

# Supplemental Material

*CBE—Life Sciences Education*

Elliott *et al.*

Improved Student Learning Through a Faculty Learning Community: How Faculty Collaboration Transformed a Large Enrollment Course from Lecture to Student-Centered.

**Supplemental Methods:**

**Protocol for observation of active learning:**

Observers recorded moments of active learning, categorized by type of activity and subject matter. Observers recorded when the activities pertained to topics relating to biological membranes, energetics, or genetics, as content assessments focused on these topics. Other topics were recorded as “other”, but included descriptions for future categorization. Descriptions included the question text (for clickers and think-pair-shares), title of the activity where applicable (e.g. “synapse worksheet”), and/or slide number of the presentation that included the relevant activity description. Observers recorded the type of activity as “clicker question”, “think-pair-share”, or “other”. Activities in the “other” category also required a description such as “worksheet” or “diagram”. When pedagogy involved multiple stages with different activity categories (e.g. group discussion followed by a new clicker question), these activities were recorded separately. Duration of the activity included time that students worked on the material, and time for student explanation of answers. Duration of activity did not include instructor explanation of answers unless the explanation was interactive.

Below is an example template for recording activities.

Date: \_\_\_\_\_

Class time or section: \_\_\_\_\_

Topic

Biological Membranes

Energetics

Genetics

Other: Specify \_\_\_\_\_

Type of activity

Clicker question

Think-Pair-Share

Other (e.g. group worksheet): Specify \_\_\_\_\_

Question text, title of activity, and/or slide number:

\_\_\_\_\_  
\_\_\_\_\_

Duration (minutes): time students worked on the activity: \_\_\_\_\_

Bloom's rating of content questions:

Content assessment questions were drawn or modified from the Biological Concepts Instrument and the Introductory Molecular and Cellular Biology Assessment. Each question is designated a unique letter-number identifier. Question identifiers containing "B" were drawn from the Biological Concepts Instrument; "I" questions were drawn from the Introductory Molecular and Cellular Biology Assessment; "M" questions were modified by co-authors ERE and CC to better align with course learning objectives.

Bloom's ranks were independently rated by three authors (ERE, CRC, and EJJ). All three raters were familiar with the topics and examples presented to students in Biology 212. Each question was assigned a rank by majority (two out of three raters agree) or consensus (Zheng et al. 2008).

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| Supplemental Table: Bloom's rankings |                 |                    |
|--------------------------------------|-----------------|--------------------|
|                                      | All three agree | Two of three agree |
| CA1                                  | 37.5%           | 62.5%              |
| CA2                                  | 18.2%           | 81.8%              |

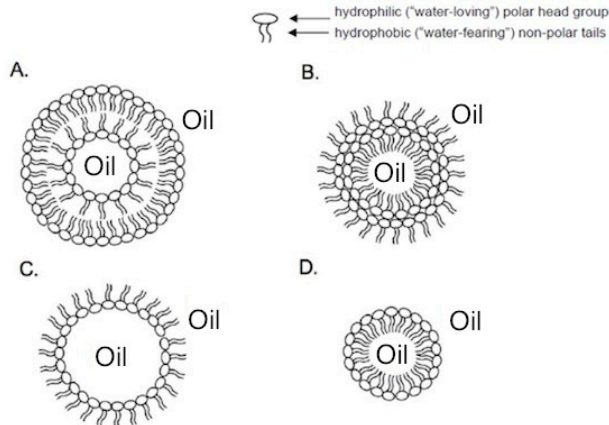
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**Questions from Content Assessment 1 (Administered in class)**

MI3a

Bloom's rank (majority value): Comprehension

The four diagrams A-D represent cross sections of spherical structures composed of phospholipids. Which of these structures is most likely to form when phospholipids are vigorously dispersed in oil?



I9

Bloom's rank (consensus value): Comprehension

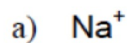
Which of the following statements comparing bacteria and eukaryotes is true?

- A. Eukaryotic cells have a nucleus surrounded by a nuclear membrane; bacterial cells don't.
- B. Eukaryotic cells don't have cell walls; many bacterial cells do.
- C. The genetic material of eukaryotic cells is DNA; the genetic material of bacteria can be either RNA or DNA.
- D. Eukaryotic cells use a different code to specify the amino acids in proteins than bacterial cells.

