Missouri State Tournament

Cell Biology C - Answer Key

Missouri State University

April 1st, 2023

Directions: This test has 60 questions, 92 points, and is 50 minutes long. If you are taking too long on one question or section, don't hesitate to move on - not every team is expected to complete the test.

- This test was written for **State level** rules.
- Each team is permitted one 8.5" x 11" note sheet and two stand-alone non-programmable, non-graphing calculators.
- There is no penalty for guessing - try to answer as many questions as possible.
- You may take apart this packet, but be sure to staple it back together **in order.**
- Write your team number in the top right corner of every page. **Lost pages may not be scored.**
- Ties will be broken by the tiebreaker questions specified within the exam.

Team Name: ANSWER KEY Points (of 92): KEY

Competitor Names: ANSWER KEY Team Number: KEY

1 Section 1: Biological Polymers and DNA

Question 1 (1 points)
Which of the following classes of molecules include examples of polymers? Select all that apply.

A. Proteins

B. Nucleic acids

C. Carbohydrates

D. Lipids

E. None of the above

Question 2 (1 points)
Fill in the blank: Transcription occurs in the **nucleus**, while translation occurs in the **ribosome**.

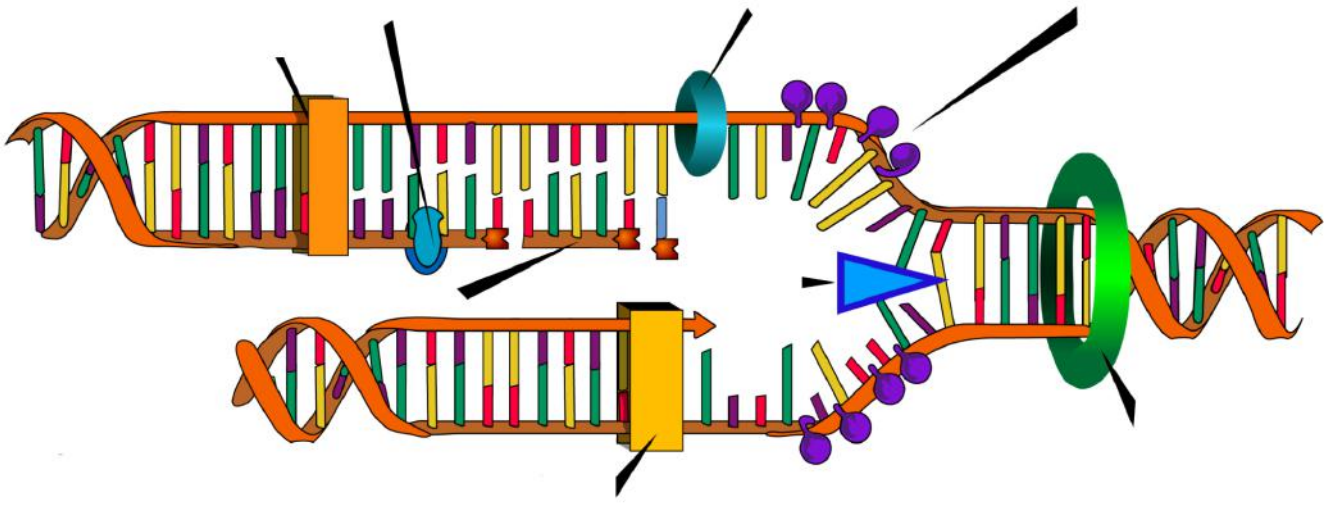
Question 3 (1 points)
Is DNA a heteropolymer, homopolymer, or neither?

A. Heteropolymer

B. Homopolymer

C. Neither

Use the following diagram to answer questions 4-6.



