Biology 12
Cell Biology

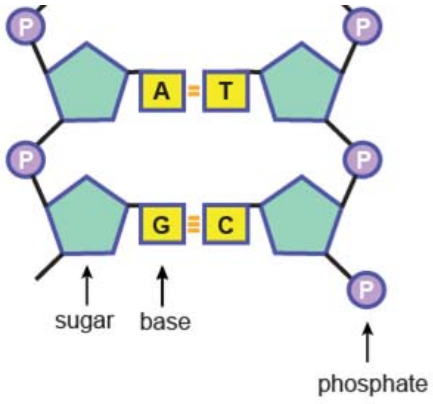
Textbook: BC Biology 12

Study Guide – Answer Key

DNA & Enzymes

Chapter 4 (DNA)

1. What was the contribution of Hershey & Chase to our knowledge of genetic material?
   Determined that DNA was the genetic material, not proteins as was previously thought
2. What was the contribution of Watson & Crick to our knowledge of DNA?
   Finalized the 3D structure of DNA as a double helix
3. Name the three subunits of DNA.
   Phosphate group, pentose sugar, nitrogenous base
   a. Draw a simplified diagram showing
      i. which are found in the "backbone" and
      ii. how complementary base pairing works
      (including number of bonds between matching base pairs)



4. Draw a diagram to show that DNA strands run antiparallel.

5. Explain why DNA replication is said to be "semi-conservative".
   New DNA consists of one old "parent" strand and one new "daughter" strand
6. Using the three types of DNA enzymes, describe the steps of DNA replication.
   1. Helicase unzips the parent DNA by breaking the hydrogen bonds between the nitrogenous bases
   2. DNA polymerase brings in new complementary nitrogenous bases to make the daughter strands
   3. Ligase binds the sugar-phosphate backbone of the lagging daughter strand
7. What is the difference between how the "leading" and "lagging" daughter strands are created during DNA replication?
   The "leading" strand is created by DNA polymerase following the DNA helicase and continually adding bases in an unbroken daughter strand. The "lagging" strand is created in Okazaki fragments as DNA polymerase can only move in one direction which is opposite to the direction of helicase. The fragments then need to bonded together using ligase to repair the sugar-phosphate backbone if needed.
8. Name (abbreviated and full) and differentiate between the three types of RNA.
   - mRNA (messenger RNA): a copy of a portion of the DNA called a gene, takes the protein "message" out of the nucleus, into the cytoplasm, and to a ribosome
   - tRNA (transfer RNA): "transfers" amino acids from the cytoplasm to the ribosome
   - rRNA (ribosomal RNA): along with proteins, makes up a ribosome
9. What is the difference between transcription and translation? Refer to both the location and the function.
   Transcription: the process of creating mRNA from DNA (occurs in the nucleus)
   Translation: the process of creating proteins from the mRNA (occurs at the ribosomes)
10. Describe the three steps of translation. Include the terms: start codon, anticodon and stop codon.
    1. Initiation: step that brings together all the translation components
       a. Small ribosomal subunit attaches to mRNA in vicinity of its start codon (AUG)
       b. tRNA anticodon (UAC) binds on
       c. Large ribosomal subunit joins small ribosomal subunit
    2. Elongation: tRNA molecules bring in amino acids one at a time by binding to the mRNA codons, the polypeptide chain increases in length
    3. Termination: one of three possible stop codons causes the ribosome to release the polypeptide

11. Given a segment of a gene from DNA, write out the mRNA codons, tRNA codons, and amino acid sequence.

EXAMPLE ONLY:

DNA	A	G	G	T	C	A	C	G	T
mRNA	U	C	C	A	G	U	G	C	A
tRNA	A	G	G	U	C	A	C	G	U
a.acid	serine	-	serine	-	alanine				

12. Discuss why the genetic code is said to be degenerate. What is the advantage of this property?
    Amino acids are coded for by more than one codon. This offers some protection against possible harmful mutations. For example if the codon UUU changes to UUC it will still code for phenylalanine allowing the final protein to remain unchanged.
13. Name the three possible causes of gene mutations.
    Errors in replication, mutagens or transposons
14. Mutations can be caused by errors in replication, mutagens or transposons.
    a. Why are errors in replication so rare?
       DNA polymerase is a fantastic at proofreading the DNA strands, only one error is made for every 1 billion bases!
    b. Give specific examples of mutagens.
       Radiation (e.g. radioactive elements, UV radiation or X-rays) or organic chemicals (e.g. pesticides and cigarette smoke)
    c. What is another name for transposons?
       Jumping genes
15. Distinguish between a point mutation and a frameshift mutation.
    Point mutations: a change in a single base; also known as a substitution mutation
    - This can result in a codon which codes for… the same amino acid (silent mutation), different amino acid (missense mutation), or a stop codon (nonsense mutation)

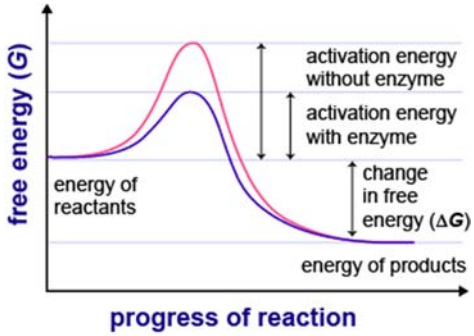
    Frameshift mutations: an extra base is added or a base is removed from the strand; also known as insertion or deletion mutations
    - Usually changes a lot of codons and therefore the amino acid sequence is drastically changed resulting in a non-functional protein
16. Using a given DNA sequence, demonstrate

