

Supplemental Material

CBE—Life Sciences Education

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Supplemental Materials

Content knowledge test - P. 2

Research skills survey - P. 7

Content Knowledge Test
(correct answers are indicated by the asterisk)

Microliters

1. Twenty-three microliters (μL) is equivalent to all of the following, except
- *a. 2,300,000 pL
 - b. 23,000 nL
 - c. 0.023 mL
 - d. 0.000023 L

Model organism

2. Yeast are considered a model organism for human biology. Which of the following is a reason for using yeast as a model organism for humans?
- a. Yeast are prokaryotes that reproduce rapidly under laboratory conditions.
 - b. The yeast genome has a similar size and organization as the human genome.
 - c. The same transcription factors regulate gene transcription in humans and yeast.
 - *d. Many of the same biochemical reactions occur in yeast and humans.

Yeast

3. The budding yeast, *Saccharomyces cerevisiae*,
- a. is a haploid eukaryote that reproduces by cell division
 - b. is a haploid eukaryote that duplicates its genome when stressed
 - *c. is a eukaryote able to reproduce as either a haploid or diploid
 - d. is a diploid eukaryote that produces gametes when stressed

Metabolism

4. Enzyme-catalyzed reactions are organized into metabolic pathways in cells. In a metabolic pathway, the product of one enzymatic reaction serves as the substrate for the next enzyme in the pathway. Imagine that a cell uses six enzymes to synthesize compound X, which is essential for life. Which of the following statements is not true?
- a. When a gene in the pathway leading to compound X acquires a mutation, cells may sometimes be able to survive by using alternative pathways.
 - b. The free energies of the products of an enzyme-catalyzed reaction are lower than the free energies of the substrates for the reaction.
 - c. Researchers can use knowledge of the pathway to design selective conditions for identifying mutants.
 - *d. Mutations in any of the six genes involved in the synthesis of compound X will produce identical phenotypes.

(Question 5 on methionine was replaced by the question on sulfur midway through the project. Therefore, question 5 was not included in the analyses of content knowledge changes.)

Methionine

5. In this class, we will be studying genes involved in the synthesis of methionine, which is an essential amino acid in humans. Which of the following is a distinguishing characteristic of methionine?
- Methionine is found only in eukaryotic proteins. Prokaryotes use formyl-methionine.
 - Methionine has a large side chain with an aromatic group.
 - Methionine has a sulfur atom in its side chain.
 - Methionine is one of the most abundant amino acids in proteins.

Sulfur

5. All living organisms incorporate sulfur into cellular structures. Which of the following statements about sulfur metabolism is true?
- Sulfur is required for the synthesis of lipids, nucleic acids and proteins.
 - Prokaryotes use sulfate as their source of sulfur, while eukaryotes all use methionine as their source of sulfur.
 - *c. Proteins contain sulfur because a few amino acids have sulfur in their side chains.
 - d. Nucleic acids contain sulfur in the pyrimidine rings of several bases.

Mutants

6. Researchers often use mutant strains to analyze biochemical pathways in model organisms. Investigators use various mutagens to generate these mutant strains. Which of the following statements about mutagenesis is true?
- *a. Either chemical agents or radiation can be used to generate mutants.
 - b. By choosing a particular mutagen, investigators can target mutations to individual genes.
 - c. In the absence of an external mutagen, cells do not accumulate mutations.
 - d. Mutant strains are unable to grow under laboratory conditions.

Selection schemes

7. Selective media is commonly used to isolate cells that have been transformed with plasmids. Which of the following statements is NOT true?
- a. Auxotrophic mutants can be isolated with both negative and positive selection schemes.
 - *b. Selective agents increase the frequency of transformation.

- c. Positive selection schemes favor cells that have acquired new functions as a result of the transformation.
- d. Negative selection schemes require replica plates, because the researcher is looking for mutants that have lost a function.