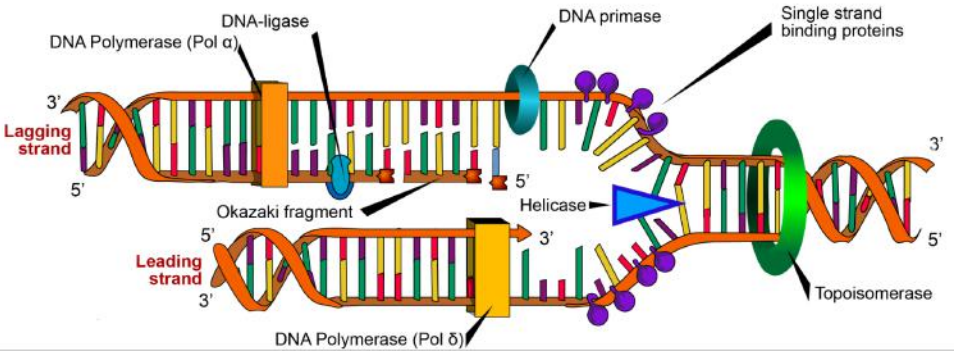
Question 4 (1 points)
What process is being depicted in this diagram?

Solution: DNA replication

Question 5 (4 points)
Label the diagram using the words in the word bank below. Not all words may be used.

DNA ligase topoisomerase DNA primase DNA polymerase RNA primase SSBs helicase leading strand lagging strand Okazaki fragments RNA polymerase exonuclease

Solution:



Question 6 (2 points)
Distinguish between the functions of DNA polymerase I and DNA polymerase III.

Solution: DNA polymerase III is mostly responsible for DNA synthesis [1], while DNA polymerase I is mostly responsible for proofreading and repair. [1]

Question 7 (1 points)
True or false: DNA is replicated from 5' to 3'. **True**

You're in the middle of a research project investigating point mutations in *Arabidopsis thaliana*, a flowering plant whose use as a model organism was popularized at the University of Missouri!

Question 8 (1 points)
To see if your plants have the mutation you want, you're going to genotype them using PCR. What enzyme do you need to add to your PCR solution to ensure that your DNA is properly amplified?

Solution: Taq polymerase

Question 9 (1 points)
TIEBREAKER: What element/ion serves as a cofactor for the enzyme described in question 8? **Mg2+**

Question 10 (1 points)
Once your PCR is done, you need to perform gel electrophoresis to separate the DNA fragments. You load the wells and switch on the power supply, only to find your DNA is flowing through the top of the gel. What mistake did you make when setting up your apparatus?

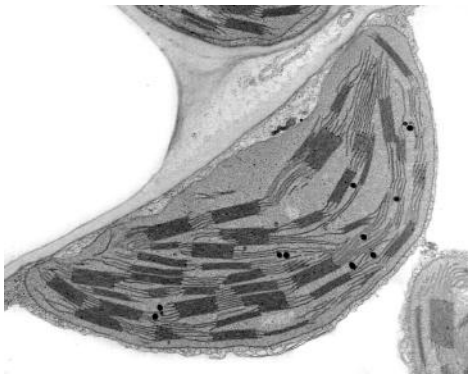
A. Didn't let the gel set long enough

B. Swapped the positive and negative electrodes

C. Used a buffer that was too acidic

D. Set the voltage on the power supply too high

2 Section 2: Organelle Blitz



Question 11 (1 points)
Which organelle is depicted in the image above? Chloroplast

Question 12 (1 points)
What technique was used to capture the image above?

