Processing the Processes:
Building on Prior Knowledge and
Using Processing Skills to Improve Comprehension in High School Biology

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ABSTRACT

This assignment is geared toward engaging learners in a processing exercise that builds on prior knowledge. Student knowledge will be tested initially, 2 days after the exercise, and delayed, 4-6 days after the exercise. 10th grade honors and general education students will be tested. My hypothesis is that that by building on prior knowledge, and incorporating a processing exercise, the students will be able to generate long-term memory of the processed information whereby both the initial and delayed tests will show the same results. T-tests will be used to determine statistical significance of the test scores. The learners will use pictures of DNA replication, a process about which they will have already learned, and relate that process to the process of protein synthesis: transcription and translation. They will have reference points upon which they can build from their prior knowledge to discern the representative pictures they will be given: DNA replication, protein synthesis, completely, and transcription and translation. They will then provide rationale as to why they have selected the particular process referencing two different pieces of evidence from each picture that supports their answer. Determinations for each answer and the rationale will be discussed. Students will be tested on select examples from the processing exercise where they will have to conclude what process it is that they are examining and provide 2 pieces of different evidence as to why they chose their answer. A test will be given to all honors and general education students following the initial exercise. Another test that asks the same information will also be given, blindly, 1 period after, providing similar examples to gauge the processing effects on memory.

RATIONALE

This past year I have seen the relevance for including processing components into my lesson plans to a greater degree. I have received very good feedback from students on the few exercises I have incorporated within my teaching framework to help them learn. Students become excited and shocked when they truly learn the information at the rate at which processing exercises allow them to. I realized late this past year students are not processing the material they are taught to the degree they need to for true learning to occur at a deeper level. I realized the relevance and importance of incorporating processing skills throughout my teaching to help students to learn at a deeper level and process information to where it is taken from their short-term memory to their long-term memory.

Over the past several decades, researchers have moved from a behavioral approach of studying learners as passive recipients of knowledge to an approach of studying learners as active participants in their own learning experiences (Bell and Kozlowski 2008; Salas and Cannon-Bowers 2001, as cited by Michele Dornisch, Rayne A. Sperling, Jill A. Zeruth (2011). This is what processing exercises do – they actively involve learners in building their knowledge.

Information is constantly bombarding our senses. We have to make sense of what it is that is coming in, and process the information. In order to process information, we have to decide to what information we are going to pay attention (PearsonEd.com, 2016). "Attention directs the extraction of meaningful information from the senses transferring it to short-term memory"(PearsonEd.com, 2016). Here is where students will actively work to enhance this memory by working repeatedly on assessing different examples of similar biological processes. Attentiveness is central to the process of encoding, which entails acquiring information and placing it into working memory storage (Brown & Craik, 2000 as cited by William R. Klemm, 2007) thereby augmenting the encoding process by enabling rehearsal making it more likely that what is being rehearsed will be put into longer-term memory storage (Klemm, 2007). This exercise will focus students' attention because they have to actively assess at what it is they are looking. They have to continue to do this repeatedly with different examples which will engage their working memories and allow for encoding to occur which will be the material to be passed on to their long-term memory (Pearson Ed, 2016). This is what the exercise I will present to students will allow for them to do.

Because certain learners can experience comprehension difficulties when they lack relevant prior knowledge (Dornish, et al. 2009), I am also building this processing exercise off of the students' prior knowledge about DNA replication, a biological process that has similarities to what they will learn about in protein synthesis. Using this background knowledge will provide a reference point for understanding, and also allow students to actively determine the differences in the biological processes at which they are looking.

Students will be able to accurately identify and justify in writing what process they have selected and why. To achieve this, students will actively compare the components of different biological processes, building on their prior knowledge from DNA replication, and make determinations of what they are seeing to determine decisively what process is being shown to them. They will select from 4 different processes: Protein synthesis as a whole, DNA Replication, and protein synthesis: transcription and translation, separately. Students will have to actively engage in the

exercise, observe what they are seeing, and use their critical thinking skills to make distinctions between processes and decisively conclude what process it is at which they are looking.

Given the different examples and repetition of this exercise at different stations, students will actively encode the information from their working memory to their long-term memory due to the time they will spend at each activity set, processing each one, seeing examples of each of the processes in different ways, and actively distinguishing one process from the other, thereby then having encoded the material through repetition and rehearsal. As a result, memory of the different processes will be established and learning gains will be achieved.

This active approach to learning where students have to actively process what they are seeing seeks to help learners develop strategies and processes that support their ability to engage in higher-order thinking, problem-solving, and transfer.

