PEAC
PRIVATE EDUCATION ASSISTANCE COMMITTEE
Trustee of the Fund for Assistance to Private Education

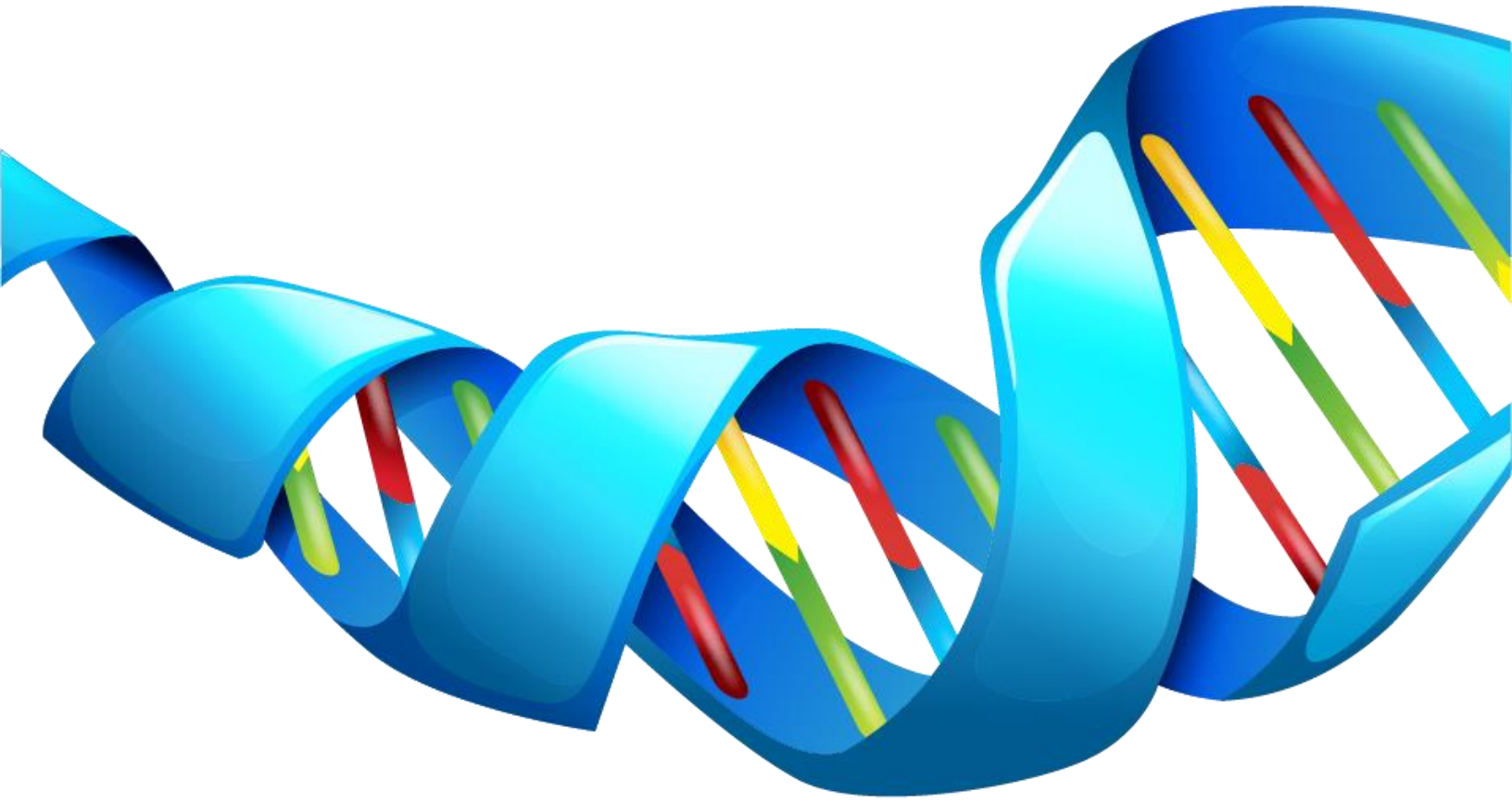
DepED
DEPARTMENT OF EDUCATION

2015

LEARNING MODULE

Science G10| Q1

Living Things and Their Environment



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NOTICE TO THE SCHOOLS

This learning module (LM) was developed by the Private Education Assistance Committee under the GASTPE Program of the Department of Education. The learning modules were written by the PEAC Junior High School (JHS) Trainers and were used as exemplars either as a sample for presentation or for workshop purposes in the JHS In-Service Training (INSET) program for teachers in private schools.

The LM is designed for online learning and can also be used for blended learning and remote learning modalities. The year indicated on the cover of this LM refers to the year when the LM was used as an exemplar in the JHS INSET and the year it was written or revised. For instance, 2017 means the LM was written in SY 2016-2017 and was used in the 2017 Summer JHS INSET. The quarter indicated on the cover refers to the quarter of the current curriculum guide at the time the LM was written. The most recently revised LMs were in 2018 and 2019.

The LM is also designed such that it encourages independent and self-regulated learning among the students and develops their 21st century skills. It is written in such a way that the teacher is communicating directly to the learner. Participants in the JHS INSET are trained how to unpack the standards and competencies from the K-12 curriculum guides to identify desired results and design standards-based assessment and instruction. Hence, the teachers are trained how to write their own standards-based learning plan.

The parts or stages of this LM include Explore, Firm Up, Deepen and Transfer. It is possible that some links or online resources in some parts of this LM may no longer be available, thus, teachers are urged to provide alternative learning resources or reading materials they deem fit for their students which are aligned with the standards and competencies. Teachers are encouraged to write their own standards-based learning plan or learning module with respect to attainment of their school's vision and mission.

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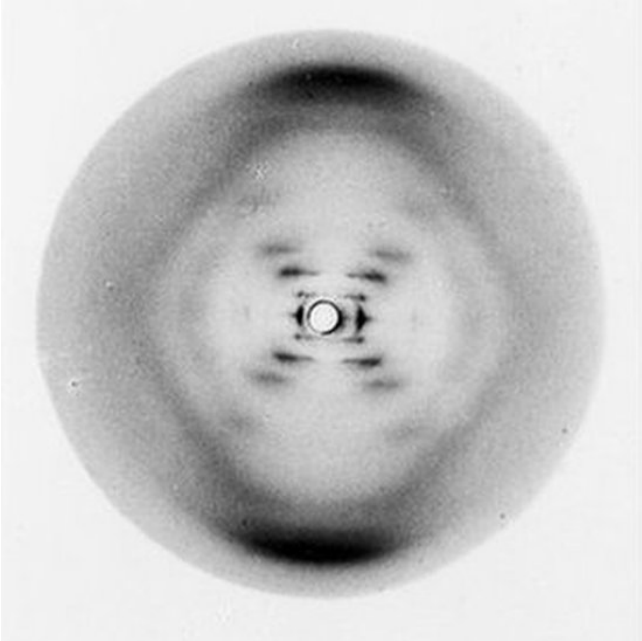
SCIENCE 10

Module 1: Living Things And Their Environment

Lesson 2: Heredity: Inheritance and Variation: The Molecular Basis of Inheritance and Variation

INTRODUCTION AND FOCUS QUESTION(S):



http://www.bbc.com/news/health-18041884

Nicknamed *Photo 51*, the image above is the first X-ray diffraction image of the **DNA**, deoxyribonucleic acid, which is dubbed as the ***molecule of life***. The discovery of the DNA structure is one of the most celebrated discoveries of the 20th century, and this photo which provided key information to that discovery has at least a claim to be the "most important image ever taken."

In the previous modules, you have explored the concept of inheritance in the cellular and subcellular level. It is now time for you to look at heredity at the *molecular* level, right where it all starts. Among the molecules you will encounter are DNA and proteins.

What is DNA and why is it so important to heredity? Why are proteins associated with DNA and traits? How are these proteins synthesized in the cell? How do

these molecules contribute to genetic variation? These are the questions you will find answers to as you go through this module.

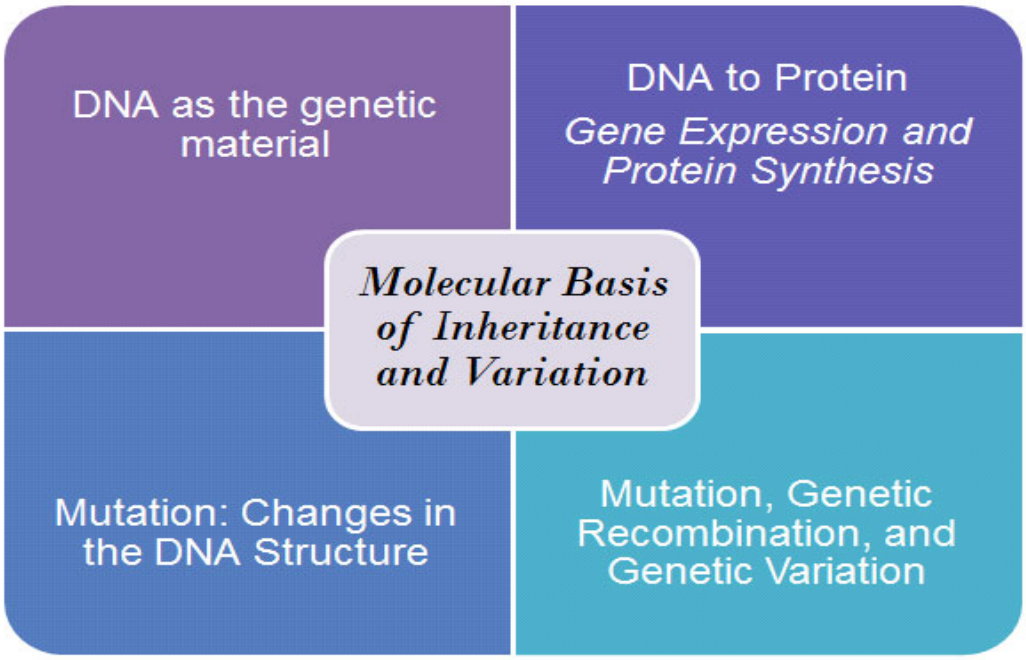
LESSON COVERAGE:
In this lesson, you will examine those questions when you take the following topics:

Lesson 2.1 – Gene Expression and Protein Synthesis
Lesson 2.2 – Mutation
Lesson 2.3 – Molecular Basis of Genetic Variation

In these topics, you will learn the following:

Lesson 2.1	• Explain how protein is made using information from DNA.
Lesson 2.2	• Explain how mutations may cause changes in the structure and function of a protein. • Discuss how mutations can be heritable.
Lesson 2.3	• Explain in different ways how genetic variation is achieved at the molecular level and discuss its implications to biodiversity and the species' adaptability and survivability.

MODULE MAP:
Here is a simple map of the above lessons you will cover:



EXPECTED SKILLS:

To do well in this module, you need to remember and do the following:

1. Read the instructions carefully before starting anything.
2. Complete **all** the activities and worksheets. Follow instructions on how to submit them.
3. Look up the meaning of words that you do not know.
4. You will frequently come across process questions as you go through different lessons. Keep a notebook (or use the Notepad) where you can write (and revise) your answers to these questions. Use also the notebook to jot down short notes, draw diagrams, and summarize what you have just read.
5. For worksheets and reports that need to be submitted, use the provided checklist and rubric to evaluate your work before submission.
6. Allow time for relaxation and recreation when you are mentally tired. Make a time table to schedule your study and recreation.