Plasmids

8. Plasmids are widely used in recombinant DNA technology. Which of the following statements about plasmids is true?
- a. Plasmids are small, circular pieces of DNA that are found exclusively in prokaryotes.
 - *b. Plasmids must have origins of replication for the host cell DNA polymerase in order to replicate.
 - c. Plasmids carry a gene encoding DNA polymerase, which enables them to replicate independently of the host cell chromosome.
 - d. The selectable markers carried by plasmids gives them a growth advantage over cells without plasmids even when a selective agent is not present.

Electrophoresis

9. Proteins and nucleic acids are often separated by electrophoresis. Which of the following is true about electrophoresis?
- a. During electrophoresis, negatively-charged molecules move toward the negative pole.
 - *b. Electrophoresis can be used to estimate the molecular weights of protein and DNA.
 - c. The rate that a molecule moves during electrophoresis depends on its charge, but not its shape.
 - d. A molecule with a higher molecular weight moves faster than a molecular with a smaller molecular weight because it is more highly charged.

Restriction endonucleases

10. Restriction endonucleases (REs) are used to fingerprint DNA molecules. Which of the following statements is true?
- a. Cleavage sites for a particular RE are regularly spread along a DNA molecule, separated by an interval characteristic of the particular RE.
 - b. Restriction endonucleases nick one strand of the DNA helix, generating nicked fragments that can be separated by electrophoresis.
 - *c. The lengths of DNA fragments produced by a particular RE vary widely.
 - d. REs are robust enzymes that resist denaturation under conditions that denature DNA.

DNA synthesis

11. DNA synthesis requires single-stranded nucleic acids that act as primers. Which of the following statements is true?
- a. Both primers must be complementary to the sense strand of the DNA template.
 - b. DNA polymerases extend the 5' ends of the primers.
 - c. Longer primers bind less specifically to the DNA template than short primers.
 - *d. Primers are incorporated into the newly synthesized DNA molecule.

PCR

12. The polymerase chain reaction (PCR) has many uses in molecular biology. Which of the following statements about PCR is true?
- a. PCR allows investigators to amplify a fragment of genomic DNA without knowing anything about its sequence.
 - *b. A typical cycle of a PCR reaction is carried out at three different temperatures.
 - c. All of the DNA molecules produced during a PCR reaction have the same length.
 - d. The DNA polymerases used in PCR reactions are found naturally in *E. coli*.

PCR cycles

13. PCR reactions involve multiple cycles of DNA synthesis. PCR reactions are performed in a thermocycler that alternates between three different temperatures. Which of the following describes the reactions that occur as the temperature of the thermocycler is increased?
- a. polymerization, annealing, denaturation
 - b. annealing, denaturation, polymerization
 - *c. annealing, polymerization, denaturation
 - d. polymerization, denaturation, annealing

DNA hybrid

14. The two strands of a DNA molecule are held together by hydrogen bonds. Which of the following statements is true?
- *a. The thermal stability of a DNA molecule depends on both its length and base composition.
 - b. Covalent bonds between the two strands of a DNA helix prevent it from denaturing at temperatures that denature proteins.
 - c. The denaturation temperature of a 200 bp DNA molecule with a 60% AT composition is higher than that of a 200 bp DNA molecule with a 60% GC composition.
 - d. Denaturation of DNA molecules is irreversible.

Transformation

15. Transformation refers to the introduction of a foreign DNA into a host cell. Which of the following statements about transformation is true?

- a. Transformation refers to the gene transfer that occurs when bacteria and yeast mate.
- b. Transformation only occurs when the foreign DNA carries a gene that will allow the transformed cells to grow in a selective medium.
- c. For successful transformation to occur, the foreign DNA must carry the coding sequence of a protein.
- *d. Transformation efficiencies are increased by treatments that weaken cell membranes.

Complementation

16. Complementation refers to the process in which

- a. cells take up foreign DNA from the environment.
- b. DNA is transferred from one species to another species.
- *c. foreign DNA supplies a function that is defective in a transformed host.
- d. cells take up foreign DNA and acquire a function that is not normally present in the host species.