Because I believe that students will actively process and remember the information they learn during the activity, I will test students initially after the lesson to form a baseline of their learning, and then again 1 school day (2 actual days) after the original processing of the material to account for their learning gains which I have hypothesized will not change. Information studies regarding forgetting and memory have revealed that learning material one day and being tested on it initially and then just one day later, showed a 46% loss of memory of the material – only a 54% learning gain (Pauk, W., 2000). Despite this, the study I will conduct I hypothesize will result in the same conclusions as Domisch, et al, 2009, that when giving immediate and delayed testing of processing for comprehension – that there were no differences in the initial and delayed testing results.

CHANGES TO ACTION RESEARCH INTERVENTION

Due to time constraints, the processing portion of this lesson was omitted, in part, in terms of the procedure. Also, the assessment style was altered.

The procedure was truncated in that each student was not responsible for writing down two reasons that justified how they identified the process they were seeing. I reviewed DNA replication with the students and informed them of the distinguishing characteristics of the process, and how it would differ from Protein Synthesis, specifically Transcription. I then provided the class with several pictures of DNA replication that were highly different, but had at least two of the distinguishing factors on each of them for identification purposes. I asked students to identify the process as a class. They could not. I went through a few more, and finally, after about 4 different pictures of it, they were able to clearly identify the process of DNA replication.

I spent less time on Protein Synthesis, Transcription and Translation. Students were able to distinguish Transcription from DNA replication by two points –RNA polymerase instead of DNA polymerase and only one side of DNA being copied instead of two.

The distinguishing factors I pointed out for Translation had to do with the presence of the ribosome, the process occurring in the cytoplasm, the presence of amino acids and tRNA. I went over these with the students and then asked for volunteers. There were not enough of these pictures to assess fully and do a choral response. Also, there was not enough time for further processing.

Further, I was only able to do all of this with the honors students. There was not enough time even to do this with the on-level students.

CONNECTIONS
Bench to Bedside connections include the following:

- The Pompe Predicament
    - Lesson 4 – Science Take-Out: From DNA to Protein Structure and Function
    - Lesson 5 – Patient DNA Sequences of Pompe

DATA COLLECTION & ANALYSIS

For my data collection, instead of giving a quiz following the processing exercise and then one the next class, I only had time to do a brief follow-up assessment right after the picture analysis, and I did NOT do a post quiz two days following due to time.

For the assessment, students were given a two different pictures – the first was of Translation and the second was of Transcritpion. They were to:

> Identify the process
> List three reasons we discussed in class that distinguished the process as what they indicated.

Analysis of the results showed that the processing was not fully effective. Less than half of each of my three honors classes showed proficiency in understanding fully all of the components of each of the three processes. However, over 80% of the students did answer the questions right in terms of being able to accurately identify the processes as Transcription or Translation – a result that would allow them to pass a benchmark, likely.

I have since given them a post-test, but over a month later, and only 42% of them were able to accurately identify the processes correctly. Though retention was lower that would be expected if I had given them the material two days later, it was still higher than the forgetting curve which states that, " information studies regarding forgetting and memory have revealed that learning material one day and being tested on it initially and then just one day later, showed a 46% loss of memory of the material – only a 54% learning gain.

Given this research, extrapolating would show that my showed greater gains in comprehension than would have been expected, a likely result of processing.

LITERATURE CITED

Dornisch, M, Sperling, R.A., Zeruth, J.A. (2011). The Effects of Levels of Elaboration on Learners' Strategic Processing of Text**.**
Instructional Science, Volume 39, Issue 1, pp 1–26.

Klemm, William R. (2007). The Journal of Effective Teaching, Vol. 7, No.1, 61-7.

Pauk, W. (2000). Forgetting: The Relentless Foe. *CESC Courses: How to Study*, pp 1 – 6.

Pearsoned.com (2016). The Nature of Memory. *Degrees* Digital Magazine, Issue 4.

LESSON PLAN

TITLE

Building on Prior Knowledge and Using Processing Skills to Improve Comprehension in High School Biology

KEY QUESTION(S)

1. How does DNA code for physical traits?
2. What are the key components involved in DNA replication?
3. In what does DNA replication result?
4. What is transcription?
5. What are the key processes within transcription? Where does it occur? In what does it result?
6. How does DNA replication compare and contrast with transcription? How are the processes similar and different? What components are different?
7. What is translation?
8. What are the key processes within translation? Where does it occur? In what does it result?
9. How is transcription different from translation? What do they have in common?
10. How does DNA replication compare and contrast with translation? How are the processes similar and different? What components are different?