Solution: Transmission electron microscopy/electron microscopy

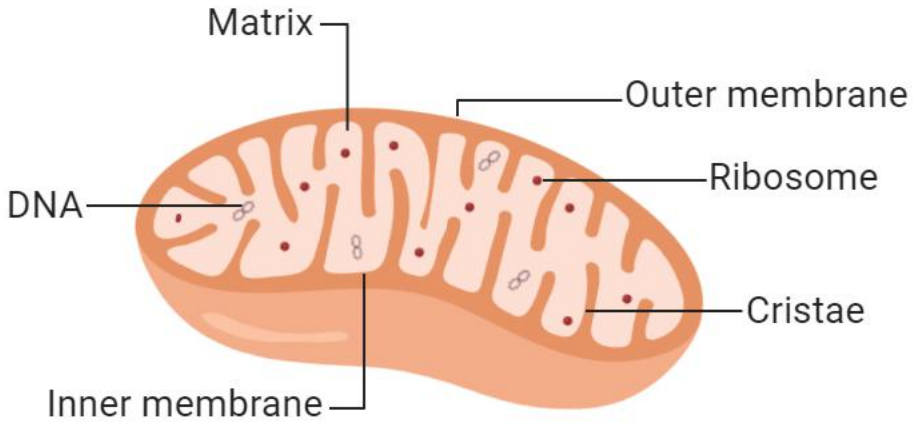
Question 13 (2 points)
Match the listed organelles to the correct function.

Golgi apparatus	Stores DNA
Rough endoplasmic reticulum	Houses ribosomes used for protein synthesis
Nucleus	Stores water and waste products
Vacuole	Packages small macromolecules

You're doing a study to figure out how different tissues in the same organism perform different functions. You've isolated pancreas cells and muscle cells from mice and looking at them under a microscope it seems like they have different amounts of mitochondria.

Question 14 (3 points)
Construct a diagram of the mitochondria, including as many details as possible.

Solution:



Question 15 (2 points)
Mitochondria and chloroplasts are organelles that are believed to have evolved through endosymbiosis. Explain two pieces of evidence which support this theory.

Solution: Double membrane, presence of circular DNA, self-replicating via binary fission, etc. Accept any two valid pieces of evidence.

Question 16 (2 points)
Would you expect your pancreas cells or muscle cells to have more mitochondria in them? Justify your answer.

Solution: Muscle cells [1], because they need more ATP for functions like movement. [1]

Satisfied with your examination of eukaryotic cells, you turn to a sample of E. coli to figure out how prokaryotic cells function.

Question 17 (1 points)
You notice a rigid cell wall present in the bacteria, similar to the cell wall you know exists in plants. What is the bacterial cell wall made of? **Peptidoglycan**

Question 18 (1 points)
Bacteria lack the membrane-bound organelles found in more complex organisms. Which of the following organelles is present in both prokaryotes and eukaryotes?

A. Nucleus

B. Mitochondria

C. Ribosome

D. Lysosome

Question 19 (2 points)
The DNA you observe in the E. coli is very different to the DNA you observed in your mouse cells. Describe two differences between prokaryotic and eukaryotic DNA.

Solution: Prokaryotes have circular chromosomes and are not packaged with proteins, eukaryotes have linear chromosomes tightly bound to proteins

Question 20 (1 points)
True or false: All bacteria are prokaryotes, but not all prokaryotes are bacteria. **True**

3 Section 3: Proteins, Enzymes, and Inhibition

Question 21 (1 points)
Which of the following best describes the secondary structure of a protein?

A. Interactions between the backbones of individual amino acids

B. The sequence of amino acids in a protein chain

C. Interactions between peptides forming a complete protein

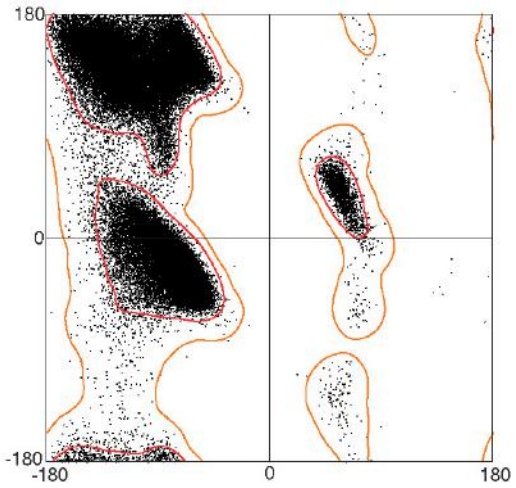
D. The sum of interactions that form the complete 3D structure of a protein

Question 22 (3 points)
You are examining a protein that has a tyrosine-rich region and an aspartate-rich region. Which region do you expect to find in the interior of the protein and why?