PRE-ASSESSMENT:

Let's find out how much you already know about this module. Click on the letter that you think best answers the question. Please answer all items. After taking this short test, you will see your score. Take note of the items that you were not able to correctly answer and look for the right answer as you go through this module.

(A) 1. During cell division, each new daughter cell must have the same copy of genetic information found in the DNA. Which of the following refers to the process of copying a DNA molecule?
   A. Replication
   B. Transcription
   C. Translation
   D. Reverse Transcription

(A) 2. In order to produce a protein, segments of the DNA called *genes* must be expressed. During ***transcription*****,** specific segments of the DNA are copied in order to produce what molecule?
   A. Amino acid
   B. cDNA
   C. Polypeptide
   D. RNA

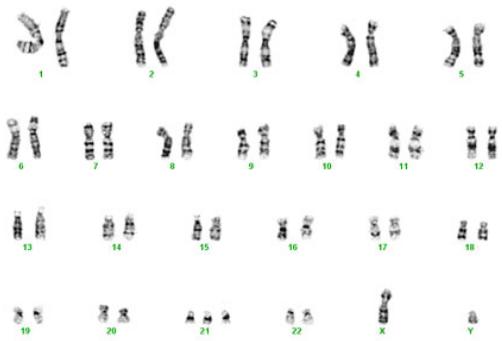
(A) 3. Which of the following events happen during ***translation***?
   A. DNA nucleotide sequences are changed into amino acid sequence.
   B. RNA gets translated into DNA.
   C. Sequence of codons in the mRNA directs the sequence of amino acids.
   D. The amino acid sequence forms into a protein and denatures.

(A) 4. If a mutation has occurred in a gene coding for a specific protein, which of the following is **not** likely to occur?
   A. Protein will not be formed.
   B. Protein will be formed but in lower amounts.
   C. Protein will have an additional function.
   D. Protein will not have any amino acid.

(A) 5. Consider this DNA sequence: AGT CGA. If a substitution happens in the fourth base such that the new sequence copied during replication is AGT AGA, what kind of mutation has occurred?
   A. Chromosomal aberration
   B. Frameshift mutation
   C. Point mutation
   D. Polyploidy

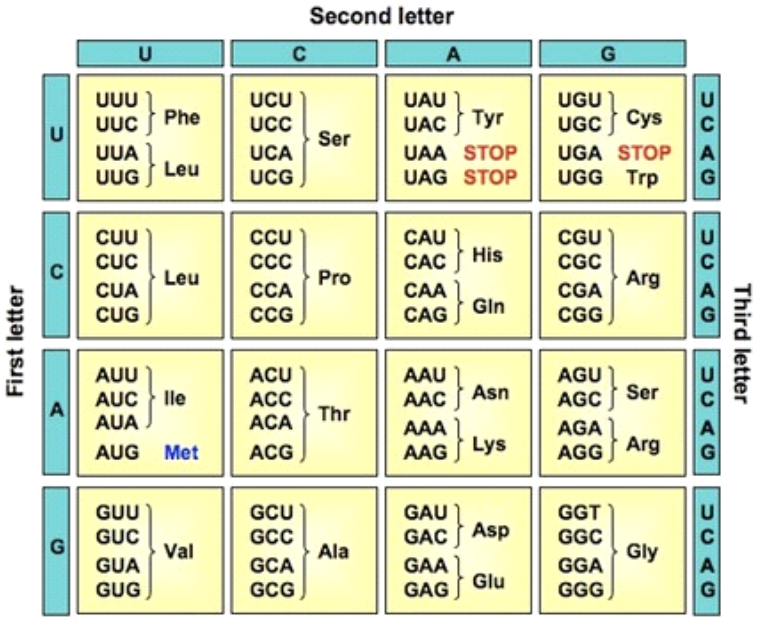
(A) 6. A mutation always causes a mutant phenotype. What can be said of this statement?
   A. True, mutations are errors in DNA replication and will definitely affect protein production.
   B. True, a change in the DNA structure causes a change in both the genotype and phenotype.
   C. False, some changes in the DNA do not alter the amino acid sequence.
   D. False, mutations are not always harmful, and may sometimes lead to better phenotypes.

(A) 7. Down syndrome is a chromosomal condition that is associated with intellectual disability, a characteristic facial appearance, and weak muscle tone (hypotonia) in infancy. Below is a diagram of the set of chromosomes found in each cell of an individual with Down syndrome:



Based on the diagram, what type of genetic change causes Down syndrome?
   A. Base substitution
   B. Inversion
   C. Monosomy
   D. Trisomy

(A) 8. Refer to the given genetic code chart to predict the type of mutation and the protein produced if the mRNA codon **GAG** is changed to **GAA**.



A. Missense mutation. Protein is non-functional.
B. Neutral mutation. Protein may still be functional.
C. Nonsense mutation. Protein synthesis stops.
D. Silent mutation. Protein produced is the same.

(M) 9. Why is the DNA considered as the cell's ***genetic material?***

I. The DNA is variable *between* species and able to store information that causes species to vary from one another.
II. The DNA is able to undergo rare changes, called mutations, that provide genetic variability for evolution.
III. The DNA is constant *within* a species and able to be replicated with high fidelity during cell division.
IV. The DNA is a macromolecule, found inside the cell, which contains sugar, nitrogen, and phosphate groups.

A. I only
B. I and II
C. I, II, and III
D. I, II, III, and IV

(M) 10. A 38-year old male appears slightly overweight for his 6-foot, pear-shaped stature. He has narrow shoulders, enlarged breasts, and barely any facial hair. Recently, he got to see a documentary on genetic

conditions; interestingly, one of them seemed to describe his physical features. He also learned that the Y-chromosome is responsible for male traits, while the X-chromosome holds genes for female traits. He started to get concerned and thought of seeing an expert to determine if he has the said condition. The condition that he suspects that he might have is Klinefelter's syndrome; it is a genetic condition in males that is characterized by having female characteristics. What might be found in his karyotype?

A. 3 chromosomes in chromosome 21
B. XXY in chromosome 23
C. only the X chromosome in chromosome 23
D. only the Y chromosome in chromosome 21

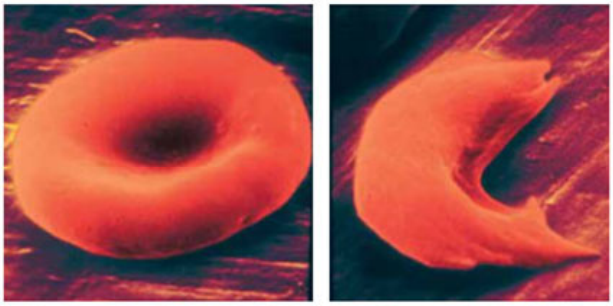
(M) 11. Refer to the following early genetic experiments:

- Yanofsky showed that the order of observed mutations in the *E. coli* tryptophan synthetase gene was the same as the corresponding amino acid changes in the protein.
- Crick and Brenner demonstrated, from a large series of double mutants of the bacteriophage T4, that the genetic code is read in a sequential manner starting from a fixed point in the gene, the code was most likely a triplet and that all 64 possible combinations of the 4 nucleotides code for amino acids, i.e. the code is degenerate since there are only 20 amino acids.

What can be concluded from these experiments?

A. A change in the amino acid sequence will cause a change in the protein product.
B. Any change in the DNA structure is considered as mutation.
C. Information stored in the DNA is used in the synthesis of protein.
D. There are many possible combinations of the four nucleotides that make up the DNA.

(M) 12. Below is a diagram comparing a normal red blood cell from a sickled red blood cell. The latter is found in individuals suffering from sickle-cell anemia.



Normal phenotype Sickle-cell phenotype

Investigation of hemoglobin in the red blood cells of persons with sickle cell disease showed its structural difference with hemoglobin in normal individuals. In one location, normal hemoglobin contains the negatively-charged amino acid glutamate, and in sickle cell hemoglobin, the glutamate is replaced by the nonpolar amino acid valine.
What is the most likely explanation for this structural difference?

A. During replication, a single base change in the DNA occurred that led to the synthesis of a faulty protein.
B. During transcription, a copying error occurred in the mRNA transcript which led to the production of a defective protein.
C. During translation, an incorrect amino acid becomes attached to the tRNA molecule thereby causing a change in the protein structure.
D. During protein folding, a lack of enzyme causes incorrect folding and modification of the protein structure.

(M) 13. Which of the following situations illustrate a mutation that may be passed on by the parent to its offspring?

A. A man with normal chromosomes had a hip X-ray without a protective shield. A year later, his wife gives birth to a child with a chromosomal aberration.
B. An embryo missing one copy of chromosome 3 is miscarried very early in pregnancy.
C. Exposure to excessive UV radiation causes changes in the DNA of a skin cell, leading to basal cell carcinoma (skin cancer).
D. In a very early human embryo, a mistake in mitosis causes loss of a chromosome in one daughter cell. The resulting child is a fertile male.

(M) 14. In 1996, Susan Rosenberg, then a young professor at the University of Alberta, undertook a risky and laborious experiment. Her team painstakingly screened hundreds of thousands of bacterial colonies grown under different conditions. Rosenberg's findings suggested that bacteria were capable of increasing their mutation rates, which might in turn produce strains capable of surviving new conditions. This raised questions from the scientific community because it **disagrees** with which long accepted idea in Biology?

A. Adaptive mutation occurs when microorganisms are able to choose which genes to mutate.
B. Mutations are much less random and more purposeful.
C. Mutations occur randomly, creating a mixture of harmful, harmless or beneficial outcomes, which in turn fueled the process of natural selection.*
D. Organisms can in some cases control how they mutate, enabling them to more rapidly evolve to adapt to new environments.

(T) 15. If all members of a species have the same set of genes, how can there be genetic variation?
Who among the following gave a correct explanation?
A. Francis pointed out that while there may be similar set of genes for all members of a species, each of these genes give rise to different phenotypes.
B. Frederick explained that even though there are similar types of genes for species, each gene comes in different forms called alleles.
C. James clarified that members of the same species have the same set of genes, but being exposed to different environment cause them to have varied genotypes.
D. Rosalind discussed that the same set of genes found among members of the same species undergo different genetic processing.

(T) 16. Gene duplication is defined as any duplication of a region of DNA that contains a gene.
You are one of the biologists who believe in the *gene-duplication hypothesis of evolution.* If you are asked to explain how gene duplication can contribute to evolution, which of the following statements will you most likely use?
A. Mutation can cause the duplication of a gene that allows one copy of the gene to mutate and evolve to perform a new function.
B. Mutation can cause the duplication of a gene that doubles the amount and functionality of the trait-causing protein.
C. Mutation can cause the duplication of a gene that may lead to the production of a disease-causing protein.
D. Mutation can cause the duplication of the whole genome that give rise to entirely new species.