SCIENCE SUBJECT

Biology

GRADE AND ABILITY LEVEL

10^{th} grade honors and on-level biology

SCIENCE CONCEPTS:

- DNA Replication
- Protein synthesis: transcription & translation

OVERALL TIME ESTIMATE

3 ¼ days

Processing

LEARNING STYLES

Visual, auditory, and kinesthetic.

VOCABULARY

Adenine
Amino Acids
Cytosine
Cytoplasm
Deletion mutation
DNA polymerase
DNA Replication
Duplication mutation
Frameshift mutation
Guanine
Hydrogen bonds
Insertion mutation
Missense mutation
mRNA
Nonsense mutation
Nucleus
Okazaki fragments
Polypeptide
Protein
Protein synthesis
Replication fork
Ribosome
RNA Polymerase
Semi-conservative replication
Transcription
Translation
tRNA
Tyrosine
Uracil

LESSON SUMMARY: This lesson will allow students to build on prior knowledge they have about DNA replication to provide a reference point for understanding the process of protein synthesis. The lesson will use hands-on pictures of various processes of which they have to use critical thinking skills to process what process they are observing using their knowledge of the parts of each process.

Processing

STUDENT LEARNING OBJECTIVES WITH STANDARDS:

The student will be able to...

1. SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (Also assesses SC.912.L.16.4, SC.912.L.16.5, and SC.912.L.16.9.)
2. SC.912.L.16.5 Explain the basic processes of transcription and translation and how they result in the expression of genes.
3. SC.912.L.16.4 Explain how mutations in the DNA sequence may or may not result in phenotypic change. Explain how mutations in gametes may result in phenotypic changes in offspring.

MATERIALS: Sort materials and indicate number required for different types of grouping formats (Per class, Per group of 3-4 students, Per pair, Per student). Be as specific as possible. No need to list basic instructional items like paper, pencil, chalkboard, or overhead projector.

- ESSENTIAL:
    - Replication, Transcription and Transcription process pictures large enough to use as models for students to see all the parts. 3 different model pictures of each, all of which show the entirety of what components are included in each of the processes.
    - Science Take Out: From DNA to Protein Structure & Function
    - Pages 64 – 66 in the Pompe Predicament Workbook – Patient DNA Sequences

  SUPPLEMENTAL:
    - The Pompe Predicament Workbook, UF CPET Publication
    - The War of the 21st Century: The Cell Cycle, Cancer and Clinical Trials Workbook, UF CPET Publication

BACKGROUND INFORMATION:

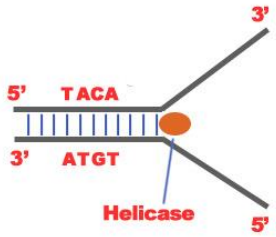
1. DNA replication
2. Protein synthesis
3. Mutation

1. DNA Replication

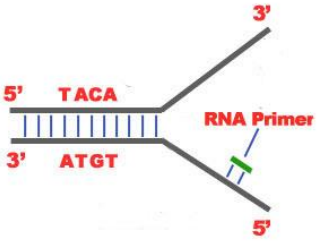
The next we have to do is to shed light into the mystery of the **steps of DNA Replication** of the Eykaryotes.

1)The first major step for the **DNA Replication** to take place is the breaking of hydrogen bonds

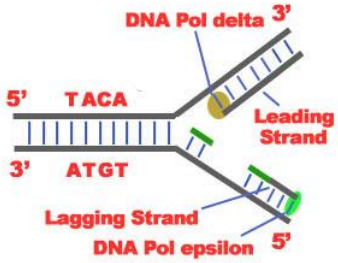
between bases of the two antiparallel strands. The unwounding of the two strands is the starting point. The splitting happens in places of the chains which are rich in A-T. That is because there are only two bonds between Adenine and Thymine (there are three hydrogen bonds between Cytosine and Guanine). **Helicase** is the enzyme that splits the two strands. The initiation point where the splitting starts is called "origin of replication".The structure that is created is known as "**Replication Fork**".



2) One of the most important **steps of DNA Replication** is the binding of **RNA Primase** in the initiation point of the 3'-5' parent chain. **RNA Primase** can attract RNA nucleotides which bind to the DNA nucleotides of the 3'-5' strand due to the hydrogen bonds between the bases. RNA nucleotides are the primers (starters) for the binding of DNA nucleotides.