Promoters

17. Gene promoters

- a. control the translation of genes.
- *b. contain the binding site for RNA polymerase.
- c. regulate the transcription of eukaryotic genes, but not prokaryotic genes.
- d. are always located at the 5' end of the protein coding sequence.

Western blots

18. Which of following best describes the procedures used in western blots?

- a. Western blots use molecular hybridization to detect DNA molecules.
- b. Western blots use molecular hybridization to detect RNA molecules.
- c. Western blots use antibodies to detect DNA molecules.
- *d. Western blots use antibodies to detect protein molecules.

Databases

19. In this course, we will make extensive use of online databases to obtain information about *MET* genes. Which of the following statements about online databases is incorrect?

- a. Similar information about a gene or protein is available in multiple databases.

- b. Professional curators add links to a record as it is processed for secondary databases.
- *c. All of the information in databases is correct.
- d. Databases receive financial support from governments.

Homologs

20. Homologs are similar, but not identical, protein or DNA sequences. Which of the following statements about homologs is correct?

- *a. Natural selection plays an important role in determining how homologs are distributed between species.
- b. When a protein coding sequence is compared in two different organisms, the nucleotide sequences are more similar than the amino acid sequences.
- c. Homologs refer only to similar sequences found in different species. Homologs are not found within a single species.
- d. If homologs of Gene A and Gene B are present in the genomes of two divergent species, one can expect that they will show the same degree of sequence similarity, reflecting their evolutionary distance.

Research Skills Survey

Q1 Thank you for taking the time to complete this survey. The first section of this survey concerns your knowledge and skills. The second section asks for some information about you. Your responses will be analyzed anonymously, so please respond honestly.

Q2 What is your Eagle ID number?

Q3 Please indicate your level of agreement with each of the following statements.

	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
I feel confident in my ability to construct a testable hypothesis. (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I could recognize what a testable hypothesis is in a research design. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I could explain what a control is in the context of an experiment. (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident that I could design controls for an experiment. (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to choose appropriate technology (i.e. methods) to answer a research question. (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I can recognize what goals are realistic for an experiment. (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

use scientific articles as background for a hypothesis. (7)					
I feel confident in my ability to assemble a bibliography. (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident communicating the results of an experiment to a group of my peers. (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident communicating the results of an experiment to a group of scientists. (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident using technical vocabulary when presenting the results of an experiment. (11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to write a paper in scientific format. (12)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to write a clear and succinct research paper. (13)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I can recognize when my data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

<p>have the quality that one expects from published data. (14)</p>					
<p>I feel confident in my ability to produce publication-quality results when I perform an experiment. (15)</p>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<p>I feel confident in my ability to obtain reproducible results when I repeat an experiment. (16)</p>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<p>I feel confident in my ability to locate gene-specific information in a scientific database (e.g National Center for Biotechnology Information) (17)</p>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<p>If I need to locate information about a gene for my experiment, I know where to search for that information. (18)</p>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

When working with a group on an experiment, I can effectively divide the tasks between group members. (19)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to do research with others. (20)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I find it helpful to work with a team when doing research. (21)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to work with a team to interpret data from an experiment. (22)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to read and analyze scientific papers. (23)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel confident in my ability to understand graphs and tables in scientific papers. (24)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q4 What is your sex?

- Male (1)
- Female (2)

Q5 What is your graduation year?

- 2014 (1)
- 2015 (2)
- 2016 (3)
- 2017 (4)

Q6 What is your official major?

- Biology (1)
- Biochemistry (2)
- Psychology (3)
- Environmental Geoscience (4)
- Other (please specify) (5) _____

Q7 Are you a pre-medical student?

- Yes (1)
- No (2)

Q8 Do you have any prior research experience?

- Yes (1)
- No (2)