(T) 17. One of your projects in the *Institute of Molecular Biology and Biotechnology* is the creation and distribution of online educational materials for use by high school students. If you want to explain how genetic variation is achieved at the molecular level, which of the following will you use?
A. Brochure
B. Interactive animation
C. Journal Article
D. Lecture

(T) 18. Cuticular proteins are crucial components of the insect cuticle. Qiao et al (2014) studied a deletion mutation in a gene coding for a cuticular protein in silkworm, BmorCPR2. The dysfunctional protein lost chitin-binding ability, leading to reduced chitin content in larval cuticle and

limitation of cuticle extension. These variations in silkworm caused by mutation may lead to:

A. better adaptability of the mutant silkworm.
B. increased reproductive capacity of the mutant silkworm.
C. lower mortality rate of the mutant silkworm.
D. serious defects in larval adaptability of the mutant silkworm.

(T) 19. Male house finches (*Carpodus mexicanus*) vary in the amount of red pigmentation in their head and throat feathers. Colors range from pale yellow to bright red. The colors come from carotenoid pigments that are obtained from the birds' diet, because no vertebrates are known to synthesize carotenoid pigments. Thus, it can be said that the brighter red the male's feathers are, the more successful he has been at acquiring the red carotenoid pigment by his food-gathering efforts.

During breeding season, female house finches prefer to mate with males with the brightest red feathers. Which of the following is the **most** favorable condition for male house finches to attract female mate?

A. Alleles that promote more efficient food-gathering skills of males should increase over the course of generations.
B. Alleles that promote more effective deposition of carotenoid pigments in the feathers of males should increase over the course of generations.*
C. Both A and B
D. Neither A nor B

(T) 20. Swine may be infected by a bird flu virus or a human flu virus, or both viruses in an individual pig at the same time. When both viruses are present in an individual, it is possible for genes from bird flu virus and human flu virus to be combined, thereby producing a genetically distinctive virus, which can then cause widespread disease.

Given this situation, who among the following might be making an inaccurate conclusion/decision?

A. An infectious disease specialist warned that the occurrence may lead to an outbreak or epidemic because a new strain of virus exists.
B. A molecular biologist confirmed that during such occurrence, viruses undergo genetic mutation, combination, and reassortment of the genetic material.
C. A population geneticist made a remark that this occurrence enhances the genetic variability of the human species.
D. A team of health workers reviews the epidemiological situation regularly and recommends new vaccine strains whenever necessary.

EXPLORE

***Variation**, in biology, refers to any difference between cells, individual organisms, or groups of organism. Variation may be shown in physical appearance, metabolism, fertility, mode of reproduction, behavior, learning and mental ability, and other obvious or measurable characters.*

***Molecules**, in chemistry, are groups of atoms bonded together representing the smallest fundamental unit of a chemical compound that can take part in a chemical reaction.*

What role could the tiny molecules possibly play in variation? Your goal in this section is to start exploring this relationship.

Let's begin by examining a case of variation in humans.

ACTIVITY NO. 1: CASE ANALYSIS – Human Skin Color Variation

Read the given case carefully:

Modern Human Diversity - Skin Color
http://humanorigins.si.edu/evidence/genetics/skin-color/modern-human-diversity-skin-color

Why do people from different parts of the world have different colored skin? Why do people from the tropics generally have darker skin color than those who live in colder climates? Variations in human skin color are adaptive traits that correlate closely with geography and the sun's ultraviolet (UV) radiation.

As early humans moved into hot, open environments in search of food and water, one big challenge was keeping cool. The adaptation that was favored involved an increase in the number of sweat glands on the skin while at the same time reducing the amount of body hair. With less hair, perspiration could evaporate more easily and cool the body more efficiently. But this less-hairy skin was a problem because it was exposed to a very strong sun, especially in lands near the equator. Since strong sun exposure damages the body, the solution was to evolve skin that was permanently dark so as to protect against the sun's more damaging rays.

Melanin, the skin's brown pigment, is a natural sunscreen that protects tropical peoples from the many harmful effects of ultraviolet (UV) rays. UV rays can, for example, strip away folic acid, a nutrient essential to the development of healthy fetuses. Yet when a certain amount of UV rays penetrates the skin, it helps the human body use vitamin D to absorb the calcium necessary for strong bones. This delicate balancing act explains why the peoples that migrated to colder geographic

zones with less sunlight developed lighter skin color. As people moved to areas farther from the equator with lower UV levels, natural selection favored lighter skin which allowed UV rays to penetrate and produce essential vitamin D. The darker skin of peoples who lived closer to the equator was important in preventing folate deficiency.

There is also a third factor which affects skin color: coastal peoples who eat diets rich in seafood enjoy this alternate source of vitamin D. That means that some Arctic peoples, such as native peoples of Alaska and Canada, can afford to remain dark-skinned even in low UV areas. In the summer they get high levels of UV rays reflected from the surface of snow and ice, and their dark skin protects them from this reflected light.

Process Questions:
1. Describe how skin color differs for the human species.
2. Why do our skin colors vary? Enumerate some of the factors mentioned in the text.
3. ***How do you think does variation arise in human skin color?*** Write your **hypothesis** and explain briefly why you came up with such hypothesis.

This is only the first step in your exploration of *human skin color variation and the factors affecting it*. You will go back to this case in the succeeding sections of this module.

ACTIVITY NO. 2: Eliciting Prior Knowledge through K-W-L Chart

In the previous activity, you examined the factors that affect skin color. Environment plays a big role in the evolution of skin color in humans. A natural substance, called melanin, gives our skin its color. It also gives color to our hair and the iris of our eyes.

The traits or characteristics that organisms inherit and possess are provided by **substances** found in their bodies. Usually, these trait-giving substances are in the form of proteins.

Recall what you know about proteins and other biological macromolecules. ***How are these proteins synthesized in the cell?*** Could the differences in the proteins affect the way organisms grow and develop? To what extent do proteins influence variety among species? ***How exactly does variation arise?***

Write what you **know** about these questions in the **K** column of the K-W-L chart. Then, write what you **want to know** about the topic in the **W** column. Leave the third column blank.

K-W-L Chart		
How are proteins synthesized in the cell? *How does genetic variation arise?*		
WHAT I **K**NOW	WHAT I **W**ANT TO KNOW	WHAT I **L**EARNED

Each organism has a set of unique and different traits. Learn in this module how this variation in traits is achieved. Learn further how this variation of traits affects an organism's adaptability and survivability. **Your task at the end of this unit will have you explain in the molecular level how traits develop and how traits vary from generation to generation.**

End of EXPLORE:
You looked at variation, which is a *broad* concept in biology. You looked at molecules, substances, and proteins which are *small* entities that play important roles in organisms.

The contrast of "big" and "small" may have overwhelmed you. But you need not worry. This module will take you to a guided, step-by-step journey through the *tiny* molecules and their *huge* impact to variation of species and populations.

Let's start to find answers by doing the next activity.

FIRM-UP

Let's start small. In this section, you will be introduced to the "tiny" molecules found inside the cell that are the bases of inheritance. You will learn about the structure of these molecules and the processes they undergo. You will also learn what kind of action these processes do to our traits.

*Do **self-monitoring** of your progress in the different topics through the checklist below. The topics that will be covered in this section are indicated in the checklist.*

Topics	*Is the topic clear to you?*		
	YES	*A LITTLE*	*NOT YET*
DNA is the genetic material.			
DNA makes copies of itself through Replication.			
Information from the DNA is copied to RNA through Transcription.			
Information from DNA (and RNA) is 'translated' to protein.			

ACTIVITY NO. 3: Uncovering Mendel's "hereditary factors"
(*DNA is the genetic material.)*

Gregor Mendel explained in the year 1865 that traits are passed from the parent to the offspring through "hereditary factors."
In the early 20th century, scientists establish that Mendel's "hereditary factors" are called **genes**. The **gene** is the unit of inheritance and different forms of the same gene are called **alleles**.

But the individual genes make up a bigger whole. Humans, for instance, have about 30,000 genes. All these genes are found in a very long genetic material, the **DNA** or deoxyribonucleic acid.

Interactive A: DNA Structure

Click on the links below to learn what the DNA is.

http://www.pbs.org/wgbh/nova/genome/dna_flash.html - Journey into DNA

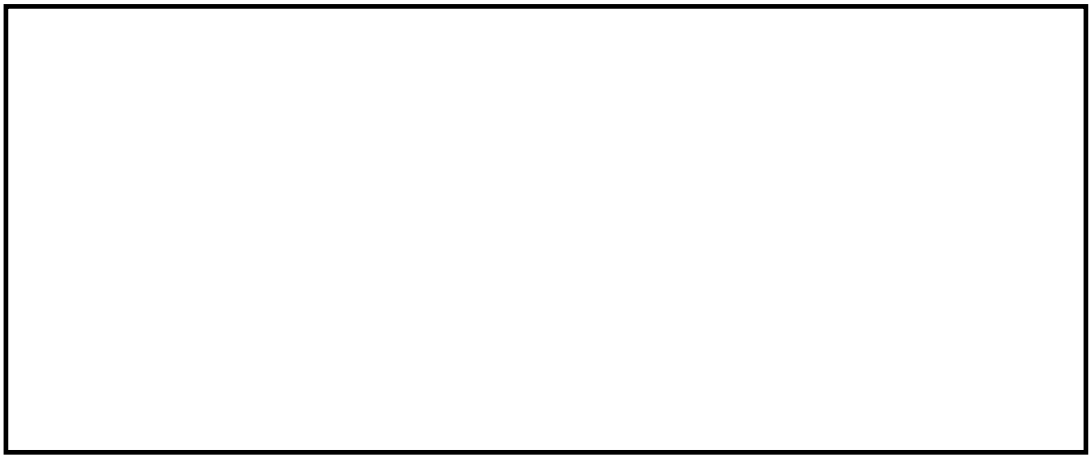
http://learn.genetics.utah.edu/content/molecules/dna/ - What is DNA?

http://www.nature.com/scitable/topicpage/dna-is-a-structure-that-encodes-biological-6493050 - DNA is a structure that encodes biological information

http://www.johnkyrk.com/DNAanatomy.html - DNA Anatomy

Process Questions:

1. Instructions providing all of the information needed for an organism to grow and live are found in the DNA. What do these instructions ***look*** like? Answer this question by drawing the detailed structure of DNA in the box provided below:



2. How can the DNA molecule hold information? Answer this question by *labelling* the parts of the DNA structure that enables it to encode a detailed set of plan for the cells of our body.
3. Why is the DNA considered as the genetic material?

Interactive B: Discovery of the DNA

Click on the link below to go to an interactive timeline about discoveries related to the DNA.

http://www.learner.org/interactives/dna/history.html - How DNA was discovered

Take note of the important conclusions made by each of the scientists/ group of scientists who studied DNA. Use the table below to summarize all information:

Scientists	Experiment (***Remember!*** *Summarize. Do not "copy and paste." Include only the most important ideas. Put together the main ideas in meaningful sentences.)*	Conclusion (***Remember!*** *Summarize. Do not "copy and paste." Include only the most important ideas. Put together the main ideas in meaningful sentences.)*

Process Questions:
1. What are the important conclusions that led the scientists to decide that the DNA is the *substance/molecule of inheritance?* Explain.
2. What parts of the DNA structure enables it to perform its function as the *genetic material*?