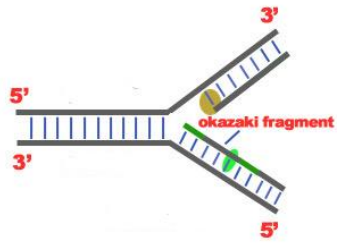


3) The **elongation** process is different for the 5'-3' and 3'-5' template. a)**5'-3' Template**: The 3'-5' proceeding daughter strand -that uses a **5'-3' template**- is called **leading strand** because **DNA Polymerase** can "read" the template and continuously adds nucleotides (complementary to the nucleotides of the template, for example Adenine opposite to Thymine etc).

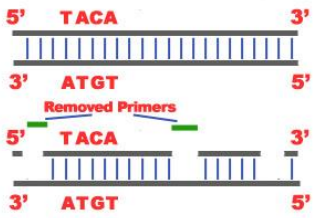


b)**3'-5'Template**: The **3'-5' template** cannot be "read" by DNA Polymerase. The replication of this template is complicated and the new strand is called **lagging strand**. In the lagging strand the RNA Primase adds more RNA Primers. **DNA polymerase** reads the template and lengthens the bursts. The gap between two RNA primers is called "**Okazaki Fragments**".

The RNA Primers are necessary for DNA Polymerase to bind Nucleotides to the 3' end of them. The daughter strand is elongated with the binding of more DNA nucleotides.



4) In the lagging strand the **DNA Pol I -exonuclease-** reads the fragments and removes the RNA Primers. The gaps are closed with the action of DNA Polymerase (adds complementary nucleotides to the gaps) and DNA Ligase (adds phosphate in the remaining gaps of the phosphate - sugar backbone).
Each new double helix is consisted of one old and one new chain. This is what we call **semi-conservative replication**.



5) The last **step of DNA Replication** is the **Termination**. This process happens when the DNA Polymerase reaches to an end of the strands. We can easily understand that in the last section of the lagging strand, when the RNA primer is removed, it is not possible for the DNA Polymerase to seal the gap (because there is no primer). So, the end of the parental strand where the last primer binds isn't replicated. These ends of linear (chromosomal) DNA consists of noncoding DNA that contains repeat sequences and are called **telomeres**. As a result, a part of the telomere is removed in every cycle of DNA Replication.

6) The DNA Replication is not completed before a **mechanism of repair** fixes possible errors caused during the replication. Enzymes like **nucleases** remove the wrong nucleotides and the DNA Polymerase fills the gaps.

2. Protein Synthesis

Protein synthesis is one of the most fundamental biological processes by which individual cells build their specific proteins. Within the process are involved both DNA (deoxyribonucleic acid) and different in their function ribonucleic acids (RNA). The process is initiated in the cell's nucleus, where specific enzymes unwind the needed section of DNA, which makes the DNA in this region accessible and a RNA copy can be made. This RNA molecule then moves from the nucleus to the cell cytoplasm, where the actual the process of protein synthesis take place.

What is protein synthesis – The details!

All cells function through their proteins. Protein function is defined by their molecular function , localization within cell and involvement in a particular biological process. All components of protein function are defined by the exact composition, structure and conformation of the proteins, which is encrypted within the DNA region (called locus) encoding that protein. With the process of protein synthesis biological cells generate new proteins, which on the other hand is balanced by the loss of cellular proteins via degradation or export.

Transcription is the first of overall two protein synthesis steps. During transcription, the information encoded in the DNA is copied to a RNA molecule as one strand of the DNA double helix is used as a template. The RNA molecule is sent to the cytoplasm, which helps to bring all components required for the actual protein synthesis together – **amino acids**, **transport RNAs, ribosomes**, etc. In the **cytoplasm** the protein polymers are actually "synthesized" through chemical reactions – that is why the process is known as "protein synthesis" or even more precisely – "protein biosynthesis".

The RNA copy of the protein genetic information encoded in DNA molecule is produced in the nucleus and it is called **messenger RNA (mRNA).** Each mRNA encodes the information for a single protein and is much smaller in size compared to the DNA molecule. This makes possible for mRNA molecules to exit the nucleus through tiny openings called nuclear pores. Once it exits the nucleus and enters the cytoplasm, the mRNA could interact with a cellular structure known as a ribosome, which serves as the cell's assembler within the process of protein synthesis. The ribosome consists of proteins and ribosome RNA molecules (rRNA), which are organized in two subunits. The mRNA initially binds to just one of the ribosome sub-units.

