UNIT 3 ANSWER KEY

INTRODUCTION AND DNA

1. DNA and RNA are nucleic acids which are really just polymers (chains of) nucleotide monomers.

2. What are the three key parts of any nucleotide?
   - **a.** phosphate
   - **b.** pentose sugar
   - **c.** nitrogenous base

3. In DNA, a **G** always pairs with a __C___ whereas an **A** always pairs with a __T___.

4. Please write the complimentary sequence for the following strand of DNA:

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

5. If a DNA strand contains 34% adenine bases then it must also contain:
   - **a.** 34 % thymine bases
   - **b.** 16 % guanine bases
   - **c.** 16 % cytosine bases

A - T : 34 + 34 = 68 %.

G - C : 100 - 68 = 32 %.

32 ÷ 2 = 16 %.

6. DNA replication ideally results in the formation of two identical daughter strands of DNA. Why is it necessary for a cell to perform DNA replication?

   = need two identical copies of each chromosome so that when the cell divides each daughter cell can receive a copy and thus, have all the genetic information to function properly

7. DNA replication is termed __semi-conservative___ as it ideally results in two identical double helices that each contain one original "parent strand" and one brand new, complimentary "daughter" strand.

8. Describe the three key steps of DNA replication **in your own words.** Include what occurs, where in the cell it occurs and any enzymes that are involved for each step.

   Step 1. = the enzyme helicase separates the complimentary strands of the double helix by breaking the hydrogen bonds between complimentary base pairs…this forms two separate templates aka parent strands that can be used to build new complimentary strands

   Step 2. = the enzyme DNA Polymerase helps bring in base pairs that are complimentary to the parental strands

   Step. 3. = the enzyme ligase works with DNA polymerase to bond the successive bases together to form complimentary daughter strand to the parental strand thus, forming two new, identical (barring mutation) DNA double helices (each formed by complimenting the two original parental strands)

9. Please complete the following chart that compares and contrasts DNA and RNA molecules. Use the terms listed below to fill in the blanks.

nucleus and cytoplasm	smaller molecule	mRNA, tRNA, rRNA
nucleus only	larger molecule	DNA only
one	ribose	controls cell activities
two	deoxyribose	protein synthesis
single stand	A, G, C, T	
double helix	A, G, C, U	

	DNA	**RNA**
Location in cell	nucleus only	nucleus and cytoplasm
Number of strands	two	one
Shape of molecule	Double strand	Single strand
Size of molecule	Larger molecule	Smaller molecule
Sugar found in molecule	deoxyribose	ribose
Nitrogenous bases	A,G,C,T	A,G,C,U
Types	DNA only	mRNA, rRNA, tRNA
Function	Controls cell activities	Protein synthesis

DNA Replication

1. __Replication___ is the process of making an identical strand of DNA and occurs in the nucleus.

2. Protein synthesis refers to the process of using the information encoded in DNA to make proteins and involves two steps:
- **a.** __Transcription___ where DNA is used as a template to make mRNA.
- **b.** __Translation___ where mRNA is used to direct the synthesis of proteins.

3. Please state where in the cell the following processes occurs:
- **a.** Replication: _____nucleus_____
- **b.** Transcription: _____nucleus_____
- **c.** Translation: _____cytosol_____

PROTEIN SYNTHESIS

1. Why is the genetic code considered "universal"?
= because the same codons code for the same amino acids in all living things

2. Please complete the following table. Replication has been filled out as an example.

	Replication	**Transcription**	**Translation**
Overall Process	DNA → DNA	DNA → mRNA	mRNA → protein
Location	nucleus	nucleus	cytosol
Key Enzymes	helicase, DNA polymerase, ligase	RNA polymerase	ribosomes
Additional Notes	involves making a new copy of the entire genome for the purposes of cell division	forms immature mRNA that must then be processed to become mature and exit to cytosol	requires additional assistance from rRNA (part of the ribosome) and tRNAs which transfer amino acids to the growing aa chain

3. Please list the steps of translation and provide a brief description of each step.

Step 1. = Initiation where small ribosome subunit binds to start codon of mRNA, the initiator tRNA binds complimentary to the mRNA's start codon and then the large ribosomal subunit binds to the complex such that the initiator tRNA is located in the P site of the ribosome.