Before you end this activity, complete the exercise found in the link below:

http://learn.genetics.utah.edu/content/molecules/builddna/ - Build a DNA molecule

http://www.nobelprize.org/educational/medicine/dna_double_helix/dnahelix.html - DNA, the Double Helix

Process Questions:
1. What are the components of the DNA molecule?
2. How are these components arranged in order to build a DNA molecule?
3. How is DNA related to proteins? ***How are proteins synthesized in the cell?***

ACTIVITY NO. 4: "Be a Careful Reader"
(*DNA makes copies of itself through Replication.)*

In the previous activity, you studied the DNA molecule. You have already understood its double-helical structure. You have also seen how its structure relates to its function as genetic material. Learn more about how "structure fits

function" for DNA as you study another crucial process that our genetic material undergoes – its own **replication**.

Below are several learning materials on DNA replication:
http://science.howstuffworks.com/life/cellular-microscopic/dna3.htm - How DNA works

https://www.youtube.com/watch?v=27TxKoFU2Nw – DNA replication process

http://www.johnkyrk.com/DNAreplication.html - DNA makes DNA

In this module, you will come across a lot of reading materials, some of which may be too long and complicated. For you to better understand the content of the given materials, always follow these four strategies: (taken from www.interventioncentral.org)

1. **Prediction.** Before you begin to read, look at the main title, scan the material to read the major headings, and look at the illustrations. Based on these clues, try to **predict** what the material is about. Write your prediction in the space provided.
2. **List Main Ideas.** Stop after each paragraph or major section of the learning material. Construct one or two complete sentences that sum up only the most important idea(s) that appear in the section. Good summary sentences include key concepts or events but leave out less important details. Write these summary (main idea) sentences down and continue reading.
3. **Question Generation.** Look at the ideas that you have summarized as you work through the learning material. For each main idea listed, write down at least one question that the main idea will answer.
4. **Clarifying.** Sometimes in your reading you will run into words, phrases, or whole sentences that really don't make sense. Here are some ways that you can clarify the meaning of your reading before moving on:
   - If you come across a word whose meaning you do not know, read the sentences before and after it to see if they give you clues. If the word is still unclear, look it up in a dictionary.
   - Reread the phrase or sentence carefully and try to understand it. If it contains words such as "them", "it" or "they", be sure that you know what nouns to which these words refer.

Ready to summarize information about DNA replication? Complete the given worksheet:

DNA Replication			
Predicting	Listing Main Ideas	Questioning	Clarifying

I think that the learning materials will talk about/show…	*The most important ideas are…*	*For each main idea, these are the questions that might be asked…*	*These are terms /concepts/ ideas that are not yet clear to me…*
Summarizing: *Here's a summary of what I learned about DNA Replication:*			

Process Questions:
1. Why does the DNA molecule need to make identical copies of itself?
2. Why does DNA replication need to be error-free? Why does the DNA need to be a "careful reader?"
3. What is the importance of DNA replication to DNA's function of storing genetic information?

Quick Review:
Click on the letter that corresponds to the best answer:
1. During DNA replication, the parental strand is GAATCT. What will be the complementary DNA strand?
    A. GAATCT
    B. CTTAGA
    C. TCTAAG
2. After replication, two identical daughter molecules are produced. Each daughter molecule contains one old strand of DNA. This is because DNA replication
    A. conservative.
    B. continuous.
    C. semiconservative.

For nos. 3-5, choose from the following enzymes used in replication.
    A. DNA helicase
    B. DNA ligase
    C. DNA polymerase
3. Unwinds and unzips DNA

4. Adds new complementary DNA nucleotides to the daughter strand
5. Seals breaks in the DNA backbone

ACTIVITY NO. 5: "Pass the Message"
(*Information from the DNA is copied to RNA through Transcription.)*

You've seen from the previous activities how DNA is a very important molecule. So important that every cell in an organism's body has to have the same DNA; and that if ever a cell is to divide itself, it has to first make sure it has identical copies of its DNA. It is important, during replication, to preserve and pass on the **same** information found in the DNA.

The DNA is found inside the nucleus; the molecule **does not** go out of there. However, the instructions contained in the DNA go beyond the nucleus to reach other parts of the cell. How is that made possible by the cell? To answer that question, you have to get to know another molecule: **RNA or ribonucleic acid**.

Interactive A: *What is RNA?*

Click on the links below to learn what the RNA is.

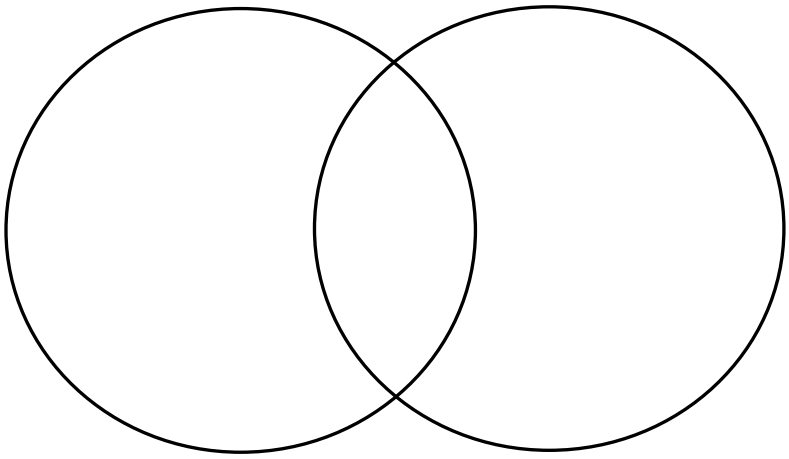
http://learn.genetics.utah.edu/content/molecules/rnamolecule/ **-** RNA, the Versatile Molecule

http://www.rnasociety.org/about/what-is-rna/ - What is RNA?

http://www.pbs.org/wgbh/nova/labs/video_popup/4/25/ - RNA VirtuaLab (video intro)

https://www.youtube.com/watch?v=0Elo-zX1k8M – Why RNA is just as cool as DNA

Process Questions:
1. What important role does RNA play in the expression of information found in the DNA?
2. Compare and contrast the *structure* of DNA and RNA through a Venn diagram.



Interactive B: Transcription

How do genes (which are found in the DNA) give rise to actual traits or characteristics? If I got that part of my mother's DNA that tell me I should also have a curly hair, how come I actually get a curly hair? How do our cells accomplish that **gene expression**?

You have now come to the first step in gene expression which is **transcription**. The RNA molecule takes part in this process.

Click on the links below to learn about transcription:

http://www.dnalc.org/resources/3d/12-transcription-basic.html - Transcription

https://www.youtube.com/watch?v=AGzsgTMgSog – video of transcription

http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/transcription.swf - transcription animation

Process questions:
1. What is transcription?
2. What molecule is produced after transcription? Why does it need to be produced?
3. What does transcription have to do with **protein synthesis**?

Read the following study about "junk" DNA, found in the given link. This will help you discover important facts and events about transcription.

http://healthland.time.com/2012/09/06/junk-dna-not-so-useless-after-all/ - Junk DNA – Not So Useless After All

4. What is "junk" DNA?
5. Do you think these portions of the DNA get ***transcribed***? Why or why not?
6. According to studies, why are junk DNA "not so useless after all?"
7. How does "junk" DNA assist the process of transcription?
8. What can you conclude about the process of gene expression in living things?

Quick Review:

Click on the letter that corresponds to the best answer:

1. If the sequence of bases in DNA is GACT, then the sequence of bases in RNA is:
   A. GACT
   B. GACU
   C. CTGA
   D. CUGA
2. The process of transcription produces
   A. cDNA
   B. mRNA
   C. protein
3. Which of the following is **not true** about transcription?
   A. In making RNA, uracil, instead of thymine, pairs with adenine.
   B. RNA is made from a DNA template.
   C. RNA is produced in the cytoplasm of eukaryotic cells.
   D. The enzyme RNA polymerase synthesizes RNA.

ACTIVITY NO. 6: "In English, Please"
(*Information from DNA (and RNA) is 'translated' to protein.)*

The first step in gene expression was covered in the previous activity. "Instructions" from the DNA is transcribed to RNA. RNA is an intermediate product that serves as a messenger from the nucleus, where the DNA is, to the ribosomes where proteins will be synthesized. Once the information from the DNA has been *transcribed* and the messenger RNA (mRNA) produced, the mRNA goes out of the nucleus to bring the information to the ribosomes.

Proteins are important molecules in our cells. They come in the form of enzymes, some hormones, and structural proteins that together dictate what our **traits** will be.

Learn more about proteins and their importance through this animation:
http://learn.genetics.utah.edu/content/molecules/proteins/ - What is a Protein?

Proteins are said to be the building blocks of our body. They constitute about 80% of the dry weight of muscle, 70% of the dry weight of skin and 90% of the dry weight of blood. Proteins make up your hair, skin, eyes, muscle, and organs. ***Collagen****, for instance, is the protein found in our bones, tendons, and ligaments, while* ***keratin*** *is the protein of nails, hair, and feathers.*
Proteins are also responsible for almost all biochemical processes that keep you alive.

Click on this link to learn more:
http://healthyeating.sfgate.com/6-primary-functions-proteins-5372.html - 6 Primary Functions of Proteins

To produce proteins, information from the DNA (brought by the mRNA) is used. However, DNA and RNA are both made up of nucleotides, while proteins are made up of amino acids. They don't "speak" the same "language." Hence, another process must happen for genes to be expressed into protein. This process is referred to as **translation.**

Before you go through the process of translation, discover first how the cell "reads" genes. Read the following excerpt:

How do cells read genes?
http://learn.genetics.utah.edu/content/molecules/dnacodes/

Like words in a sentence, the DNA sequence of a gene determines the amino acid sequence for the protein it encodes. In the protein-coding region of a gene, the DNA sequence is interpreted in groups of three nucleotide bases, called codons. Each codon specifies a single amino acid in a protein.

We can think about the protein-coding sequence of a gene as a sentence made up entirely of 3-letter words. In the sequence, each 3-letter word is a codon, specifying a single amino acid in a protein. Have a look at this sentence:

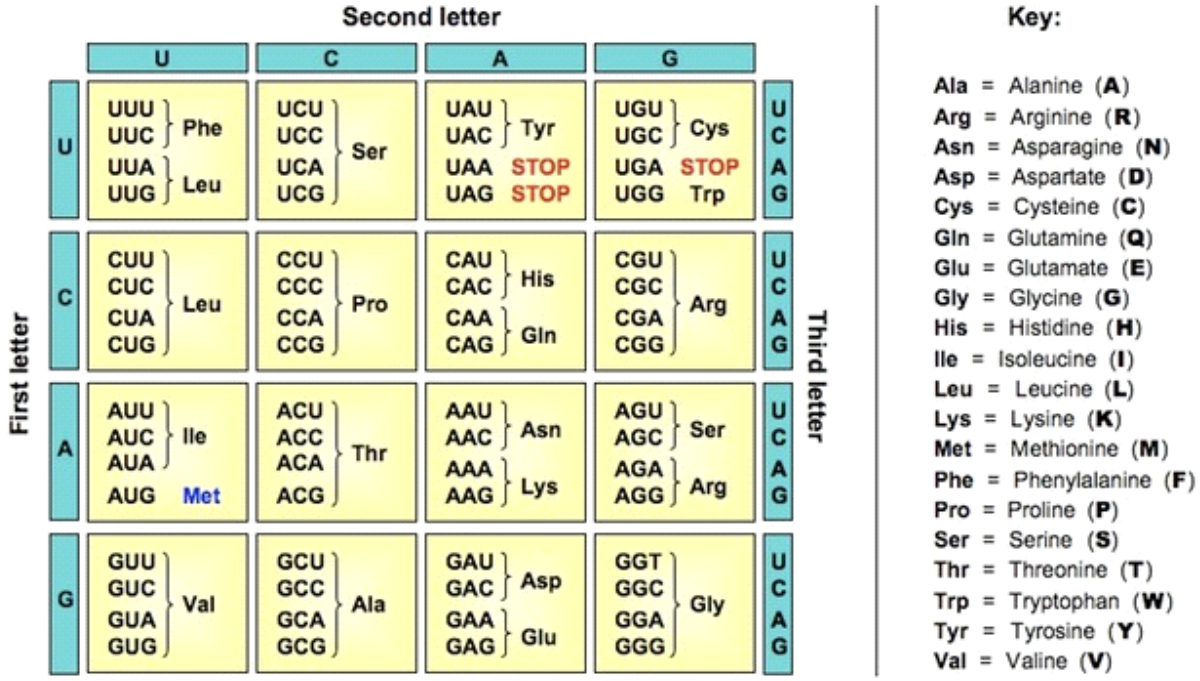
Thesunwashotbuttheoldmandidnotgethishat.