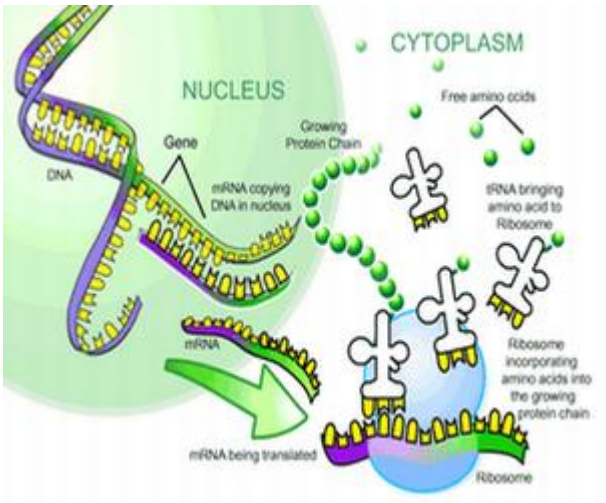
When the mRNA interacts with the big ribosome sub-unit, this triggers the approach of another RNA molecule, called **transfer RNA (tRNA).** The tRNA molecule possess a specific sequence of 3-bases (**anti-codon**), which has to complement a corresponding sequence (**codon**) within the mRNA sequence. When it finds it, it attaches to the mRNA, as the other end of the tRNA is "loaded" with an **amino acid**. At this point arrives the other sub-unit of the ribosome and a complete structure is formed. The first tRNA binds to a so called "start codon", which is one and the same for all proteins. As the complete ribosome structure is formed, another tRNA molecule approaches. The next tRNA differ from the first one and is carrying another amino acid. Again,

the tRNA must have an anti-codon that matches complementary the second codon of the mRNA. The two amino acids carried by the first two tRNAs are bind together with help from the ribosome and using cellular energy in the form of adenosine triphosphate (ATP).

The above steps repeats until there are uncoupled codon sequences on the mRNA – thus the chain of amino acids grows longer. Once the sequence of amino acids is successfully assembled in a protein, the two ribosome sub-units separate from each other, to be joined again for later use.

The actual sequence of amino acids forms the so called primary structure of the proteins. Depending on the exact composition and order of the amino acids in the protein sequence, the chain folds into a three-dimensional shape. When this happens the **protein** is complete.

The process of protein synthesis takes place in multiple ribosomes simultaneous and all throughout the cell cytoplasm. A living cell can synthesize hundreds of different proteins every single second.



3. Mutation

What kinds of gene mutations are possible?

The DNA sequence of a gene can be altered in a number of ways. Gene mutations have varying effects on health, depending on where they occur and whether they alter the function of essential proteins. The types of mutations include:

Missense mutation (illustration)

> This type of mutation is a change in one DNA base pair that results in the substitution of one amino acid for another in the protein made by a gene.

Nonsense mutation (illustration)

Processing

A nonsense mutation is also a change in one DNA base pair. Instead of substituting one amino acid for another, however, the altered DNA sequence prematurely signals the cell to stop building a protein. This type of mutation results in a shortened protein that may function improperly or not at all.

Insertion (illustration)

An insertion changes the number of DNA bases in a gene by adding a piece of DNA. As a result, the protein made by the gene may not function properly.

Deletion (illustration)

A deletion changes the number of DNA bases by removing a piece of DNA. Small deletions may remove one or a few base pairs within a gene, while larger deletions can remove an entire gene or several neighboring genes. The deleted DNA may alter the function of the resulting protein(s).

Duplication (illustration)

A duplication consists of a piece of DNA that is abnormally copied one or more times. This type of mutation may alter the function of the resulting protein.

Frameshift mutation (illustration)

This type of mutation occurs when the addition or loss of DNA bases changes a gene's reading frame. A reading frame consists of groups of 3 bases that each code for one amino acid. A frameshift mutation shifts the grouping of these bases and changes the code for amino acids. The resulting protein is usually nonfunctional. Insertions, deletions, and duplications can all be frameshift mutations.

DNA Replication	Protein Synthesis	
Hydrogen bonds: the weak bonds between strands of DNA that hold together the nucleotides. **Adenine (A)**: *Adenine* is one of the two purine nucleobases (the other being guanine) used in forming nucleotides of the nucleic acids. In DNA, *adenine* binds to thymine via two hydrogen bonds to assist	**Transcription**: DNA →RNA; During transcription, a DNA sequence is read by an RNA polymerase, which produces a complementary, antiparallel RNA strand. The RNA complement includes uracil ® in all instances where thymine (T) would have occurred in a DNA complement. **mRNA** - Messenger RNA	**Translation**: In molecular biology and genetics, translation is the process in which cellular ribosomes create proteins. In translation, messenger RNA (mRNA)—produced by transcription from DNA—is decoded by a ribosome to produce a specific amino acid chain, or polypeptide.

in stabilizing the nucleic acid structures.

