For multiple choice questions (each worth 3 points), some questions will have only one correct answer (and will say “choose ONE”). Others will have the possibility of more than one right answer (labeled “choose ALL”); there are never more than 3 correct answers. For multi-select questions (those with more than one correct answer), there is a 1pt penalty for incorrect answer choices. For short essays (each worth 5 points): confine your answers to the space provided on the scansheet. Writing outside those margins will adversely affect the machine-scoring of your exam. If the instructions say “make a table”, make a table! You may use bulleted points to express yourself, as long as your meaning is clear.

1. Which of the following are effective methods for mastering new ideas and forming long-term memories that can be accessed and used months or even years later? (choose ALL)
   a. concentrating intense studying to the hours before an exam.
   b. sleep after study and retrieval practice
   c. reading and re-reading the textbook chapters and notes several times
   d. practicing recalling ideas and vocabulary through self-quizzing
   e. elaboration: putting ideas in your own words and connecting them to what you already know

2. Sandra and Joni are both taking an intro bio class. Joni often speaks up and asks questions in class; Sandra never does. Joni tries to get Sandra to go to SI sessions or tutoring hours with her, but Sandra isn’t interested. They both get D’s on the first exam. Sandra shrugs this off, saying “I just don’t get this stuff.” Joni goes over her exam to see what went wrong in her preparation for the exam, and visits the Tutoring Center for additional help. Based on these behaviors, we might conclude that (choose ALL)
   a. Both Joni and Sandra have a “growth mind-set”, but Joni is more pro-active.
   b. Sandra is more likely to practice retrieval (remembering, self-testing) in the future.
   c. Joni is more likely to say “I don’t get this… YET!”
   d. Sandra is exhibiting signs of a “fixed mindset”.
   e. Joni is more likely to believe that the ability to learn is something you are born with, and can’t improve.

3. Which of the following is an example of a scientific hypothesis? (choose ONE)
   a. A woman notices water on the kitchen floor.
   b. “How did this get here?” the woman asks.
   c. “Maybe there is a leak in one of the pipes under the sink.”
   d. “If the water on the floor is the result of the dog knocking over his dish, and I check the dog’s dish, then I should find it empty and turned over.”
   e. None of the above. People do not use the scientific method to solve every-day problems.

4. In science, how is a theory different from a hypothesis? (choose ONE)
   a. A hypothesis is a question, and a theory is an answer.
   b. A hypothesis is an educated guess; a theory has been proven.
   c. A hypothesis is more certain than a theory.
   d. A hypothesis is a testable statement; a theory is a big explanatory framework.
   e. All of the above are correct.
5. Regarding the laws of thermodynamics, (choose ALL)
a. the first law states that energy can neither be created nor destroyed.
b. the first law states that the degree of entropy (disorder) in the universe tends to increase.
c. living organisms are energy transformers: they acquire energy from the environment and transform it into a form of chemical energy that cells can use.
d. living organisms violate the laws of thermodynamics, because they are highly ordered (the opposite of a tendency towards increasing disorder).
e. living organisms violate the laws of thermodynamics because they use up energy.

6. All cells (choose ALL)
a. store and transmit genetic information
b. transmit and receive information about their environments.
c. have a plasma membrane that creates a boundary between interior and exterior environments
d. have a nucleus to store genetic information.
e. can create energy to drive exergonic reactions.

7. Which of the features of living cells do viruses not possess? (choose ALL)
a. the ability to reproduce themselves
b. the ability to acquire and utilize energy
c. genetic information
d. the ability to transcribe and translate their genetic information
e. an exterior membrane

8. Evolution (choose ALL)
a. is a change in the genetic make-up of a population of organisms over time.
b. can occur in an individual, a population, or a species.
c. occurs due to survival of the fittest, when the strongest out-compete the weakest and take over their territory.
d. requires that there be heritable variation amongst individuals in a population.
e. occurs through the mechanism of natural selection: the differential reproductive success of some individuals.

9. Rifampin is an antibiotic used to treat the bacterium \textit{M. tuberculosis} which causes the disease tuberculosis in humans. Rifampin works by binding to and disabling bacterial ribosomes. A tuberculosis patient was treated with rifampin for 3 months. He initially seemed to be cured, and rifampin therapy was discontinued. But when he was retested some months later, his lungs were teeming with a mutant strain of \textit{M. tuberculosis}. A second round of drug therapy with rifampin was started, but it was ineffective, and the patient died. Which of the following statements are TRUE about this scenario? (choose ALL)
a. The patient became resistant to the antibiotic, and it no longer worked.
b. Rifampin interferes with protein synthesis in normal \textit{M. tuberculosis} cells.
c. The mutations were caused by the presence of the antibiotic.
d. The mutations already existed in the population of bacteria and were selected for by the antibiotic.
e. The mutant bacterial had greater reproductive success than the normal bacteria.
10. Regarding the chemical bonding that characterizes biological molecules (choose ALL)
   a. H-bonds (hydrogen bonds) are weak bonds that easily break and reform.
   b. Covalent bonds form between atoms with opposite partial charges.
   c. Partial charges in atoms occur when they form covalent bonds with atoms of the differing electronegativity.
   d. Ionic attractions are the strongest kinds of bonds in biological molecules in cells.
   e. Hydrophobic effects are weak, but the sum of many of them can be quite powerful—as in the formation of the plasma membrane.