If you were to split this sentence into individual 3-letter words, you would probably read it like this:

The sun was hot but the old man did not get his hat.

This sentence represents a gene. Each letter corresponds to a nucleotide base, and each word represents a codon.

To know what amino acid is coded by a given codon, a genetic code chart is used:



Notice that the genetic code is **degenerate,** this means more than one codon codes for the same amino acid. The genetic code is **unambiguous,** each triplet code has only one meaning. Notice also that the code has start and stop signals.

Click on the links below to learn about the process of translation:

http://www.nobelprize.org/educational/medicine/dna/b/translation/translation.html - Translation

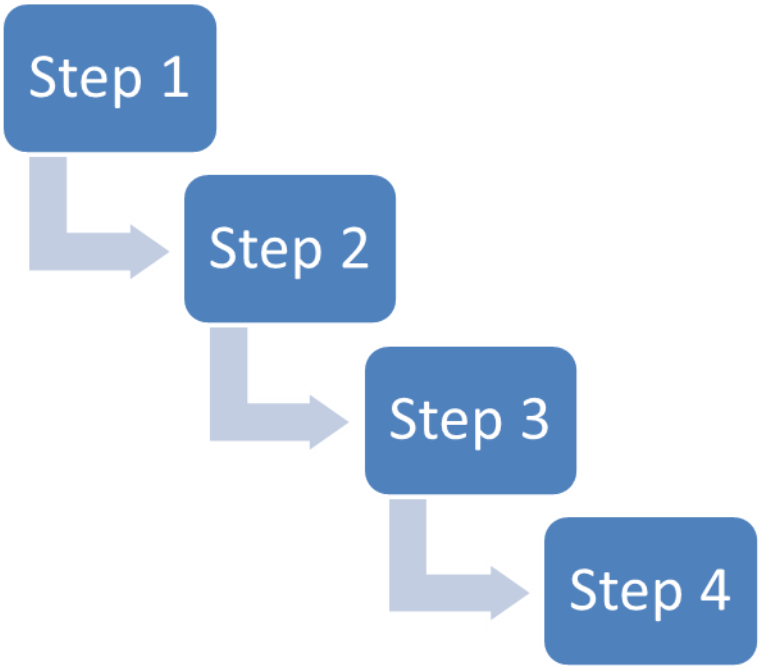
https://www.youtube.com/watch?v=h5mJbP23Buo – Protein Synthesis and the Lean, Mean Ribosome Machines

http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::535::535::/sites/dl/free/0072437316/120077/micro06.swf::Protein+Synthesis – Protein Synthesis

http://learn.genetics.utah.edu/content/molecules/transcribe/ - Transcribe and Translate a Gene

Process Questions:

1. What information is "translated" in the process of protein synthesis?
2. How does the cell pick up this information? Discuss all the molecules involved and the action of these molecules.
3. **How are proteins synthesized in the cell?** Answer this question through a graphic organizer:



4. Do all cells of the body produce the same protein? Do all genes get expressed at the same time? Explain.
5. What would happen if a change/irregularity happens in any of the steps? How will this change affect the protein?

Quick review:

Determine the amino acid coded by the following mRNA codons:

1. CUU
2. ACA
3. GAC
4. UUU

Determine the amino acid sequence that can be produced from this **DNA** strand:

T A C T G T C A G G A A A A A T C T A T T

ACTIVITY NO. 7: CASE ANALYSIS – Human Skin Color Variation

Recall the first activity you did in this module. It was an analysis of the case of skin color variation in humans. Retrieve the text as well as your initial analysis to the case.

Now that you have learned a great deal about DNA and protein synthesis, we can already discuss the case in more detail. Answer the following questions after reviewing the text *Modern Human Diversity – Skin Color.*

1. What are the **three** factors that affect skin color in humans? Write each factor in the columns of the given table:

Factor 1: _____	Factor 2: _____	Factor 3: _____

2. How does each of these factors determine whether people will develop lighter or darker skin color?

   To answer this, go back to the text and *summarize* the main points for each factor. *List* the most important *ideas* and write a summary using as many of the main idea words as possible. Your list and summary should appear in the appropriate columns of the table:

Factor 1: _____	Factor 2: _____	Factor 3: _____

3. What substance, which was mentioned in the text, gives color to our skin?

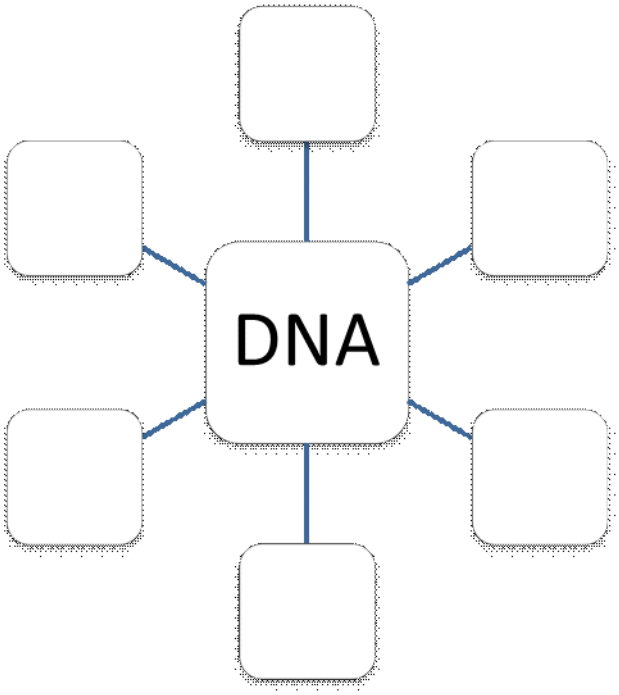
   How do you think does this substance give color to our skin? Why does it give a lighter color to one, and a darker color to another? Make a detailed guess and **illustrate** that in the box provided below:

EXPLAINING HUMAN SKIN COLOR VARIATION **(CONCRETE)**

At present, the genetics of skin color is still largely unclear, even for the biologists and experts. In the succeeding section, however, we will still look at some studies that attempt to know and target the *actual* genes that control human skin color and how it varies for peoples of different races.

It doesn't yet fully answer our query about skin color variation. But, studying those will deepen your understanding of the molecular basis of inheritance and genetic variation.

Before ending this section, review and look back at how DNA has come to be called the substance of inheritance, our genetic material. Show, through a cluster map, the many substances and processes that rely on the DNA. Use http://www.spicynodes.org/ to construct your map.



End of FIRM UP:
In this section, the discussion was about the DNA and how information from the DNA is used to synthesize proteins.

How did you do?

Skills	*Self-Assessment*		
	YES	*A LITTLE*	*NOT YET*
I can infer, based on its structure, that the DNA is the genetic material.			
I can explain how DNA makes copies of itself through Replication.			
I can differentiate DNA and RNA structure, as well as their corresponding functions.			
I can describe how information from the DNA is copied to RNA through Transcription.			
I can interpret nucleotide codes and their corresponding amino acids			

using the genetic code and following the steps in the process of Translation.			

Go back to the previous section and compare your initial ideas with the discussion. How much of your initial ideas are found in the discussion? Which ideas are different and need revision?
Now that you know the important ideas about this topic, let's go deeper by moving on to the next section.

DEEPEN

In the previous section, you learned about the flow of genetic information from the DNA to the RNA to proteins. That is the ***central dogma of molecular biology.***

Your goal in this section is to take a closer look at these processes by studying actual proteins and their synthesis. You will also learn about the consequences (or benefits) if an error or change occurred in the processing of DNA. Learn how such changes may have implications to an organism's adaptation and survival.

ACTIVITY NO. 8: "Transcribe and Translate"
(*Changes in the DNA may affect protein production.*)

Have you ever experienced sending a wrong message to somebody? Or you delivered a message and it was misinterpreted by someone? On some occasions, this may bring negative consequences. But there could also be some instances when it could actually lead to something positive and good. Or, it may not have any effect at all.

The process of replication is not entirely error-free. Changes may happen to the DNA sequence. Such change is called **mutation**.

What happens if there is a mutation in the DNA sequence? Click on the link below to do an activity about mutation. In this virtual lab, you will complete mRNA and protein sequences based on the given information. Compare the original and mutated sequences to see the impact of the mutation.

http://www.mhhe.com/biosci/genbio/virtual_labs/BL_26/BL_26.html - Virtual Lab: DNA and Genes

Process Questions:
1. Describe the differences between the original and mutated sequences.

2. How many amino acids were changed or affected?
3. What do you think will be the impact of this mutation? Why?
4. Does changing the sequence of nucleotides always result in a different amino acid sequence? Explain.

Learn more about mutation by exploring the learning materials found in the following links:

http://biology.about.com/od/basicgenetics/ss/gene-mutation.htm - Gene mutation

http://www.uvm.edu/~cgep/Education/Mutations.html - Mutations

http://learn.genetics.utah.edu/content/variation/mutation/ - What is Mutation?

In order for you to get the most out of the materials provided, you will be introduced to another writing strategy.

Just as the cell transcribes and translates information from the DNA, you will also try to "transcribe" and "translate" the information given about mutation using the **POW+TREE Strategy**.

<table>
<tr><td colspan="2">Pick an idea or opinion.</td></tr>
<tr><td rowspan="4">Organize and generate notes and ideas for each part of the TREE:</td><td>Topic Sentence</td></tr>
<tr><td>Reason</td></tr>
<tr><td>Explanation</td></tr>
<tr><td>Ending</td></tr>
<tr><td colspan="2">Write and say more.</td></tr>
</table>

Process Questions:
1. What are the causes of mutation? Explain each.
2. Differentiate the types of mutation.
3. ***How can mutation affect protein synthesis in the cell?*** Discuss thoroughly.