Step 2. = Elongation where a second tRNA binds complimentary to the mRNA's second codon such that the second tRNA is located in the A site of the ribosome. The ribosome catalyzes the transfer of the amino acid from the tRNA in the P site to the tRNA in the A site, forming a peptide bond between the two amino acids. The ribosome then shifts down the mRNA by a single codon such that the empty tRNA is now in the E site of the ribosome and the tRNA with the growing amino acid chain is now in the P site of the ribosome and the A site is now open and available for a new complimentary tRNA. The empty tRNA exits the E site to be recycled while a new, complimentary tRNA comes into the A site and the entire process is repeated.

Step 3. = Termination where the ribosome encounters a termination codon (stop codon) on the mRNA. A release factor will complimentary bind to the mRNA stop codon such that it is in the A site of the ribosome, when the ribosome goes to transfer the amino acid changing to this release factor it cannot do so and the amino acid chain polypeptide/protein) is released from the ribosomal complex. All other components are released from the complex and may be recycled and used again to produce more copies of the protein.

4. If an enzyme is composed of 687 amino acids, how many bases would the mature mRNA that encoded for it have? = each codon is coded for by 3 bases so…3 x 687 = 2061 bases

5. The codon table allows you to determine the amino acid sequence of a polypeptide based on the mRNA sequence.

6. Use a codon table to determine the amino acid sequence encoded for by the following mRNA sequence.

mRNA: AUG GAA GCU ACG

a.a. methionine – glutamic acid – Alanine - threonine

7. Use a codon table to determine the amino acid sequence encoded for by the following DNA sequence.

DNA: CCG CTC TTA CTT

mRNA: GGC GAG AAU GAA

a.a: glycine – glutamic acid – asparagine – glutamic acid

8. What would be the sequence of the 4 tRNAs' anticodons, in order, that would be used to translate the following DNA sequence into a protein?

DNA: CGG TTG TGT TAG

tRNA: CGG UUG UGU UAG

NOTE: the code for tRNA is exactly the same as DNA except where there is a T in DNA there is a U in tRNA. The reason for the difference is that RNAs have uracil rather than thymine

9. What is a mutagen and give three examples of mutagens.
A mutagen causes a base pair to be removed, added or replaced from a gene. Some mutagens include x-ray radiation, chemical poisons, pollution, other environmental contaminants, UV rays, etc.

10. A mutagen causes a base pair to be removed from a gene that codes for a protein within a cell. Name the type of mutation and the likely effect of this mutation on protein synthesis.

= If a single base pair from a gene is removed it is known as a deletion and a frame shift mutation. As the entire reading frame of the gene is shifted, the entire code downstream of the mutation will be translated incorrectly likely leading to a completely non-functional protein. If this protein is essential for cellular function the cell and potentially the organism will die.

11. Given the following normal DNA sequence, determine the mRNA and amino acid sequence that corresponds to it. Do the same with the mutated DNA, then name and describe each type of point mutation.

Normal DNA: TAC CAT TTT CCG AAA ATT
mRNA: AUG GUA AAA GGC UUU UAA
amino acids: methionine-valine-lysine-glycine-phenylalanine

Mutated DNA x: TAC CAT TT**C** CCG AAA ATT

mRNA: AUG GUA AA**G** GGC UUU UAA
amino acids: methionine-valine-**lysine**-glycine-phenylalanine

This is a silent mutation since the codon still codes for the same amino acid. The protein produced will function normally.

Mutated DNA y: TAC CAT **A**TT CCG AAA ATT

mRNA: AUG GUA **U**AA GGC UUU UAA
amino acids: methionine-valine

This is a non-sense mutation since an early stop codon is introduced. This ends translation pre-maturely and the resulting protein will be non-functional or partial functioning.