EXAMPLE ONLY	T	G	T	T	A	G	C	G	A		
a. frameshift mutation	T	G	**C**	T	T	A	G	C	G	A	*added a C to the sequence at 3rd base
b. pointshift mutation	T	G	**A**	T	A	G	C	G	A		* changed the T to an A at the 3rd base

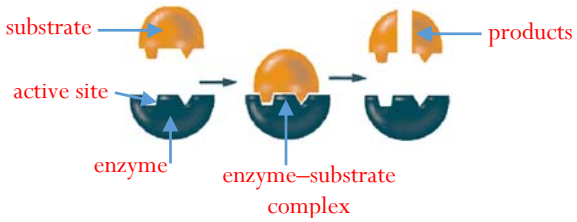
    c. the completed amino acid sequence for each
       i. ACA-AUC-GCU = threonine-isoleucine-alanine *original sequence
       ii. ACG-AAU-GGC = threonine-asparagine-glycine *changed 2nd and 3rd moment
       iii. ACU-AUC-GCU = threonine-isoleucine-alanine *ended up with the same sequence (silent mutation)
17. Discuss two specific uses for genetic engineering.
    Producing a product such as insulin or vaccines from transgenic bacteria.
    Treating genetic disorders by studying the gene's function in a transgenic animal.
18. List one beneficial use for each of: transgenic bacteria, plants, and animals.
    Transgenic bacteria: increasing the ability of bacteria to breakdown oil (clean up oil spills)
    Transgenic plants: that produce human antibodies that can deliver radioisotopes to tumor cells
    Transgenic animals: create larger animals to increased food supply
19. Distinguish between a transgenic organism and a cloned organism.
    Transgenic organisms contain DNA from a foreign source whereas a cloned organism is simply an identical copy of the original organism.
20. What is the Human Genome Project? Explain its importance to humanity.
    The project determined the entire 3.2 billion base pair sequence of human DNA. This knowledge opened up great possibilities for biomedical research such as screening for particular diseases. We were also to determine where the variation in our species came from and how that variation changes an individual's susceptibility to disease. From there specific medical treatments could be tailored for the individual.

Chapter 5 (Enzymes)

21. Give an example of a body process that is endergonic and one that is exergonic.
    Endergonic: protein synthesis, nerve impulse conduction, muscle contractions
    Exergonic: cellular respiration
22. Explain whether an anabolic reaction is more likely to be exergonic or endergonic.
    Anabolic reactions are more likely be endergonic as energy will be required for molecules to join together.
23. Use the template below to show the effect of an enzyme on the energy of activation required for a reaction.
    a. Include the terms: energy of reactant, energy of product, energy of activation (with enzyme), energy of activation (without enzyme)



24. What gives an enzyme the ability to be substrate specific?
    An enzymes specificity is determined by the shape of the active site.
    Each enzyme has a unique active site that will only fit the desired substrate.
25. Draw a diagram explaining the lock-and-key model of enzyme specificity.
    a. Label the enzyme, active site, substrate, enzyme-substrate complex and products.



26. How does the induced fit model differ from the lock-and-key model?
    Scientists originally thought that the enzyme and substrate fit together perfectly with no change in shape, hence the model referred to as the "lock-and-key". However, it is now understood that the enzyme undergoes a slight conformational change in shape to better accommodate the substrate.
27. Why is only a small amount of enzyme required in a reaction?
    Since enzymes are not used up in the reaction they can speed up one reaction after another until there is no more substrate left.
28. Name two things that will increase enzyme activity and two that will decrease enzyme activity.
    Ensure all answers are unique and not just the reverse of another answer.
    NOTE: for the key there is repetition between the increase and decrease just to show the possibilities for the answer.
    INCREASE: gentle increase in temperature, moving towards the ideal pH, increasing the amount of substrate
    DECREASE: reducing the temperature, drastically increasing the temperature, changing the pH away from the optimum, decreasing the amount of substrate, adding an enzyme inhibitor
29. Explain why denaturing an enzyme causes a change in its ability to act as a catalyst.
    a. Name two things that could denature an enzyme
    If the shape of an enzyme is changed, so is its function as the active site will no longer fit the desired substrate.
    Enzymes can be denatured by high temperatures and extreme pH changes.

30. Describe the difference between non-competitive and competitive enzyme inhibitors. Give an example of each.
    Non-competitive: bind to an enzyme in a location other than the active site, changes the shape of the enzyme slightly. These are potentially reversible but can cause slow death if exposed for a prolonged period of time.
        Examples: heavy metals (lead and mercury) or arsenic
    Competitive: binds to the active site which blocks all substrate from binding with the enzyme. Exposure to these tends to cause rapid death as they are irreversible.
        Examples: cyanide or penicillin (kills bacteria)
31. Why do low temperatures slow enzymatic activity?
    With less energy, the molecules move around more slowly and will "bump" into each other less often. This means that fewer enzyme-substrate complexed will be created and fewer overall product made.
32. During an experiment, it was discovered that increasing the amount of substrate did not speed up the reaction. Explain.
    This would indicate that all the enzymes were currently attached to substrates and there were no more available to work on additional substrates.
33. How does a cofactor differ from a coenzyme?
    A cofactor is an inorganic ion, such as a mineral, while a coenzyme is an organic, non-protein, molecule, such as a vitamin.
34. Where is the thyroid located and what element is needed to create thyroxine?
    The thyroid is located in the neck (specifically in the front of the neck, wrapped around the trachea just below the larynx)
35. Discuss the effect of the thyroid hormones on metabolic rate.
    Thyroid hormones increase the metabolic rate by stimulating cells to metabolize more glucose and use more energy.