Solution: The tyrosine rich region [1], as it is hydrophobic and hydrophobic amino acids are clustered towards the center of a protein [2]

Question 23 (1 points)
True or false: Phosphorylation always activates a protein. **False**

Use the chart below to answer questions 24-26.



Question 24 (1 points)
What type of chart is depicted above? **Ramachandran plot**

Question 25 (1 points)
What are the x and y axis on this chart? **Phi and psi**

Question 26 (2 points)
TIEBREAKER: Black points are clustered in some regions of this chart, while other parts completely lack points. What is responsible for these "forbidden" regions without points?

Solution: Steric hindrance. [1] Phi and psi are bond angles, and the rotation of the C-C bonds is restricted based on the size of the side chain so not all bond angle combinations are possible.

You're studying a new enzyme named pigeonase. It's found in the kidneys of birds, but you're unsure as to its function. To help figure it out, you performed an experiment where you added different concentrations of its substrate birdsoate to test tubes and measured the formation of the product sciolyene after 30 seconds. Your results are in the table below, which you will use for questions 27-29.

[birdsoate] (μM)	[sciolyene] (μM)
10	10
20	30
40	60
60	75
80	80
90	80

Question 27 (1 points)

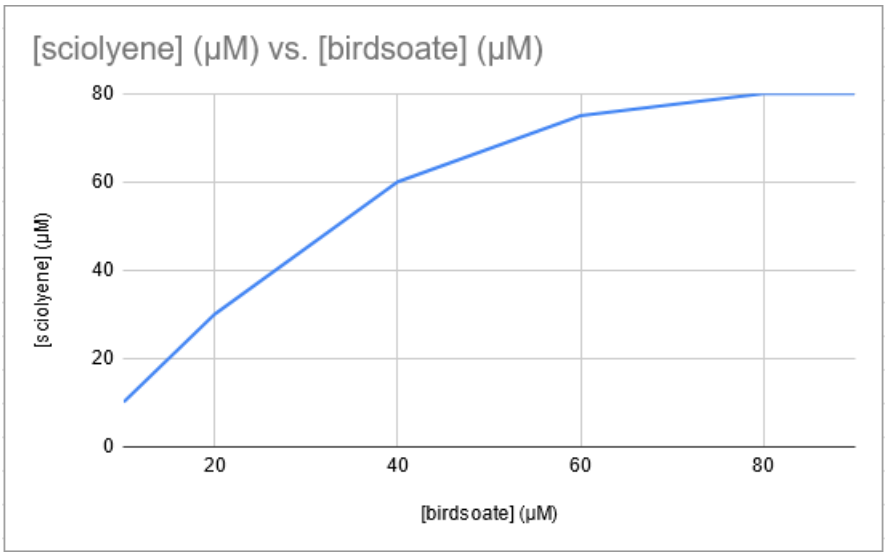
Identify the independent and dependent variables in this experiment.

Solution: Independent - substrate concentration, dependent - product formation

Question 28 (3 points)

Graph the data in the table above, being sure to label your axes.

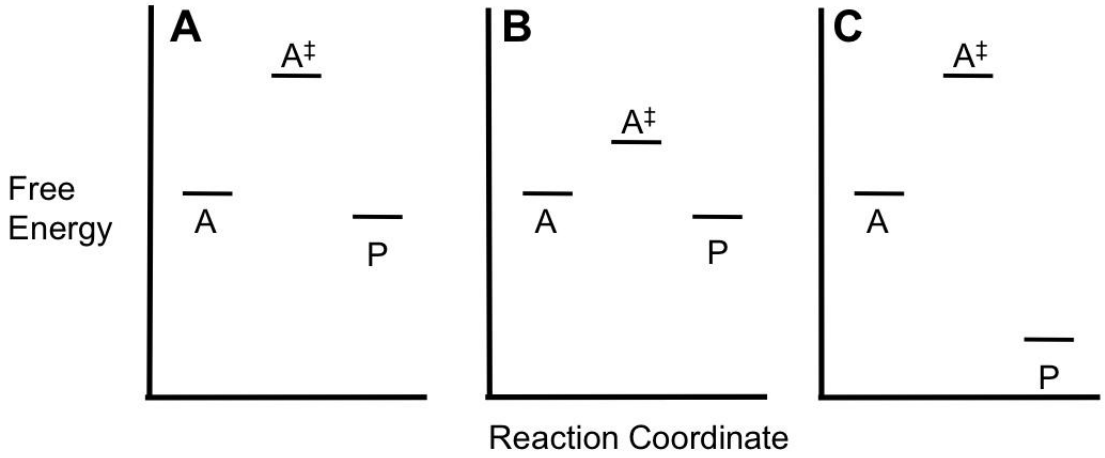
Solution:



