino acid? ________________

<click “next”>

Slide 3: Types of Mutations

During replication, transcription, or translation of a gene, mistakes can happen.

A. The most common type of mutation in a gene is called a “point mutation”. This is called by the replacement of a single base nucleotide with another nucleotide of the genetic material, DNA or RNA. In simple terms, it means that one “letter” of the DNA is in a spot that it doesn’t belong.

The term point mutation includes the substitution, insertion, or deletion of a single base (nucleotide) during replication or transcription. See page 240 in your Modern Biology textbook for help with this topic.

Define the following terms:

1) Substitution:
GENE MUTATIONS

Name: ___________________________ Date: ___________________________ Period: ___________________________.

2) Insertion:

3) Deletion:

B. **Frameshift mutations** are serious mutations caused by **insertion** or **deletion** of nucleotide bases in a gene sequence.

Let’s look at an example. Start with the sentence: **THE FAT CAT ATE THE RAT**

Note how the letters are sequenced into groups of three (like a codon). This 3-letter “reading frame” determines the exact sequence of amino acids in a protein.

1. Now, YOU re-write the sentence, taking away the first letter (T). BEFORE you re-write it, be sure to regroup the letters into groups of three, keeping the usual 3-letter “reading frame”.

Write it below:

2. Does the sentence still make sense?

3. If this were a gene, would it still work?

4. Look at the original sentence (above). Now, re-write it again, but this time, rather than taking a letter away, **ADD** a letter “T” between the words “fat” and “cat”. Write the new sentence below, making sure, again, to **shift your frame** to group the letters into threes.

5. What kind of mutation did you just simulate?

C. Frameshift mutations are typically very serious, almost always **causing nonfunctional proteins** to be made. Frame shifts usually result in **missense, nonsense, or silent mutations**.

Do a **web search** (ex: Google) to define following:

**Missense Mutation:**

**Nonsense Mutation:**

**Silent Mutation:**
Many times, a $3^{rd}$ base substitution will result in a “silent mutation”. What amino acid do TTA and TTG code for? _________________. Does the third base change make a difference, in this case? _____

Slide 4: The Causes of Mutations

What are the two causes of mutations?

1. 

2. 

Slide 5: The Effects of Mutations

1. What are three specific examples of “somatic” cells in your body?

2. What is a “germ” cell?

3. What kind of mutations can affect YOU, but won’t be passed onto your offspring?

4. What are three possible outcomes of germ line mutations?

5. Why are mutations in control (regulatory) genes so much more serious than mutations in a gene that codes for a single protein? Explain.

6. What is the role of a Hox gene?

7. What could a mutation in a Hox gene result in? (Hint: look at the picture of the fruit fly heads)
GENE MUTATIONS

Name:                                      Date:                                      Period:

<click “next”>

Slide 6: Case Study: Sickle cell anemia

1. Sickle cell (SC) anemia is a genetic disease with severe symptoms, including ___________ and ___________. The disease is caused by a mutated version of the gene that helps make _________________, a protein that carries ____________ in red blood cells.

2. Look at the picture of the sickle cells point mutation. Is this an example of a substitution, insertion, or deletion? ______________________.

3. If the DNA base triplet of the gene changes does it also change the mRNA codon that is transcribed from the DNA? ______ (yes? no?)

4. Does this lead to an incorrect amino acid in the hemoglobin protein? ______

5. Does this amino acid change the shape of the protein (hemoglobin)? ______

6. Below, sketch a picture of a normal red blood cell (containing normal hemoglobin) and next to it, sketch a sickled red blood cell.

7. If a person inherits only one copy of the SC hemoglobin gene (from one parent), but also inherits one normal copy of the hemoglobin gene (from the other parent), they are called “carriers”, because they are not so affected by the disease (due to the fact that they can at least make some normal red blood cells). Carriers of the sickle cell allele actually have an advantage, in that they are resistant to _______________ (disease), because the parasites that cause this disease are killed inside sickle-shaped blood cells.