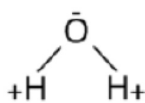
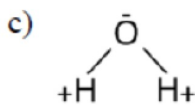
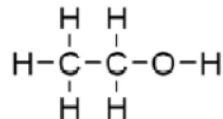
I10

Bloom's rank (majority value): Application

Which of the following substances will be **least likely to diffuse** through a pure phospholipid bilayer membrane that contains no proteins?



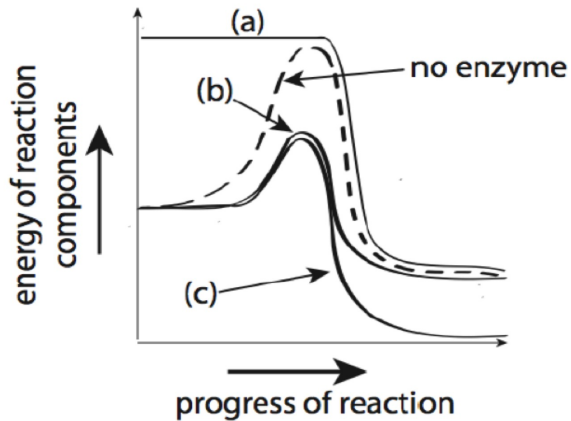
b)

d)  $\text{O}=\text{O}$

I11

Bloom's rank (majority value): Analysis

In the diagram below, the dashed line represents the energetics of this reaction WITHOUT an enzyme. Which of the solid lines (a, b, c) in the diagram best represents the way the **curve would look in the presence of an enzyme catalyst** that increases the reaction rate?



B3

Bloom's rank (majority value): Comprehension

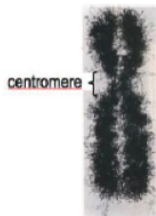
In which way are plants and animals **different** in how they obtain energy?

- A. Animals use ATP; plants do not.
- B. Plants capture energy from sunlight; animals only capture chemical energy.
- C. Plants store energy in sugar molecules; animals do not.
- D. Animals can synthesize sugars from simpler molecules; plants cannot.

I12

Bloom's rank (consensus value): Comprehension

The photograph below shows a single replicated chromosome (consisting of two sister chromatids) just before mitosis. This chromosome contains:

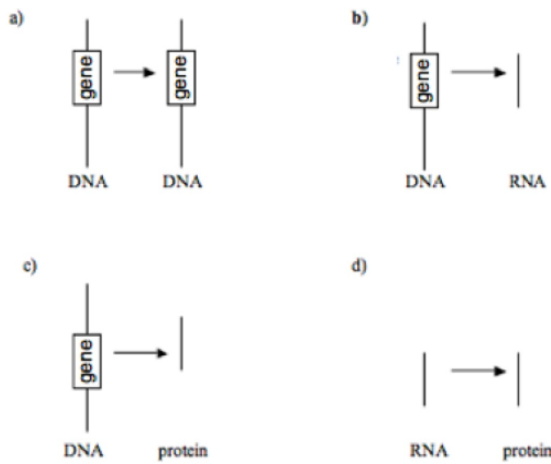


- a) Two single-stranded DNA molecules
- b) One double-stranded DNA molecule.
- c) Two double-stranded DNA molecules.
- d) Many double-stranded DNA molecules.

I13

Bloom's rank (majority value): Knowledge

Transcription is best represented by which of the following diagrams?



B4

Bloom's rank (consensus value): Comprehension

What is it about nucleic acids that makes copying genetic information straightforward?

- Hydrogen bonds are easily broken.
- The binding of bases to one another is specific
- The sequence of bases encodes information.
- The shape of the molecule is determined by the information it contains.

**Questions from Content Assessment 2 (Administered online)**

I1

Bloom's rank (majority value): Comprehension

Which of the following statements about DNA synthesis at the replication fork of a replicating DNA molecule is FALSE?