Question 29 (2 points)

Calculate the Km and Vmax for pigeonase.

Solution: Km = 26.6, Vmax = 80



Question 30 (3 points)

For a reaction A → P, which reaction will have the fastest rate? Justify your answer.

Solution: B [1], because it has the lowest activation energy. [2]

4 Section 4: Membranes and Signal Transduction

Question 31 (1 points)
You find a mutant cell line with significantly higher membrane fluidity than normal. Which of the following would you expect to find in this mutant cell membrane?

A. A large number of saturated lipid tails

B. Low amounts of cholesterol

C. A high proportion of short fatty acids

D. A reduction in the amount of double bonds present in the fatty acid tails

Question 32 (2 points)
Distinguish between active and passive transport.

Solution: Active transport requires energy to move molecules, but passive does not

Question 33 (2 points)
For each of the molecules below, identify whether they would require passive or active transport to pass through the membrane.

Small, uncharged molecules **Passive transport**

Glucose **Active transport**

Water **Passive transport**

Ions **Active transport**

You're studying the mechanism of action of a new drug called fluoximide, which you believe acts on GPCRs. GPCRs play a large role in the function of many drugs, including opioids and antihistamines.

Question 34 (1 points)
What does GPCR stand for? **G-coupled protein receptor**

Question 35 (1 points)
Fluoximide is an agonist, binding to GPCRs and resulting in the inhibition of adenylyl cyclase. If adenylyl cyclase is inhibited, would you expect the intracellular concentration of cAMP to increase or decrease? **Decrease**

Question 36 (1 points)
Based on your answer to the previous question, would you expect the release of neurotransmitters to be inhibited or promoted? **Inhibited**

Question 37 (2 points)
Another major family of cell surface receptors is RTKs, receptor tyrosine kinases. Describe one thing that makes RTKs distinct from GPCRs.

Solution: RTKs are enzymes which can trigger many cell responses while GPCRs are proteins which trigger one cell response. Other valid differences will also be accepted.

Question 38 (1 points)
List the three steps of signal transduction.

Solution: reception, transduction, response

Question 39 (1 points)
Which of the following types of signaling utilizes hormones?

A. Autocrine

B. Paracrine

C. Endocrine

D. None of the above

Question 40 (1 points)
True or false: All signaling molecules are perceived by membrane receptors. **False**

5 Section 5: Bioenergetics and Metabolism

Question 41 (1 points)
True or false: ATP is the only molecule that cells use for energy. **False**

Question 42 (3 points)
For each step of cellular respiration, identify where in the mitochondria it takes place.

Glycolysis **Cytosol**

Krebs cycle **Matrix**

Oxidative phosphorylation **Inner membrane**

Question 43 (2 points)
The pentose phosphate pathway produces NADPH similarly to the light-dependent reactions in photosynthesis. What other major product is produced by this pathway, and what is it used to synthesize?

Solution: Ribose 5-phosphate [1], used to synthesize nucleotides [1]

You're investigating the differences between how plants and animals produce energy. However, while you wait for your cells to grow you're looking back at your notes on cellular respiration.

