

Name: _____

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AP Biology — Practice Exam

Instructions: A four-function calculator (with square root) is permitted. Show the formula and substitution for every calculation.

Time Limit: 60 minutes

Multiple Choice (15 questions)

- [1 point] 1. Water evaporating from the leaves of a 30-meter tree pulls a continuous column of water upward through the narrow xylem vessels, and the column does not break under the tension. Which property of water, and the interaction that produces it, best explains this?
- A. The high specific heat of water, produced by its polar covalent bonds
 - B. Cohesion between water molecules, produced by hydrogen bonding
 - C. The lower density of ice than of liquid water, produced by a rigid hydrogen-bond lattice
 - D. The ability of water to dissolve ionic compounds, produced by hydration shells
- [1 point] 2. A cylinder of potato tissue with a water potential of -3.0 bar is placed in an open beaker of 0.2 M sucrose solution at 300 K. Solute potential is given by $\Psi_s = -iCRT$, with $i = 1$ for sucrose and $R = 0.0831$ liter bars per mole per kelvin. Which prediction is correct?
- A. Water moves into the tissue, because the solution has the higher solute concentration
 - B. Water moves into the tissue, because the solution's water potential is about $+5.0$ bar, higher than the tissue's
 - C. There is no net movement of water, because the pressure potential of an open beaker is zero
 - D. Water moves out of the tissue, because the solution's water potential is about -5.0 bar, lower than the tissue's
- [1 point] 3. An enzyme-catalyzed reaction is measured at a series of substrate concentrations, with and without compound X. With X present, the maximum reaction rate is unchanged, but a much higher substrate concentration is needed to reach half of that maximum. Compound X is most likely:
- A. a competitive inhibitor that binds reversibly to the active site
 - B. a noncompetitive inhibitor that binds to an allosteric site and changes the enzyme's shape
 - C. a cofactor that the enzyme requires for catalysis
 - D. a denaturing agent that unfolds the enzyme

- [1 point]** 4. Cells are treated with a chemical that makes the inner mitochondrial membrane freely permeable to protons, so no proton gradient can be maintained across it. Which of the following would be observed?
- A. ATP production increases, because protons can reach the matrix without passing through ATP synthase
 - B. Oxygen consumption stops, because electrons can no longer be passed to oxygen
 - C. Oxygen consumption continues, but ATP production by ATP synthase falls sharply
 - D. Glycolysis stops, because NAD^+ is no longer regenerated
- [1 point]** 5. Isolated chloroplasts are illuminated with an ample supply of CO_2 until the Calvin cycle reaches a steady state. The CO_2 supply is then removed abruptly while the light stays on. In the first seconds afterward, which change in the concentrations of RuBP and 3-phosphoglycerate (3-PGA) is expected?
- A. Both rise, because ATP and NADPH continue to be produced
 - B. 3-PGA rises and RuBP falls
 - C. RuBP rises and 3-PGA falls
 - D. Both fall, because the light reactions stop without CO_2
- [1 point]** 6. Epinephrine binds to a G protein-coupled receptor on a liver cell. The activated G protein switches on adenylyl cyclase, which makes many molecules of cAMP; cAMP activates protein kinase A, which activates further enzymes that ultimately break down glycogen. A single bound epinephrine molecule can cause the release of millions of glucose molecules. This is best explained by:
- A. amplification, because each activated component of the cascade activates many molecules of the next
 - B. the hydrophobic nature of epinephrine, which lets it diffuse into the cell and act directly on glycogen
 - C. positive feedback, in which released glucose stimulates more epinephrine to bind the receptor
 - D. the receptor's own enzymatic activity, which converts ATP directly into glucose
- [1 point]** 7. A cell carries a mutation that disables a protein which normally halts the cell cycle at the G1 checkpoint when DNA damage is detected. Compared with a normal cell exposed to the same DNA-damaging radiation, this mutant cell would most likely:
- A. complete mitosis but fail to carry out cytokinesis
 - B. arrest permanently in G1 whether or not its DNA is damaged
 - C. be unable to replicate its DNA, because the checkpoint protein is required for DNA polymerase activity
 - D. continue through S phase and divide despite the damage, passing mutations to its daughter cells