Cytosine (C): is one of the four main bases found in DNA and RNA. Pairs with guanine in DNA and RNA.

DNA Polymerase: DNA polymerase (DNAP) is a type of enzyme that is responsible for forming new copies of DNA, in the form of nucleic acid molecules.

Guanine (G): is one of the four main nucleobases found in the nucleic acids DNA and RNA, the others being adenine, cytosine, and thymine (uracil in RNA). In DNA, guanine is paired with cytosine.

Nucleus: the central and most important part of an object, movement, or group, forming the basis for its activity and growth.

Okazaki fragments: Okazaki fragments are short, newly synthesized DNA fragments that are formed on the lagging template strand during DNA replication. They are complementary to the lagging template strand, together forming short double-stranded DNA sections.

Replication fork: The point at which the two strands of DNA are separated to allow replication of each strand.

Semi-conservative Replication: relating to or

(mRNA) is a large family of RNA molecules (RNA: Ribonucleic acid is one of the three major macromolecules (along with DNA and proteins) that are essential for all known forms of life. Life DNA, RNA is made up of a long chain of components called nucleotides. Each nucleotide consists of a nucleobase, a ribose sugar, and a phosphate group. RNA directs the synthesis of proteins.) that convey genetic information from DNA to the ribosome, where they specify the amino acid sequence of the protein products of gene expression.

RNA Polymerase: an enzyme that produces primary transcript RNA. In cells, RNAP is necessary for constructing RNA chains using DNA genes as templates, a process called transcription.

Uracil (U): one of the four nucleobases in the nucleic acid of RNA that is represented by the letter U. U*racil* binds to adenine via two hydrogen bonds. In DNA, the *uracil* nucleobase is replaced by thymine.

Amino Acids: Any of a large number of compounds found in living cells that contain carbon, oxygen, hydrogen, and nitrogen, and join together to form proteins. *Amino acids* contain a basic *amino* group (NH_2) and an acidic carboxyl group (COOH), both attached to the same carbon atom.

Cytoplasm: the material or protoplasm within a living cell, excluding the nucleus.

Ribosome: a minute particle consisting of RNA and associated proteins, found in large numbers in the cytoplasm of living cells. They bind messenger RNA and transfer RNA to synthesize polypeptides and proteins during translation.

Polypeptide: A linear chain consisting of many amino acids often between 10 and 100.

Protein: A molecule composed of polymers of amino acids joined together by peptide bonds. It can be distinguished from fats and carbohydrates by containing nitrogen. Can be folded into different secondary, tertiary and quaternary configurations.

tRNA: transfer RNA / tRNA is a type of RNA molecule that helps decode a messenger RNA (mRNA) sequence into a protein. tRNAs function at specific sites in the ribosome during translation, which is a process that synthesizes a

being genetic *replication* in which a double-stranded molecule of nucleic acid separates into two single strands each of which serves as a template for the formation of a complementary strand that together with the template forms a complete molecule, each one containing the original and one newly synthesized strand of DNA. **Tyrosine (T)**: is one of the four main bases found in DNA and RNA. Pairs with adenine.		protein from an mRNA molecule.

Mutation Vocabulary – See background information.

ADVANCE PREPARATION:

1. Find various pictures of DNA replication, Protein synthesis, Transcription and Translation. They should all have differences from the others – having components that are not included in the others, but collectively include all the parts of each of the processes. Copy them onto a sheet of paper – at least 2 per sheet. Make sure they are large enough to see the detail & related components for students to accurately identify the components and describe them.
2. Cut out each copy of the process pictures. Number each one, randomly.
3. Place these process pictures around on tables or at stations in pairs of 2 or three. Have at least 1 DNA replication and 1 of the other processes at each table/station for comparison.

PROCEDURE AND DISCUSSION QUESTIONS WITH TIME ESTIMATES:

Day 1 (¼ day) – only 20 minutes (Review DNA Replication after Genetics test.)