11. Which of the following statements are correct about the terms “polar” and “nonpolar” (choose ALL)
   a. Polar molecules are hydrophobic.
   b. Polar molecules are composed in large part of atoms that do not share electrons equally in their covalent bonds.
   c. Nonpolar molecules are able to diffuse easily in water.
   d. Nonpolar molecules are hydrophilic.
   e. Both polar and nonpolar molecules play important roles in the aqueous (water-based) environments of the cell.

12. The figure below shows the interactions between several H₂O (water) molecules. Which of the following statements about this phenomenon are FALSE? (choose ALL)

   a. It is hydrogen bonds that connect the oxygen to two hydrogens within a single water molecule.
   b. It is hydrogen bonds that connect the oxygen of one water molecule to the hydrogens of other water molecules.
   c. Once formed, hydrogen bonds are difficult to break.
   d. Water molecules can form H-bonds (or other weak interactions) with other polar molecules, such as sugars and proteins.
   e. Water molecules can form H-bonds because the oxygen and hydrogen atoms have partial charges.
13. Regarding the terms hydrophobic and hydrophilic, (choose ALL)
   a. hydrophilic molecules contain mostly polar covalent bonds.
   b. the atoms in hydrophobic molecules share electrons ~equally in their covalent bonds.
   c. hydrophilic molecules dissolve in water-- meaning that the covalent bonds break and the atoms of the molecule separate.
   d. hydrophilic molecules can form H-bonds, or other weak electromagnetic attractions, with water molecules.
   e. hydrophobic molecules can move (diffuse) freely in water.

14. Why are the octane (C\textsubscript{8}H\textsubscript{18}) molecules shown below unable to diffuse (move) freely in water? (choose ALL)

   a. because they have the same charge as water
   b. because their oxygens are repelled by the water molecules
   c. because their atoms have no partial charges
   d. because they are unable to H-bond with water
   e. because they are polar

**Essay 1:** Please confine your answer to the space provided on the scansheet. Compare solubility of salt (NaCl) and sucrose (C\textsubscript{12}H\textsubscript{22}O\textsubscript{11}) in water by answering the following questions (NUMBER YOUR ANSWERS!)

1) Are both NaCl and sucrose soluble in water?
2) Are there any differences between the behaviors of the compound NaCl and the molecule sucrose in water? Explain.
3) Are bonds disrupted when either of these substances is mixed into water? Explain.
15. Carbon is the basis of important organic molecules in cells. What is so special about carbon—compared to silicon, for example, which sits right below it in the periodic table? (choose ALL)

a. Carbon has more valence electrons than silicon.
b. Carbon is less electronegative than silicon.
c. Carbon is the basis of life rather than silicon, because silicon is rare and carbon is common on the surface of Earth.
d. Carbon forms a variety of stable bonds (single, double, triple).
e. Carbon-based molecules are structurally diverse.
Questions 16-18 refer to the following molecules: A, B, C, and D

16. Which of the molecules above would be found in a polynucleotide? (choose ONE)
   a. A and B
   b. A and C
   c. A only
   d. B only
   e. C only

17. Which of the molecules shown above is/are able to diffuse freely in (is soluble in) water? (choose ALL)
   a. A
   b. B
   c. C
   d. D

18. Which of the molecules shown above would be least soluble in water? (choose ONE)
   a. A
   b. B
   c. C
   d. D
   e. C and D are equally insoluble

19. Carbohydrates (choose ALL)
   a. are polymers made of monosaccharides (simple sugars).
   b. can be either polar or nonpolar.
   c. include simple sugars that are linear or ring-shaped.
   d. function primarily in information storage in the cell.
   e. can serve as energy sources or structural components (such as cell walls) in cells.
20. With regard to lipids (e.g., fatty acids) and the other 3 classes of macromolecules—proteins, carbohydrates, and nucleic acids (choose ALL)
   a. lipids are mostly made up atoms that share electrons *unequally* in their covalent bonds.
   b. only lipids do not form polymers.
   c. only lipids cannot move freely in water; they are not water soluble.
   d. lipids are the only ones that play roles in energy storage.
   e. lipids are mostly hydrophobic.