Mutated DNA z: TAC CAT TTT C**G**G AAA ATT

mRNA: AUG GUA AAA G**C**C UUU UAA
amino acids: methionine-valine-lysine- **alanine**-phenylalanine

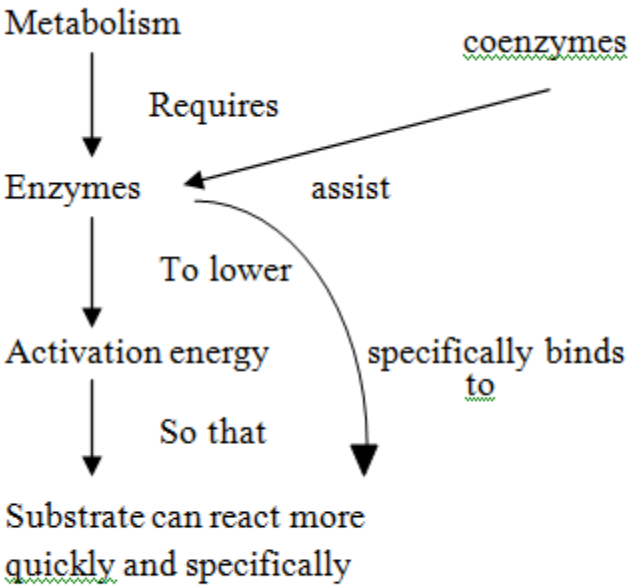
This is a missense mutation since the mutated codon codes for a different amino acid. As a result, the protein produced may be partially functioning or non-functioning.

12. Choose **ONE** of the following topics to research and write a paragraph about.

Answers will vary.

Introduction Enzymes/Thyroxin

1. Create a web connecting the terms below. Please show how the terms are connected.
- Metabolism
- Enzyme
- Substrate
- Coenzyme
- Activation energy



2. Thyroxin is an important example of a hormone in our body:

a. Where is thyroxin made? = thyroid

b. What is its function? = regulate oxygen consumption and therefore, overall rate of metabolism

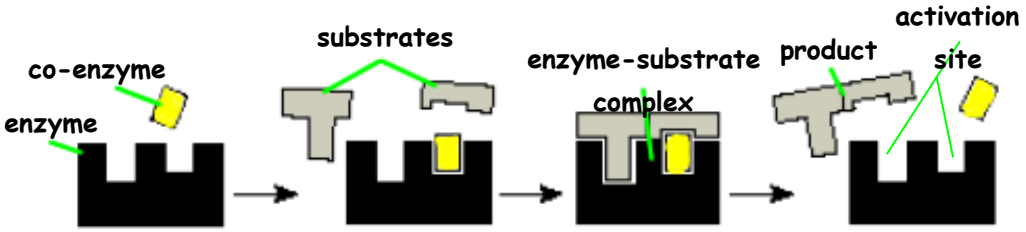
c. What is the effect of too little thyroxin?
= hypothyroidism…slower metabolism, lethargic, weight gain, enlarged thyroid

d. What is the effect of too much thyroxin?
= hyperthyroidism…faster metabolism, "nervous energy", weight loss, bulging eyes, enlarged thyroid

ENZYMES

1. Chemical reactions in cells occur at lower temperatures because enzymes __lower____ the activation energy for the reaction.

2. Label the diagram with the following terms: enzyme, substrates, co-enzyme, enzyme-substrate complex, product, and activation site.



Enzyme Catalyzed Reaction

3. The activation site on an enzyme is the region where the substrate fits with the proper geometry for a reaction to occur. This "fit" between the enzyme and substrate is called the lock and key model.

4. Explain the lock and key model of enzyme action. Why does denaturation of the enzyme prevent it from functioning properly?

= the three dimensional shape of the enzyme's activation site is complimentary and specific to the three dimensional shape(s) of its substrate(s)

= when an enzyme is denatured its three-dimensional shape is altered, typically such that it no longer compliments its substrate(s) three-dimensional shape(s), and thus, it can no longer bind to the substrate(s) to lower the reaction's activation energy and speed up (catalyze) the reaction.

5. Compare the effect of adding more enzyme versus more substrate to an enzyme catalyzed reaction.

= adding more enzyme increases the reaction rate as more collisions between enzymes and substrates results in a higher reaction rate.
= adding more substrate will increase the reaction rate as well; however, at a certain point the enzyme active sites become saturated and reaction rate will plateau at the maximum rate.