Many known diseases are caused by mutation. Click on the link below to learn about some common genetic disorders:

http://www.steadyhealth.com/articles/The_16_Most_Common_Genetic_Diseases_a1547.html - The 16 Most Common Genetic Diseases

http://www.cdc.gov/ncbddd/birthdefects/DownSyndrome.html - Facts about Down Syndrome

4. As you have read, these diseases are usually resulting from lack of a necessary protein or presence of wrong or malfunctioning proteins. ***How does mutation contribute to the production of faulty proteins?***

Quick Review:
Review the animation and answer the questions that follow to test your understanding.

http://highered.mheducation.com/sites/0072552980/student_view0/chapter9/animation_quiz_5.html - Addition and Deletion Mutations

ACTIVITY NO. 9: SITUATION ANALYSIS

You have looked at mutation and the effects it may have in protein synthesis. You have also explored *real* situations related to the said topic.

This next activity will have you examine more real-life situations that illustrate protein synthesis.

PROBLEM 1

What makes a firefly glow?

http://learn.genetics.utah.edu/content/molecules/firefly/

Process Questions:
1. Why is it possible for a firefly to produce its own light?
2. ***How is the protein (luciferase) synthesized in the cell?*** What results from this?
3. If the synthesis is altered, what is the possible outcome?

PROBLEM 2

Viruses have no cells. How come they can "*live*?"

Tinkering with translation: protein synthesis in virus-infected cells
Walsh, Matthews, and Mohr, January 2013
http://www.ncbi.nlm.nih.gov/pubmed/23209131

Viruses are obligate intracellular parasites, and their replication requires host cell functions. Although the size, composition, complexity, and functions encoded by their genomes are remarkably diverse, all viruses rely absolutely on the protein synthesis machinery of their host cells. Lacking their own translational apparatus, they must recruit cellular ribosomes in order to translate viral mRNAs and produce the protein products required for their replication. In addition, there are other constraints on viral protein production. Crucially, host innate defenses and stress responses capable of inactivating the translation machinery must be effectively neutralized. Furthermore, the limited coding capacity of the viral genome needs to be used optimally. These demands have resulted in complex interactions between virus and host that exploit ostensibly virus-specific mechanisms and, at the same time, illuminate the functioning of the cellular protein synthesis apparatus.

Process Questions:
1. What determines the size, composition, complexity, and functions of a virus?
2. ***How are viral proteins synthesized if viruses don't have cells?***
3. What may happen if the viral protein synthesis is altered? Why do many scientists find ways to alter this process in viruses?

PROBLEM 3

Why are some people born with a disease?

http://www.dnalc.org/resources/3d/17-sickle-cell.html - Disease and Mutation: Sickle Cell

Process Questions:

1. What happens to the red blood cells of individuals with sickle cell anemia? Explain why this happens.
2. Why do cells produce abnormal or faulty proteins?
3. ***How are these proteins synthesized in the cell?***
4. Can the production of these proteins be prevented? If yes, how? If no, why not?

You have looked at different situations related to protein synthesis. Put together in the table below your answers to the essential question that was asked for each problem.

	PROBLEM 1	PROBLEM 2	PROBLEM 3
ESSENTIAL QUESTION: ***How are proteins synthesized in the cell? What happens if the process is altered?***	What makes a firefly glow? *Cells in the firefly's tail produce…*	Viruses have no cells. How come they can "***live***?" *Tinkering with translation: protein synthesis in virus-infected cells* *Protein synthesis in viruses…*	Why are some people born with a disease? *Disease and Mutation: Sickle Cell* *Sickle-cell anemia is a disease that results due to alteration in the synthesis of…*

Process Questions:

1. Look at your answers to the essential question in the above table. What do all the answers have in common?
2. Are all the factors the same? How do the answers differ? What are the different factors that affect protein synthesis in cells?
3. Complete the following statement and support your answer with examples from the above situations.

The synthesis of proteins…

Supporting reasons and examples:

Be sure that everything is clear to you before you move on to the next activity. Use the following self-monitoring guide:

Skills	RED I still need more activities to understand all the concepts.	YELLOW More than 50% of the concepts I fully understand.	GREEN I understand all and will be able to apply.
I can describe the relationship between DNA, RNA, and proteins.			
I can prove, *by discussing the processes and showing examples*, that the DNA holds the genetic information that are expressed as traits.			
I can investigate the effects of mutation on protein synthesis, and the consequent effects to the organism.			

ACTIVITY NO. 10: CASE ANALYSIS – Human Skin Color Variation

It is now time for you to go back to the case you have been investigating in the previous sections.

Read the following additional information:

Rees in 2003 made a study entitled Genetics of Hair and Skin Color. According to the study, "differences in skin and hair color are principally genetically determined and are due to variation in the ***amount, type, and packaging of melanin polymers*** *produced by melanocytes secreted into keratinocytes."*

Let us get to know **melanin** in more detail then.

Melanin is the substance that gives skin, hair, and eyes their color. Melanin is also found in the light-sensitive tissue at the back of the eye (the retina), where it plays a role in normal vision. Melanin is produced in specialized cells called melanocytes.

Tyrosinase *is an enzyme located in melanocytes. This enzyme is responsible for the first step in melanin production. It converts a protein building block (amino acid) called tyrosine to another compound called dopaquinone. A series of additional chemical reactions convert dopaquinone to melanin in the skin, hair follicles, the colored part of the eye (the iris), and the retina.*

The ***TYR gene*** *provides instructions for making the enzyme tyrosinase.*

(Taken from: http://ghr.nlm.nih.gov/gene/TYR)

Process Questions:

1. ***How is tyrosinase (a protein) synthesized in the cell?*** Based on what you know about gene expression and protein synthesis, make a **simple model** of the synthesis of tyrosinase from the TYR gene.

EXPLAINING HUMAN SKIN COLOR VARIATION
SYNTHESIS OF TYROSINASE
A Model
(REPRESENTATIONAL)

2. Do you think melanin and tyrosinase could play a role in human skin color variation? How may they contribute to variation? Explain.

The next activity will help you analyze this case more deeply. The focus is on **genetic variation**.

ACTIVITY NO. 11: VIDEO ANALYSIS

Biodiversity, the variety of life on earth, is crucial to both the abiotic and biotic components of the ecosystem. One level of biodiversity is **genetic diversity.** It refers to the total number of genetic characteristics in species.

Genetic diversity allows populations to adapt to changing environments. With more variation, there is higher chance that some individuals will possess variations of genes and alleles that are more suited for the environment. Those individuals have higher chance of survival and will produce more offspring bearing that allele. The population will continue to survive through generations because of the success of these individuals.

How does genetic variation arise?

To help you understand how genetic variation occurs at the molecular level, watch carefully the following videos and answer the questions that follow:

VIDEO 1

https://www.youtube.com/watch?v=z9HIYjRRaDE – Where do Genes come from?

Process Questions:

1. According to the video, what makes it possible for **new** genes to enter a population?
2. ***How does genetic variation arise?***

VIDEO 2

https://www.youtube.com/watch?v=xkVv52EyKzc – Are Mutations Heritable?

Process Questions:

1. What are heritable mutations?
2. How can mutations in genes be passed from the parent to offspring?

3. What is/are the possible contribution/s of heritable mutations to genetic variation?
4. ***How does genetic variation arise?***

Before you leave this topic on heritable mutations, spend some time thinking about this additional question: ***Does mutation happen randomly or does it happen as a response to the environment?*** Gather pertinent resources and discuss this controversial issue with your classmates through an online discussion forum.

VIDEO 3

https://www.youtube.com/watch?v=11iYk0Yrx3g - Genetic Variation, Gene Flow, and New Species

Process Questions:
1. In terms of genetic variation, why is sexual reproduction more advantageous than asexual reproduction?
2. ***How does genetic variation arise from sexual reproduction?***

You have looked at three different videos related to genetic variation. Put together in the table below your answers to the essential question that was asked for each problem.

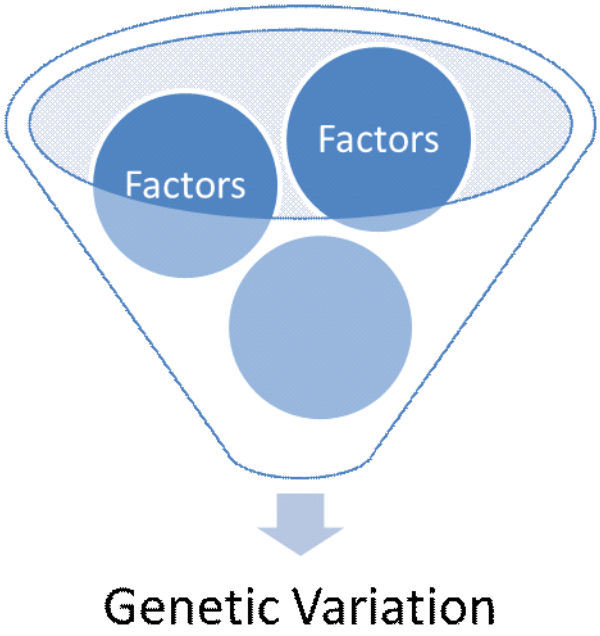
	VIDEO 1	VIDEO 2	VIDEO 3
ESSENTIAL QUESTION: ***How does genetic variation arise?***	Where do Genes come from? *Genetic variation may arise from…*	Are Mutations Heritable? *Genetic variation may arise from…*	Genetic Variation, Gene Flow, and New Species *Genetic variation may arise from…*

Process Questions:

1. Look at your answers to the essential question in the above table. What do all the answers have in common?
2. Are all the factors the same? How do the answers differ? What are the different ways by which genetic variation can be attained?
3. Complete the following statement:

Genetic variation arises as a result of …

Present your supporting reasons and examples through a funnel graphic organizer. Modify as you see fit:



Read the article found in the given link:
http://evolution.berkeley.edu/evolibrary/news/120301_chipmunks - Climate change causes loss of genetic diversity

Process questions:
1. Describe the situation of alpine chipmunks (*Tamias alpinus)* in the Yosemite National Park. Why is it now difficult for park visitors to encounter the chipmunks?
2. Discuss all the factors that led to the supposed loss of genetic variation in alpine chipmunks.
3. Based on the analysis you've done, suggest measures that may be taken in order to improve genetic variation in alpine chipmunks.

ACTIVITY NO. 12: Summarizing New Knowledge through K-W-L Chart

Recall the two focus questions that you dealt with in the different activities:

- ***How are proteins synthesized in the cell?***
- ***How does genetic variation arise?***

Write your final answers to these questions in the **L** column of the K-W-L chart. Compare your new answers with your answers in the previous columns.

K-W-L Chart		
How are proteins synthesized in the cell? *How does genetic variation arise?*		
WHAT I **K**NOW	WHAT I **W**ANT TO KNOW	WHAT I **L**EARNED

End of DEEPEN:
In this section, the discussion was about mutation and genetic variation.

What new realizations do you have about the topic? What new connections have you made for yourself? What helped you make these connections?

Now that you have a deeper understanding of the topic, you are ready to do the tasks in the next section.

TRANSFER

Your goal in this section is apply your learning to real life situations. You will be given a practical task which will demonstrate your understanding.