<click “next”>

Slide 7: Mutations are Random

Read the example of some head lice being more (or less) susceptible to medicated shampoo.

1. Which hypothesis (A or B) is supported by scientific evidence? _____ . Briefly explain below:

2. Slight genetic differences (mutations) in different individuals mean that some may survive while others perish. How did the Lederbergs demonstrate this? Briefly describe.
Part Three:
In each of the following DNA sequences, you will use the mRNA and amino acid sequences to identify the mutation that occurred.

Amino acid chains will become proteins. Remember back to the function of enzymes, which are proteins, and how a change in the shape of proteins will change their ability to work. Consider this: changing the sequence of amino acids in a chain can change how the protein is folded and shaped, therefore changing its function.

Original DNA Sequence:  T A C A C C T T G G C G A C G A C T
Corresponding mRNA Sequence: 
Corresponding amino acid sequence:

Mutated DNA Sequence #1:  T A C A T C T T G G C G A C G A C T
Corresponding mRNA sequence?
Corresponding amino acid sequence?
Circle the mutation. How many amino acids are different from the original protein? ________
What kind of mutation is this? (circle ALL that apply) Point mutation Frame shift
Silent Insertion Deletion Nonsense Missense

Mutated DNA Sequence #2:  T A C G A C C T T G G C G A C G A C T
Corresponding mRNA sequence?
Corresponding amino acid sequence?
Circle the mutation. How many amino acids are different from the original protein? ________
What kind of mutation is this? (circle ALL that apply) Point mutation Frame shift
Silent Insertion Deletion Nonsense Missense

Mutated DNA Sequence #3:  T A C A C C T T A G C G A C G A C T
Corresponding mRNA sequence?
Corresponding amino acid sequence?
Circle the mutation. How many amino acids are different from the original protein? ________
What kind of mutation is this? (circle ALL that apply) Point mutation Frame shift
Silent Insertion Deletion Nonsense Missense
Discussion Questions:

1. If mutated DNA Sequence #1 occurred in a single cell, would it be a more serious problem in a body cell or in a gamete (sex cell)? What might be the consequences of each?

2. Mutated DNA Sequence #2 occurred in a reproductive cell of a fish, which was later fertilized to become an embryo (offspring). If the mutation occurred in a gene that coded for growth hormone (GH) how might it impact the new organism (offspring)?

3. In reference to the above question (#2) what if the mutation occurred in a gene that coded for a skin pigment in fish that normally appears blue and, as a result of the mutation, now appears brown. How might it impact the organism’s survival?

4. DNA replication, transcription, and translation all have enzymes whose job it is to attach the complementary nucleotides to an existing strand.
   - These enzymes “miss” mistakes at an average rate of about 1 mistake per every 1,000,000,000 base pairs per generation.
   - Humans have about 3 billion DNA base pairs in each diploid cell.

How many mistakes would you expect to find in a human’s DNA if a cell divides FIVE times? Show your math.
Part Four: Addition and Deletion Mutations - McGraw Hill animation Quiz 4


2. Watch the animation (use volume, it has audio explanation too). You can replay it if you miss something.
3. Answer the QUIZ questions below the animation window. Record your answers (both the letter and the answer) below:
   1. 
   2. 
   3. 
   4. 
   5. 

Part Five: Mutations and biological evolution.

Not all mutations cause bad things to happen to genes. Sometimes a mutation changes the function of a gene for the better. This might give the next generation of organisms a novel (new) trait that actually helps them to better compete for resources.

1. Go to http://www.dnai.org/lesson/go/1738/1419

2. Read through the slides.

What is a “mutagen”? Give a specific example of one.

3. On slide 3, choose LARGE video size and play it.
4. Read the text on the left of the video.

Your textbook (pg. 880) states that modern humans are thought to have diverged (evolutionary lineage split) from Neanderthals around 160,000 years ago. Below, explain how a genetic “molecular clock” can be used by evolutionary biologists to determine this timeframe. (If it helps, this “clock” is mentioned on pg 344 of your textbook).