21. Phospholipids, which make up the plasma membranes in cells, (choose ONE)

   ![Phospholipid Structure](image)

   a. are entirely nonpolar.
   b. are entirely polar.
   c. are part protein and part lipid.
   d. cannot interact with water.
   e. spontaneously form bilayer sheets in water.
22. The figure below shows two plasma membranes and the phospholipids that form them. Which of the following statements about this topic are correct? (choose ALL)

- Membrane A has lower permeability because the phospholipid heads are nonpolar and they block diffusion.
- Membrane A has lower permeability because its fatty acid tails are saturated.
- The fatty acid tails in membrane B allow for higher permeability because they pack tightly together via Van der Waals forces.
- Membrane B allows for easier diffusion of molecules in and out of the cell.
- Both of these membranes slow the diffusion of polar molecules into and out of the cell.

23. Polymers are assembled and dis-assembled via condensation and hydrolysis reactions. Which of the following statements are correct about this topic? (choose ALL)

- Diagram A) shows a condensation reaction, in which an enzyme removes a water molecule in order to join two monomers.
- Diagram B) shows an endergonic reaction that would require an input of energy.
- Both reactions are catalyzed by enzymes.
- The reaction in diagram A results in a decrease in entropy; reaction B shows an increase in entropy.
- Reaction A) is a catabolic reaction; B) is an anabolic reaction.
24. Regarding the structure of amino acids, (choose ALL)

![Amino Acid Structure](image)

a. the amino acid pictured above is classified as nonpolar, because the R-group is composed mostly of carbons and hydrogens.
b. this amino acid is considered a polar amino acid due to the NH₃⁺ and COO⁻.
c. all amino acids are exactly the same in one part of their structure: the amino-alpha carbon-carboxyl backbone.
d. the R-group of the amino acid above is comprised of atoms with differing electronegativity.
e. this amino acid has an R-group that is hydrophilic, allowing it to easily interact with water.

25. Would the amino acid shown below be a good substitute for the one shown in the diagram above, in question 24, if the goal is to maintain the same shape and chemical properties? (choose ONE)

![Amino Acid Structure](image)

a. yes, this would be a good substitute; both are about the same size, and their amino-alpha carbon-carboxyl ‘backbones’ are identical
b. yes, because both of these amino acids are polar
c. no, this would not be a good substitute, because there are more carbons in the R-group of the one shown above
d. no, this would not be a good substitute because the R-group in this amino acid is polar (the one in Q 24 is nonpolar).
e. none of the above answers is correct.

26. Proteins (choose ONE)

a. are strings of amino acids or nucleic acids linked by phosphodiester bonds.
b. function primarily as energy storage in cells.
c. are not polymers, as the other four classes of macromolecules are.
d. form spontaneously in cells; no enzyme catalyst is required.
e. have functions that are determined by their precise 3-dimensional shapes.
27. Nucleotides -- the building blocks of nucleic acid polymers like DNA and RNA, (choose ALL)

![Nucleotide Structure]

- a. can exist as monophosphates, diphosphates, or triphosphates.
- b. vary in their sugars: the sugar in DNA, deoxyribose, is more stable and less reactive due to the missing oxygen at the 2' position.
- c. can have any one of ten different bases.
- d. are linked to one another in a polynucleotide strand by peptide bonds.
- e. are nonpolar molecules.

28. Figure A below represents a portion of a double-stranded DNA molecule; figure B is a bigger view of the same molecule: two polynucleotides (polymers of nucleotide monomers) held together in a double-helix. Which of the following statements about this topic is FALSE? (choose ONE)

![DNA Structure]

- a. The bold arrows in both diagrams represent the backbone of the DNA: phosphodiester bonds between one nucleotide and the next in the polymer.
- b. The bonds that hold the two polynucleotides chains to one another are weak H-bonds.
- c. In figure A, two purines nucleotides are covalently bonded to one another.
- d. In figure A, a guanine nucleotide and a cytosine nucleotide form a phosphodiester bond with one another.
- e. In both figures, a purine of one polynucleotide is always H-bonded to a pyrimidine in the other.
Essay #2: Please confine your answer to the space provided on the exam scansheet. Make a table like the one below and fill in the information regarding the two types of bonds that characterize double-stranded DNA:

<table>
<thead>
<tr>
<th>Type of bond</th>
<th>Role (what does this bond do?)</th>
<th>Why does this type of bond make sense for this type of role?</th>
<th>Under what circumstances would this bond be broken?</th>
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</table>

29. The DNA of a particular cell is determined to consist of 15% thymine (T). What percentage of the cell’s DNA is guanine (G)? (choose ONE)  
   a. 0%  
   b. 15%  
   c. 30%  
   d. 35%  
   e. 70%

30. In DNA molecules, complementary base pairs always include one purine nucleotide and one pyrimidine nucleotide. Which of the following statements about this phenomenon are correct? (choose ONE)  
   a. This ensures that the two strands are parallel.  
   b. This ensures that the double-stranded DNA has uniform diameter.  
   c. Either of the purines can pair-bond with either of the pyrimidines.  
   d. Each purine can pair-bond with either of the pyrimidines.  
   e. None of these answers is correct.