- [1 point] 8. In pea plants, round seed (R) is dominant to wrinkled (r) and yellow seed (Y) is dominant to green (y); the two genes assort independently. A plant heterozygous for both traits is crossed with a plant that is heterozygous for seed shape but homozygous recessive for seed color ($RrYy \times Rryy$). What fraction of the offspring is expected to have round, green seeds?
- A. $\frac{3}{16}$
 - B. $\frac{3}{8}$
 - C. $\frac{1}{4}$
 - D. $\frac{9}{16}$
- [1 point] 9. Two parents who are both unaffected by a certain condition have four children: two unaffected daughters, one unaffected son and one son who has the condition. The mother's father also had the condition; no one in the father's family has ever had it. Which mode of inheritance is consistent with this family?
- A. X-linked recessive
 - B. Autosomal dominant
 - C. X-linked dominant
 - D. Y-linked
- [1 point] 10. A student crosses two pea plants heterozygous for stem height ($Tt \times Tt$) and expects a 3:1 ratio of tall to dwarf offspring. Of the 200 offspring, 160 are tall and 40 are dwarf. The critical value of chi-square at $p = 0.05$ with 1 degree of freedom is 3.84. Which conclusion is correct?
- A. The chi-square value is about 0.67, which proves that the 3:1 hypothesis is true
 - B. The chi-square value is about 2.67, less than 3.84, so the student rejects the null hypothesis
 - C. The chi-square value is about 2.67, less than 3.84, so the student fails to reject the null hypothesis that the ratio is 3:1
 - D. The chi-square value is 200, far above 3.84, so the 3:1 hypothesis is rejected
- [1 point] 11. In *E. coli*, a mutation changes the lac repressor so that it can no longer bind allolactose (the inducer) but still binds the operator normally. When these cells are grown in a medium containing lactose and no glucose, the lac operon genes would be:
- A. transcribed at normal induced levels, because the cAMP-CAP complex overrides the repressor
 - B. transcribed constitutively, because the repressor can no longer be regulated
 - C. transcribed only when glucose is added to the medium
 - D. not transcribed, because the repressor stays bound to the operator even in the presence of lactose
- [1 point] 12. A short mRNA segment reads 5'-AUG UUC GGA AAA UAG-3' and is translated as Met-Phe-Gly-Lys followed by the stop codon UAG. A mutation deletes the first U of the second codon. Which best describes the effect on the polypeptide?
- A. Only the second amino acid changes; the rest of the polypeptide is unaffected
 - B. Every codon after the first is read in a new frame, so the amino acids after methionine change and the original stop codon is no longer read
 - C. Translation ends immediately after methionine, because the deletion creates a stop codon
 - D. The polypeptide is unchanged, because the deletion falls at the third (wobble) position of a codon

- [1 point] 13. In a large, randomly mating population of moths, the pale wing phenotype is recessive and is shown by 16% of individuals. Assuming the population is in Hardy-Weinberg equilibrium, approximately what percentage of the moths with the dominant (dark) phenotype are heterozygous?
- A. About 57%
 - B. 48%
 - C. 60%
 - D. 40%
- [1 point] 14. A population of 500 deer lives in a reserve whose carrying capacity is 2,000 deer. The population's maximum per capita growth rate is 0.4 per year. Using the logistic growth model $\frac{dN}{dt} = r_{max}N\frac{K-N}{K}$, the population growth rate at this moment is closest to:
- A. 375 deer per year
 - B. 200 deer per year
 - C. 50 deer per year
 - D. 150 deer per year
- [1 point] 15. In a lake, phytoplankton capture 1.5×10^6 kJ of solar energy per square meter per year as gross primary productivity and use 40% of it in their own respiration. Zooplankton eat the phytoplankton and small fish eat the zooplankton, with 10% of the energy available at each level passing to the next. How much energy per square meter per year is incorporated into the small fish?
- A. 90,000 kJ
 - B. 15,000 kJ
 - C. 9,000 kJ
 - D. 900 kJ

Short Answer (2 questions)

- [8 points] 16. Experimental design and data analysis. A student investigates how temperature affects the rate of cellular respiration in germinating pea seeds. Equal masses of seeds are placed in respirometers: sealed tubes fitted with a graduated pipette that measures changes in gas volume. Each tube also contains potassium hydroxide (KOH), which absorbs carbon dioxide. Three seed respirometers and one respirometer filled with glass beads of the same volume are run at each of 10°C, 20°C, 30°C and 40°C for 20 minutes. After correcting the seed readings using the bead tubes, the mean volume of oxygen consumed by the seeds was 0.20 mL at 10°C, 0.48 mL at 20°C, 0.90 mL at 30°C and 0.54 mL at 40°C.

[2 points] (a) Identify the independent and dependent variables in this experiment, and explain the purpose of the respirometers containing glass beads.

[2 points] (b) Explain why KOH must be present for the change in gas volume to measure oxygen consumption, and state the null hypothesis the student is testing.

[2 points] (c) Calculate the rate of oxygen consumption at 30°C in milliliters per minute, and calculate the percent change in the volume of oxygen consumed between 30°C and 40°C.

- [2 points]** (d) Explain the decrease in oxygen consumption at 40°C in terms of enzyme structure. Then predict the result for seeds that were boiled for ten minutes, cooled, and run at 30°C, and justify your prediction.

- [4 points]** 17. Conceptual analysis. Freshwater snails in a lake vary in shell thickness, and the variation is largely heritable. Thick-shelled snails grow more slowly and reproduce later than thin-shelled snails, because building a thicker shell uses energy. Six years ago a crab species that crushes and eats snails was introduced to the lake. Surveys show that thick-shelled snails made up 20% of the population before the crabs arrived and make up 65% today.

- [1 point]** (a) Describe how natural selection, rather than a change in individual snails, explains the increase in thick-shelled snails.

- [1 point]** (b) Explain why thick-shelled snails made up only 20% of the population before the crabs were introduced.

- [2 points]** (c) Predict how the percentage of thick-shelled snails would change over the next several generations if the crabs were removed from the lake, and justify your prediction.