ACTIVITY NO.13: CASE ANALYSIS – Human Skin Color Variation

You now reached the concluding part of this case analysis of human skin color variation. This time, you will **write** your own analysis of the case based on the topics you learned about *gene expression, mutation, and genetic variation.*

Use as references the related activities you accomplished in the previous sections. Below are additional references as well:

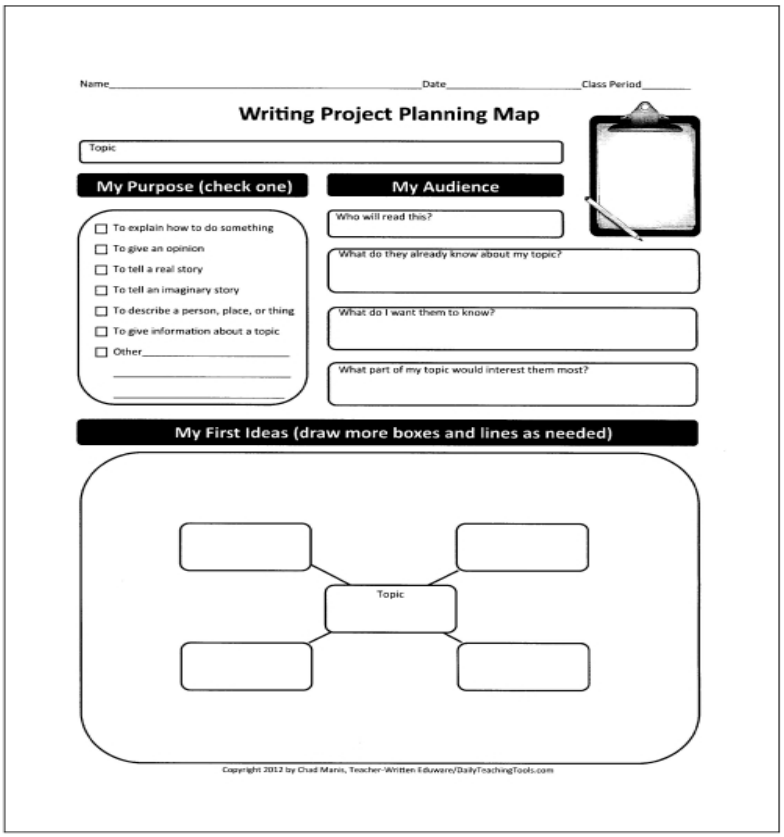
http://www.scientificamerican.com/article/researchers-identify-huma/ - Researchers Identify Human Skin Color Gene

http://medicalxpress.com/news/2014-01-skin-gene-global-populations-reveal.html - Studies of a skin color gene across global populations reveal shared origins

http://humanorigins.si.edu/evidence/genetics/skin-color/modern-human-diversity-genetics - Modern Human Diversity – Genetics

Process Questions:
1. Why is there variation in human skin color?
2. Why is this variation important?

You will communicate the information you gathered and your analysis to your classmates. Choose the mode which you think will best communicate your thoughts. Use a **project planning map** to guide you through this task. See sample map below.



Name_____Date_____Class Period_____

Writing Project Planning Map

Topic

My Purpose (check one)

- ☐ To explain how to do something
- ☐ To give an opinion
- ☐ To tell a real story
- ☐ To tell an imaginary story
- ☐ To describe a person, place, or thing
- ☐ To give information about a topic
- ☐ Other_____

My Audience

Who will read this?

What do they already know about my topic?

What do I want them to know?

What part of my topic would interest them most?

My First Ideas (draw more boxes and lines as needed)

Topic

EXPLAINING HUMAN SKIN COLOR VARIATION
My Own Analysis
(ABSTRACT)

Before submitting your work, do a self-assessment through this checkbric:

CRITERIA	YES	NO
I have a clear idea of what the case is about. I asked questions and defined problems / variables.		
I planned the project and carried out some investigations.		
I gathered enough data and information, and evaluated them so as to include only those that are accurate and relevant to the purpose of the task.		
I organized my ideas in a manner that is easy to follow and suited to my purpose.		
I cited all references and sources of information.		
I communicated my ideas in a manner that is appropriate to the purpose and audience.		
My work is objective and evidence-based, but is creative and engaging.		

ACTIVITY NO.13: TRANSFER TASK

Read carefully your final task for this module:

Environmental change is now occurring on a global scale due to human activities and many species will have to adapt to this change or experience an ever increasing chance of extinction.

One of your projects in the Institute of Molecular Biology and Biotechnology is the creation and distribution of online educational materials (videos, video podcasts, interactive simulations, etc.) that explain the molecular basis of genetic variation and species adaptability.
The responsibility of producing the materials is left to the media team composed of a researcher, a scriptwriter, and an animator.

Materials are intended for students and are therefore expected to be informative, engaging, and creative.

Rubric:

CRITERIA	Exemplary 4	Proficient 3	Developing 2	Beginning 1
CONTENT ***What is the evidence that the student can obtain and evaluate useful information?***	Content is insightful and highly relevant to the objectives of the project, and wisely chosen to address the needs of the audience. Advanced level of scientific understanding is apparent in the information presented. Thorough research was done and all sources of information are clearly identified and credited using citations.	Content is relevant to the objectives of the project. All information presented is correct, accurate, and useful. All sources of information are clearly identified and credited using citations.	Some parts are distracting or unnecessary and some information is inaccurate, unclear, and rambling. Some sources of information are not cited.	Content is irrelevant to the objectives; information presented is very shallow, many are false and confusing. No citations were made.
COMMUNICATION ***What is the evidence that the student can communicate the information in an organized***	Information is communicated using sophisticated and varied language that is suited to the purpose, audience, and task.	Information is communicated using appropriate language and style that is suited to the purpose, audience, and task.	Information is communicated using language and style that is at times inappropriate to the purpose, audience, and task.	Information is communicated using language and style that is totally different from the purpose, audience, and task.

and effective manner?	Organization is appropriate to the purpose and audience and supports with great detail the line of reasoning; effectively hooks and sustains audience engagement.	Organization is appropriate to the purpose and audience and establishes the line of reasoning; transitions guide audience understanding.	Inconsistencies in organization and limited use of transitions sometimes confuse the audience.	A lack of organization makes it difficult to follow the ideas and line of reasoning.
CREATIVITY ***What is the evidence that the student can put together resources and information in a creative way?***	The work is put together by the student in a novel and resourceful way. The work has insightful and striking ideas. Some experimentation is done which gives the work a unique and personal style.	The work is put together by the student in a resourceful way. The work has new ideas.	The work is put together by the student following another model or work. The work has borrowed ideas from another source.	The work is entirely copied and shows no effort at all to reflect one's own ideas. The work does not acknowledge the original source that it copied.

End of TRANSFER:
In this section, your task was to explain in different ways how genetic variation is achieved at the molecular level and discuss its implications to biodiversity and the species' adaptability and survivability.

How did you find the performance task? How did the task help you see the real world use of the topic?

You have completed this lesson. Before you go to the next lesson, you have to answer the following post-assessment.

GLOSSARY OF TERMS USED IN THIS LESSON:

allele Alternative form of a gene

amino acid Organic molecule having an amino group and an acid group, which covalently bonds to produce peptide molecules.

anticodon Three-base sequence in a transfer RNA that pairs with a complementary codon in mRNA

bacteriophage Virus that infects bacteria

chromosome Chromatin condensed into a compact structure

DNA (deoxyribonucleic acid) Nucleic acid polymer produced from covalent bonding of nucleotide monomers that contain the sugar deoxyribose; the genetic material of nearly all organisms.

DNA replication Synthesis of a new double helix prior to mitosis and meiosis in eukaryotic cells and during prokaryotic fission in prokaryotic cells

enzyme Organic catalyst, usually a protein, that speeds a reaction in cells due to its particular shape.

gene Unit of heredity existing as alleles on the chromosomes

genetic code Universal code that specifies protein synthesis in the cells of all living things. Each codon consists of three letters standing for the DNA nucleotides that make up one of the 20 amino acids found in proteins.

genetic diversity Variety among members of a population

messenger RNA (mRNA) Type of RNA formed from a DNA template that bears coded information for the amino acid sequence of a polypeptide.

mutation Alteration in chromosome structure or number and also an alteration in a gene due to a change in DNA composition.

peptide Two or more amino acids joined together by covalent bonding

protein Molecule consisting of one or more polypeptides

ribosome RNA and protein in two subunits; site of protein synthesis in the cytoplasm.

RNA (ribonucleic acid) Nucleic acid produced from covalent bonding of nucleotide monomers that contain the sugar ribose; occurs in three forms: messenger RNA, ribosomal RNA, and transfer RNA.

transcription Process whereby a DNA strand serves as a template for the formation of mRNA.

transfer RNA Type of RNA that transfers a particular amino acid to a ribosome during protein synthesis.

translation Process whereby ribosomes use the sequence of codons in mRNA to produce a polypeptide with a particular sequence of amino acids.

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http://learn.genetics.utah.edu/content/molecules/dna/ - What is DNA?

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POST-ASSESSMENT:

It's now time to evaluate your learning. Click on the letter of the answer that you think best answers the question. Your score will only appear after you answer all items. If you do well, you may move on to the next module. If your score is not at the expected level, you have to go back and take the module again.

(A) 1. During transcription, information from specific genes is transferred to the intermediate molecule, RNA. After DNA has been transcribed into RNA,
   A. mRNA will then leave the nucleus.
   B. mRNA will attach to the DNA template.
   C. rRNA will begin to make new DNA strands.
   D. rRNA will supply the required amino acid from the split DNA.

(A) 2. The sequence found in the mRNA molecule determines the following except:
   A. the protein that will be synthesized.
   B. the amino acids to be brought by mRNA.
   C. the complementary DNA sequence.
   D. the amino acids that will form a protein.

(A) 3. A gene is expressed when its product, a protein, is produced and is functioning in a cell. What is the scientific term for making a protein according to the instructions found in the DNA?
   A. Replication
   B. Transcription
   C. Translation
   D. Reverse Transcription

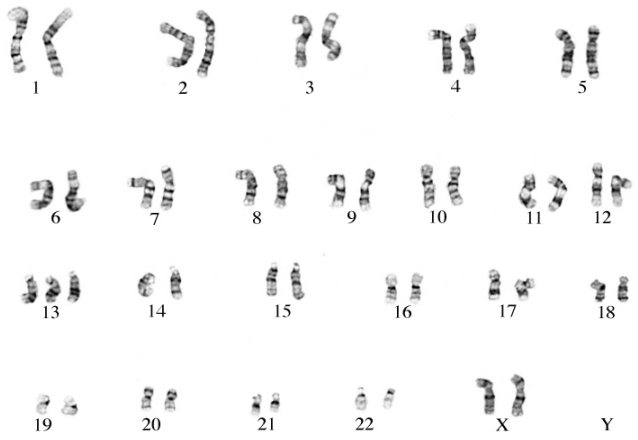
(A) 4. A mutation in a DNA segment can possibly lead to the following except
   A. change in amino acid sequence.
   B. synthesis of a different protein.
   C. no change in the protein that will be formed.
   D. retention of the original position of the bases in the gene.

(A) 5. Consider this DNA sequence: AGT CGA GGC. If an adenine base (A) is added to the sequence such that the new sequence copied during replication is AGT **A**CG AGG C, what kind of mutation has occurred?
   A. Chromosomal aberration
   B. Frameshift mutation
   C. Point mutation
   D. Polyploidy

(A) 6. Does a mutation always give rise to a mutant phenotype?