1. Ask students to write: What do you recall about DNA Replication? Prompts: What are the basic steps of DNA Replication? What are the "parts/components" of DNA Replication? (4 minutes)
2. After the 4 minutes are up, ask different students to share out answers. (2 minutes) Write their answers on the board and discuss what was left out, if anything. (4 minutes)
3. Show a quick DNA Replication video. What did they recall accurately? Ask students to add to their papers anything they had forgotten. (4 minutes)
4. Review steps and components of DNA Replication. (7 minutes)
5. Introduce RNA base-pairing rules and how they differ from DNA base-pairing rules. (1 minute)

Day 2 – Protein Synthesis

6. Bell Ringer: Review the DNA and RNA base-pairing rules. Then instruct students: Work with a partner. Create the following DNA sequence using the chalk provided: AAGGCATTA. Write the sequence on the table. Then, create the complementary sequence to the DNA strand. Have students label the top DNA strand, "Coding strand," and the bottom strand, "Template strand."What are the results? Go around and check work. Have students keep work on table. Discuss the function of DNA. (5 minutes)
7. Show a video on the Central Dogma. (4 minutes)
8. Discuss video. Also, review Dogma: DNA → RNA → Protein. Impress on them that protein synthesis is a two-step process including transcription & translation. See board for general information on protein synthesis. (4 minutes)
9. Refer back to the DNA on the table. Ask students to use the template strand to create a complementary strand of RNA from it. Show example on board of how the work should be laid out. Check student work to ensure they have made the proper corresponding bases-pairs. Inform students that they are modeling the "short-version" the first step – ask what the first step is called – choral response – ("Transcription!") Ask students where is transcription occurring? ("In the nucleus?") Give them 5 other DNA to RNA "transcription" sequences. Do a choral response with them on these to ensure they have the process. Reiterate what the process is and where it is occurring!! (10 minutes)
10. Worksheet – Pass out worksheet on Protein Synthesis. Have students work numbers 1 and 2. Label the strands of DNA. Label the strand of mRNA. Have them point to the area where they should draw an arrow to show where transcription is occurring. Between the DNA and mRNA. Ensure students to NOT move on until you have completed the first processes together as a class. (10 minutes)
11. Inform students that the next process is translation. Discuss what the mRNA transcript is and what a codon is. Show a short video clip on codons and anti-codons. Refer to diagram and example on board. Afterwards, ask them how many codons are in their mRNA strand? 3. As a result, how many amino acids will be coded for with that strand? 3. Give two more examples of codons from board, and relate to amino acids. Refer to ribosomes as the site of protein synthesis (old knowledge). Differentiate between the mRNA and the tRNA and how they operate on the ribosome to produce a strand of amino acids which eventually folds and becomes a protein. (6 minutes)
12. Inform students that "translation" is the process of literally translating the transcript. Look at two different types of codon charts. Learn to read each one. (5 minutes each) Identify each of the corresponding amino acids based on the mRNA codons. Give 5 more examples of codons, and have students use white boards to write the accurate respective amino acids for each of the codons. (5 minutes) Have students complete their work on the table and the write the right answers on whiteboards. (10 minutes total)

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13. Have students complete #3 on the worksheet making sure that they are translating from the mRNA and NOT the tRNA. Ensure they do NOT move on until you have checked that they are translating from the right strand of RNA. (13 minutes)
14. Clean-up. (3 minutes)
15. Protein Synthesis Powerpoint Lecture (15 minutes)
16. Worksheet on protein synthesis. (Homework assignment to finish)
17. Quiz tomorrow at end of class – Recognizing DNA Replication from Protein Synthesis
18. Quiz students randomly (popsicle picks) until the bell rings. Ask questions for tomorrow's bell ringer. (5 minutes)

Day 3

19. Review Homework – 15 minutes
20. Show pictures of DNA Replication and Protein Synthesis – Reivew the steps of each. (5 minutes)
21. Questions to answer for quizzing self and partners. (2 minutes)
    a. What are the two processes within Protein Synthesis and what is the correct order? (Transcription and Translation)
    b. What are the proper base-pairing rules with RNA, and how do they differ from the base-pairing rules of DNA? (A-U, G-C; A with U, not A with T)
    c. Where does each occur? (Nucleus v. Cytoplasm)
    d. If a transcript has 12 nucleotides in it, how many codons will it have? (4)
    e. What is the difference between mRNA and tRNA? (mRNA conveys the genetic information from DNA. tRNA transfers amino acids to mRNA based on the corresponding nucleotides on mRNA.)
    f. What is the end result of each? (mRNA v. polypeptide)
    g. What is the final outcome? (Protein)
22. Now that students are familiar with the overall process of DNA Replication and Transcription and Translation, discuss the processes with them. Ask students to review with their table partner what the differences are and the similarities. Have them complete a chart that lists each of the process and the particular "components" of each process that they see that "stick out" from the others. How are they different? Discuss with reference to the quiz questions. (4 minutes)
23. Go to another pair and compare notes.(2 minutes)
24. Discuss as a class. Differentiating between the processes. (4 minutes)
25. Introduce the Processing Activity with the following directions:

You will circulate around the room looking at different visuals of DNA Replication and Protein Synthesis to include both transcription and translation, together and separately, and you will use your critical thinking skills to decipher which process it is at which you are looking. You will be given two minutes at each table. Each process will have a particular

number on it. Write that number on your paper based on the particular process you encounter, and answer the following questions.