Question 44 (2 points)
Plants have an organelle called the chloroplast which they use to perform photosynthesis. However, they also utilize mitochondria to perform cellular respiration. If plants produce "energy" through photosynthesis, why do they need cellular respiration?

Solution: Photosynthesis produces energy in the form of glucose, but it needs to be converted into usable energy (ATP) through cellular respiration in order to be used by the cell

Question 45 (4 points)
TIEBREAKER: Your cells are done! You extract the mitochondria from liver cells and the chloroplast from spinach leaves and place them into separate vials at pH 7.4. However, in your excitement you forgot to label the test tubes. Measuring the pH, you find that vial 1 remained at 7.4 while vial 2 is slightly more acidic. Which organelle is in which vial? Explain how you know. *Hint: remember that pH = -log[H^+].*

Solution: Chloroplast in tube 1, mitochondria in tube 2. [2] Outer membrane of the mitochondria is very permeable to H+ ions while the outer membrane of the chloroplast is not. [2]

Question 46 (1 points)
Red blood cells are highly specialized, lacking organelles to make more space for hemoglobin. Which processes might they use to produce energy? Select all that apply.

A. Glycolysis

B. Krebs Cycle

C. Lactic acid fermentation

D. Oxidative phosphorylation

Question 47 (2 points)
Write a balanced chemical equation for photosynthesis.

Solution: 6 CO2 + 6 H2O → C6H12O6 + 6 O2

Question 48 (1 points)
Chlorophyll is the molecule that makes plants green. What is its role in photosynthesis?

Solution: Absorbing light energy which is used in photosynthesis [1]

Question 49 (1 points)
Which of the following is the most important rate limiting enzyme in glycolysis?

A. Phosphofructokinase

B. Hexokinase

C. Rubisco

D. Pyruvate kinase

Question 50 (1 points)
Which type of plant fixes CO2 directly from the air?

A. CAM

B. C3

C. C4

6 Section 6: Apoptosis, Cancer, and the Cell Cycle

Question 51 (2 points)
Place the steps of mitosis in order chronologically, from start to finish.

Solution: prophase, metaphase, anaphase, telophase. 0.5 pts each.

Question 52 (2 points)
The mitotic index is a ratio of the number of cells currently undergoing mitosis and the total number of cells in a tissue sample. Would you expect cancerous tissue to have a high or low mitotic index? Explain.

Solution: high, because cancer is characterized by uncontrolled cell division

Question 53 (1 points)
Which of the following stages of the cell cycle is the shortest?

A. M

B. G1

C. S

D. G2

Question 54 (2 points)
Distinguish between apoptosis and necrosis.

Solution: Necrosis is unplanned cell death while apoptosis is programmed cell death–apoptosis is regulated by molecular signals while necrosis is not

Question 55 (1 points)
What is the Hayflick limit?

Solution: The number of times a cell can divide before it dies

Question 56 (1 points)
True or false: Cyclin expression is consistent throughout the cell cycle. **False**

Question 57 (1 points)
Apoptosis is the programmed death of a cell. It might seem like this is a negative thing. However, apoptosis can be very beneficial for the health of an organism. Describe one reason why apoptosis may be triggered in a cell.

Solution: Cancer, viruses, just generally preventing unhealthy cells from replicating and causing further damage to an organism

Answer the following questions about tumor suppressor p53.

Question 58 (1 points)
How do tumor suppressors like p53 work to combat cancer?

Solution: They regulate cell division and trigger apoptosis if the cell is damaged irreparably

Question 59 (1 points)

Tumor suppressor p53 is kept at low levels in human embryonic stem cells (hESCs). What would happen if a mutation occurred which caused p53 to be activated in these stem cells?

Solution: Spontaneous differentiation

Question 60 (1 points)

Order the types of stem cells from least to most specialized.

A. Totipotent, multipotent, pluripotent, unipotent

B. Pluripotent, totipotent, multipotent, unipotent

C. Multipotent, unipotent, totipotent, pluripotent

D. Totipotent, pluripotent, multipotent, unipotent