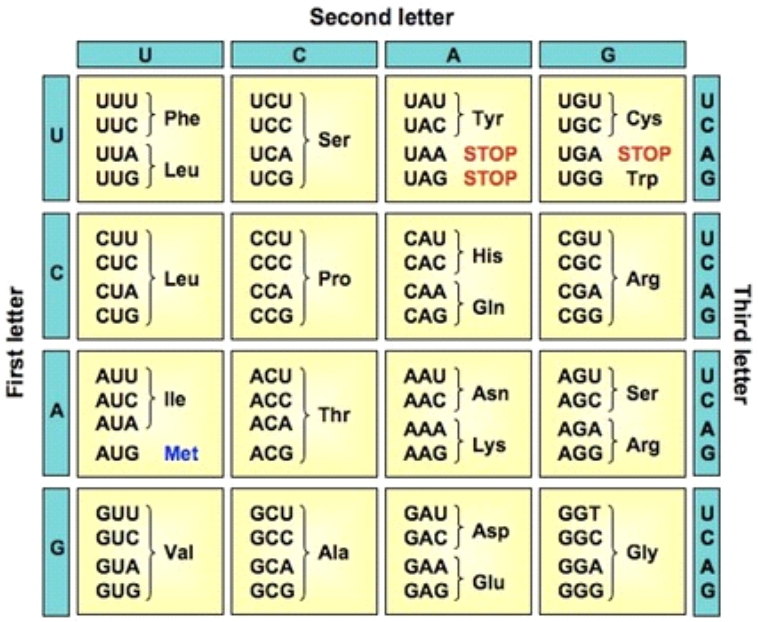
A. No, because some mutations are harmful, but some are beneficial.
B. No, some changes in the DNA do not alter the amino acid sequence.
C. Yes, a change in the DNA structure causes a change in both the genotype and phenotype.
D. Yes, mutations are errors in DNA replication and will definitely affect protein synthesis.

(A) 7. Patau syndrome is a genetic disorder associated with severe intellectual disability and physical abnormalities in many parts of the body. Due to the presence of several life-threatening medical problems, many infants with this condition die within their first days or weeks of life. Below is a karyotype of a female with Patau syndrome:



Based on the diagram, what type of genetic change causes Patau syndrome?
A. Base substitution
B. Inversion
C. Trisomy
D. Triploidy

(A) 8. Refer to the given genetic code chart to predict which mutation that changed the mRNA codon would be most likely to affect protein function.



A. AUU to ACU
B. CAC to CAG
C. GUU to GUC
D. UCC to UCG

(M) 9. In 1952, Hershey and Chase conducted a study to determine which component, DNA or protein, was responsible for the ability of a bacteriophage (a virus that infects bacteria) to take over and control the metabolic activity of the bacteria in order to produce new phages. Phages have a very simple structure – they are composed of a strand of DNA surrounded by a protein coat.

In their experiment, they used two radioactive markers to label the proteins and the DNA of the phages. To the proteins, they used a radioactive sulfur and to the DNA, radioactive phosphorus.

They allowed the phages to infect the bacteria for a short time. Then, the bacterial cells were pelleted in a centrifuge. They found that the radioactive DNA was always found with the bacterial cells while the radioactive protein was always in the supernatant (outside of the bacterial cells).

During a phage infection, it was determined that some part of the phage was injected into the bacterium and it was this injected material that conveyed the **genetic material** necessary to produce new phages. Having said this, which of the following is the conclusion made by Hershey and Chase about the genetic material of bacteriophages?

A. DNA is the genetic material.

B. Protein is the genetic material.
C. DNA and protein together serve as the genetic material.
D. Bacteriophages do not have a genetic material.

(M) 10. Linda Hunt is an American actress known as one of the lead characters in the TV series NCIS. She has taken a variety of roles both on TV and in the movies in her more than 3 decades as an actress. Her efforts have not gone unnoticed as she has received recognition from numerous award-giving bodies. Linda has Turner syndrome, a condition wherein a female would have a single X chromosome instead of the usual pair. What could be a possible consequence of having just a single X chromosome?
A. taller than usual because of genes that promote bone development
B. there could be missing genes that lead to undeveloped reproductive organs
C. inhibited breast development because of inactivated genes in the Y chromosome
D. increased muscle mass from genes found in the Y chromosome

(M) 11. George W. Beadle and Edward L. Tatum, in 1941, conducted an experiment using *Neurospora crassa*, a bread mold. First, they irradiated (exposed to radiation) a large number of *Neurospora*, and thereby produced some organisms with mutant genes. They then crossed these potential mutants with non-irradiated *Neurospora*. Normal products of this sexual recombination could multiply in a simple growth medium. However, Beadle and Tatum showed that some of the mutant spores would not replicate without addition of a specific amino acid—arginine. They developed four strains of arginine-dependent *Neurospora*—each of which, they showed, had lost use of a specific gene that ordinarily facilitates one particular enzyme necessary to the production of arginine.
What can be concluded from the experiment?
A. A change in the amino acid sequence will cause a change in the protein product.
B. A gene specifies the production of an enzyme.
C. Any change in the DNA structure is considered as mutation.
D. Radiation causes mutations in genes.

(M) 12. Amyotrophic lateral sclerosis (ALS), often referred to as “Lou Gehrig’s Disease,” is a progressive neurodegenerative disease that affects nerve cells in the brain and the spinal cord. Early symptoms of ALS often include increasing muscle weakness, especially involving the arms and legs, speech, swallowing or breathing. When muscles no longer receive the messages from the motor neurons that they require to function, the muscles begin to “atrophy” or become smaller.

Stephen Hawking, an English physicist, cosmologist, and author, suffers from ALS.

Most cases of ALS are sporadic, however some are genetic and are attributed to a faulty gene. For instance, mutation in superoxide dismutase 1 (SOD1) gene which affects the SOD1 protein is associated with ALS symptoms.

What is the most likely explanation for this genetic cause of ALS?

A. During replication, a change in the SOD1 gene occurred that led to the synthesis of SOD1 protein with a new and toxic function.
B. During transcription, a copying error occurred in the mRNA transcript of SOD1 gene which led to the production of a defective SOD1 protein.
C. During translation, an incorrect amino acid becomes attached to the tRNA molecule thereby causing a change in the SOD1 protein structure.
D. During protein folding, a lack of enzyme causes incorrect folding and modification of the SOD1 protein structure.

(M) 13. Which of the following mutations is heritable?

A. A cell in the uterine wall of a human female undergoes a chromosomal alteration.
B. A primary sex cell in human forms a gamete that contains 24 chromosomes.
C. The DNA of a human lung cell undergoes random breakage.

D. Ultraviolet radiation causes skin cells to undergo uncontrolled mitotic divisions.

(M) 14. A paper entitled "To Mutate or Not to Mutate" was posted in the Institute of Science in Society website. A quote from the paper goes:

*Contrary to views widely held not so long ago, genes **do not** as a rule mutate at random, and cells **may choose** what, or at least, when to mutate.*

Which of the following is a valid **question** to the above declaration?
A. Are all organisms capable of mutation?
B. Are mutations harmful or beneficial?
C. Does the cells' environment play a role in mutation?
D. How can we prevent mutation from happening?

(T) 15. You are one of the invited guests in the annual biologists' forum. This year's topic is "mutation-driven evolution." You've made a number of studies about the said topic and you've decided that your talk will focus on which of the following?
A. Causes and mechanisms of mutation
B. Darwin's theory of natural selection
C. Effects of mutation on population
D. Evidences of species' evolution by mutation

(T) 16. You are a writer for the journal *Trends in Evolution*. If you are currently writing an article entitled "Evolution by Gene Duplication," which of the following will you **not** include in your article?
A. In all three domains of life – bacteria, archaebacteria, and eukaryotes – large proportions of genes were generated by gene duplication.
B. Many genome sequences are determined and analyzed that demonstrated the prevalence and importance of gene duplication.
C. Many studies concluded that the origin of a new function appears to be a very rare fate for a gene that has been duplicated.
D. The doubling of a chromosomal band in a mutant of the fruit fly *Drosophila melanogaster* exhibited extreme reduction in eye size.

(T) 17. Without genetic variation, some of the basic mechanisms of evolutionary change cannot operate. Genetic variation allows new traits to enter the population. Several students investigated the different sources of variation and following are their conclusions. Who among them has an **inaccurate** conclusion?
A. Al concluded that genetic variation may arise from random changes that occur in DNA of sex cells.

B. Barbara concluded that genetic variation may arise from genetic recombination which occurs during meiosis.
C. Martha concluded that genetic variation may arise from errors in DNA replication that cause a change in the DNA sequence.
D. Oswald concluded that genetic variation may arise from cloning a gene, a portion of the DNA sequence.

(T) 18. Cystic fibrosis is an autosomal recessive disorder that causes thick, sticky mucus to build up in the lungs, digestive tract, and other areas of the body. It is one of the most common chronic lung diseases in children and young adults.
Mutations in the CFTR gene cause cystic fibrosis. The CFTR gene encodes an ion transporter protein normally expressed in the respiratory and digestive tracts. Individuals homozygous for mutated CFTR gene died at very early ages then due to lack of advanced medical intervention. Despite this, the mutation persists at relatively high frequency in populations of European descent. A possible explanation is that heterozygotes for such mutations are said to gain immunity to the lethal effects of diseases such as typhoid fever. Which of the statements below is most accurate?
A. The cystic fibrosis mutation is a beneficial mutation.
B. The cystic fibrosis mutation is a conditional mutation.
C. The cystic fibrosis mutation is a lethal mutation.
D. The cystic fibrosis mutation is a neutral mutation.

(T) 19. Bacteria use restriction enzymes to protect themselves against successful attack by bacteriophages (viruses that infect bacteria) because these enzymes can degrade the genome of the phages. The bacterial genomes are **not** vulnerable to these restriction enzymes because some bacterial DNA is *methylated*.

However there are also some bacteriophages whose genomes are methylated, and some bacteria whose DNA is non-methylated.

Over the course of time, what should occur in order to maintain **genetic variation**?
A. Methylated DNA should become fixed in the genes of all bacterial species.
B. Non-methylated DNA should become fixed in the genome of all bacteriophages.
C. Gene for DNA methylation should be eliminated in the populations over time.
D. Methylated and non-methylated strains should be maintained among both bacteria and bacteriophages.

(T) 20. Human Immunodeficiency Virus (HIV), the virus that causes Acquired Immune Deficiency Syndrome (AIDS) reproduces much more rapidly than most other viruses. It can produce billions of copies of itself each day. As it makes rapid-fire copies of itself, it commonly makes errors, which translate into mutations in its genetic code. If the mutations turn out to be beneficial to the virus's survival, it is likely that the mutated virus will reproduce itself more.

Another cause of the variability in HIV is the virus's ability to recombine and form new variants within an individual. This happens when a host cell is infected with two different variations of HIV. Elements of the two viruses may combine to result in a new virus that is a unique combination of the two parents.

Which of the following is an important implication of the high variability in HIV?

A. Anti-HIV drugs can easily target the viruses.
B. Development of a vaccine against HIV is difficult.
C. Humans can quickly develop resistance to HIV.
D. There is a slow rate of HIV evolution.