For each of the following pictures, you will indicate which of the following processes is occurring:

a. DNA Replication
b. Protein synthesis
c. Transcription
d. Translation

After you write the accurate name of the process, you will clarify why you have selected the process you chose based on clues provided within each picture.

e. You must provide *at least* 2 context clues for each of the processes.
f. Try to list *all* of the context clues we discussed in class by the time you end the exercise.

Example:

g. DNA Replication
    i. A double helix is present
    ii. Other clue discussed

26. After the exercise is complete, each of the processes will be discussed in context. Have students check work for accuracy. (15 minutes)
27. Call on students randomly to determine what clues they provided to determine how they came to their understanding, correcting any errors in reasoning, as necessary. Provide, or ask for, additional input. (10 minutes)
28. Also, after completion of that exercise, you can put up on the overhead other process pictures from google, and include choral responses at this point, as all students should know all of the processes by sight at this point. For ESE or ESOL, differentiate by providing all of the content clues in random order, on overhead, that they will be expected to use during the processing exercise.(3 minutes)
29. Follow-up with a quiz after the exercise. on the processes during the next class period that mimics the processing exercise. Each student will have to determine the process shown, and write at least two process clues with no repetition. (15 minutes)
30. Mutation Introduction – Watch video clip. (8 minutes)
31. Mutations – 4 types – review – (2 minutes)

Day 4

32. Quiz – same quiz as last class. (15 minutes)
33. Overhead notes: 4 types of mutations. Write and give examples of each. (15 minutes)
34. Discuss structure and function of proteins. Show shapes and show how sickle-cell is formed. (5 minutes)
35. Patient DNA Sequences sheet from the Pompe Predicament – Pg. 64. Give students sheets and have them work in groups of 2 to look at each of the DNA sequences to

determine what possible mutations have occurred. Students write which type of mutation they speculate have occurred based on the sequence – hint – look at whether there are not there are complete codons. Are the mutations a point mutation or frameshift mutation (deletion or insertion)? Also, after mutation hypotheses are given, provide the amount of GAA activity in each of the non-frameshift mutations. Have then students review type of mutation again given the new information. Are they kept the same or have they changed? Share with partner why you have/not changed. Review. (20 minutes)

36. The Pathophysiology of Pompe Video – https://www.youtube.com/watch?v=7xdZ-6nKHgM (2 minutes)
37. Pompe Predicament: Science Take-Out: From DNA to Protein Structure and Function. Activity 4. (25 minutes)

ASSESSMENT SUGGESTIONS:

1. SC.912.L.16.3 Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information. (Also assesses SC.912.L.16.4, SC.912.L.16.5, and SC.912.L.16.9.)
2. SC.912.L.16.5 Explain the basic processes of transcription and translation and how they result in the expression of genes.
3. SC.912.L.16.4 Explain how mutations in the DNA sequence may or may not result in phenotypic change. Explain how mutations in gametes may result in phenotypic changes in offspring.

For objective 1…At this point in the year, this will be an informal formative assessment which I will expect students to have written in their notebooks the process of DNA replication and all of the respective components.

For objective 2… This will be given in a quiz format after the processing exercise and again 2 classes after the processing exercise. The quiz will include pictures of the different processes. Students will have to provide a written explanation detailing why context clues caused them to choose the process they did as an answer. They will also be given a DNA sequence and they will have to transcribe and translate it accurately.

For objective 3…This will be an informal formative assessment where students will use the Patient DNA sequences to infer the types of mutations provided given the DNA sequences.

EXTENSIONS:

ACTIVITIES: The War of the 21st Century: Activity 4 – Keeping it All in Check: The Life of a Cell in the Cell Cycle. To be used as an extension activity for mutations.

LITERATURE: N/A

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RESOURCES/REFERENCES:

- **DNA Replication**: http://www.dnareplication.info/stepsofdnareplication.php
- **Mutations**: https://ghr.nlm.nih.gov/primer/mutationsanddisorders/possiblemutations
- **Protein Synthesis**: http://www.proteinsynthesis.org/what-is-protein-synthesis/
- **The Pompe Predicament**, UF CPET Publication
- **The War of the 21st Century**, UF CPET Publication
- **Vocabulary**: Google and Wikipedia and Biology Online Dictionary