6. Compare and contrast competitive versus non-competitive inhibition.

= competitive inhibition is when a substance, other than the substrate itself, competes with and binds to the active site of the substrate's enzyme, when the competitive inhibitor binds to the enzyme's active site the substrate can no longer do so and thus, the enzyme cannot effectively catalyze the reaction and the reaction rate slows down (common regulatory mechanism often involving a negative feedback loop)

= non-competitive inhibition is when a substance, other than the substrate itself, binds to an alternate site (allosteric site as opposed to the active site) on the substrate's enzyme, when the non-competitive inhibitor binds to the enzyme's allosteric site it alters the enzyme's three dimensional structure including its active site such that the substrate can no longer bind to the enzyme and thus, the enzyme cannot effectively catalyze the reaction and the reaction rate slows down (another common regulatory mechanism often involving a negative feedback loop)

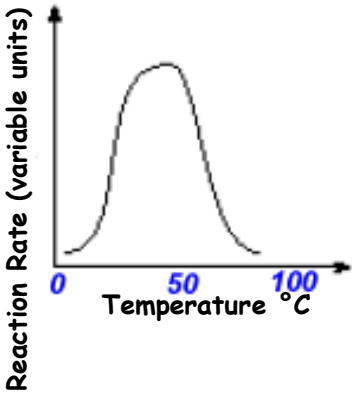
7. List two environmental factors that can change the shape of an enzyme.

= change in pH (addition of either H^+ or OH^- ions to the solution surrounding the enzyme as it tends to interfere with hydrogen bonds that influence the enzyme's three dimensional shape)

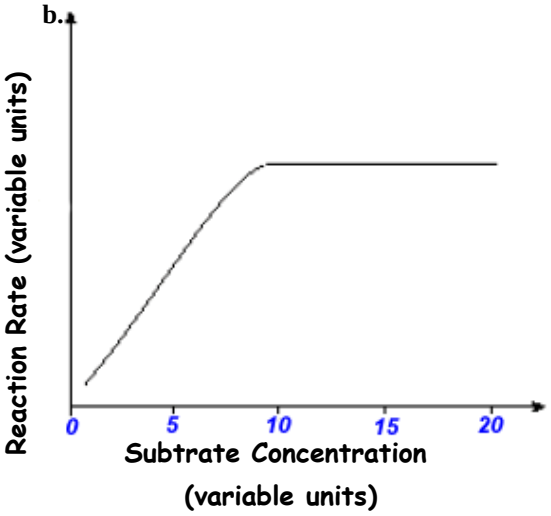
= increase in temperature (tend to disrupt bonds influencing the enzyme's three dimensional shape)

8. Label the vertical and horizontal axes in the following diagrams.

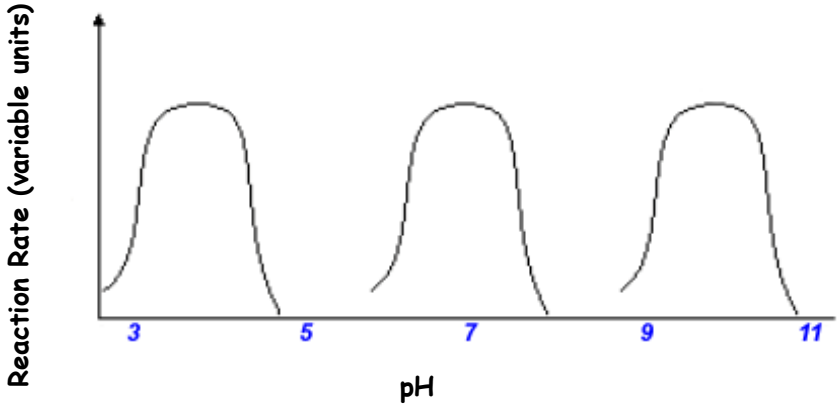
a.



b.



c.



3.4: BIOTECHNOLOGY

1. Many scientific discoveries have contributed to Modern Biotechnology. What are the two discoveries had the most impact to where we are today?

Mendels mechanism of inheritance and the production of iPS cells

2. What is the 1000 plant project (research)?

   The 1,000 plants (1KP) project is an international multi-disciplinary consortium that has now generated transcriptome data from over 1,000 plant species. One of the goals of the species selection process was to provide exemplars for all of the major lineages across the Viridiplantae (green plants), representing approximately one billion years of evolution, including flowering plants, conifers, ferns, mosses and streptophyte green algae.

3. Define GMOs and identify the process used to produce them.

   Genetically modified organisms - The key steps involved in genetic engineering are identifying a trait of interest, isolating that trait, inserting that trait into a desired organism, and then propagating that organism.