- a) Nucleotides are added at the 3' ends of all the new strands in a replicating DNA molecule.
- b) Double-stranded DNA synthesis requires both deoxyribonucleotides and ribonucleotides.
- c) The sequence of each newly synthesized single strand is identical to that of the parental single strand that served as its template.**
- d) One of the two new strands must be synthesized in fragments because the two strands have opposite directionality

I2

Bloom's rank (majority value): Comprehension

The photograph below shows a single replicated chromosome (consisting of two sister chromatids) just before mitosis. This chromosome contains:

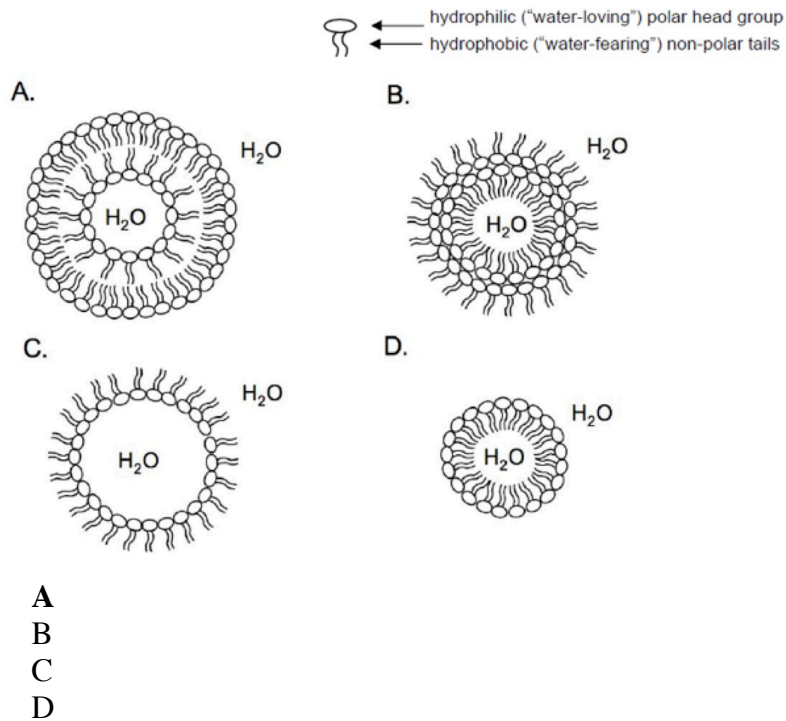


- a) DNA from one of your parents in the sister chromatid on the left and DNA from the other parent in the sister chromatid on the right.
- b) DNA contributions from both parents, resulting from recombination (crossing over).
- c) DNA from only one of your parents.**

I3b

Bloom's rank (majority value): Comprehension

A phospholipid molecule is diagrammed at the right, and the four diagrams A-D below represent cross sections of spherical structures composed of phospholipids. Which of these structures is most likely to form when a phospholipid is vigorously dispersed in water?



I4

Bloom's rank (majority value): Application

Consider a short polar charged region and a short non-polar region in a long polypeptide chain. When dissolved in water, the polypeptide will most likely fold to form a protein in which:

- The non-polar region is exposed on its surface and the polar region is interior.
- The polar region is exposed on its surface and the non-polar region is interior.**
- both the non-polar and the polar region are exposed on its surface.
- both the non-polar region and the polar region are interior.

B1

Bloom's rank (majority value): Comprehension

When we want to know whether a specific molecule will pass through a biological membrane, we need to consider ...

- the specific types of lipids present in the membrane.
- the degree to which the molecule is water soluble.**
- whether the molecule is harmful to the cell.



I5

Bloom's rank (majority value): Comprehension

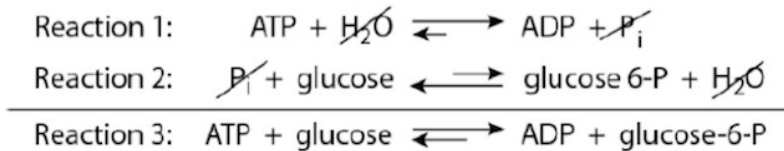
If the intracellular reaction  $A + B \rightarrow C$  proceeds in the presence of a specific enzyme and no other components, you can conclude that:

- a) the reaction would not proceed in the absence of the enzyme.
- b) the reaction would proceed in the absence of the enzyme but at a slower rate.**
- c) the reverse reaction  $A + B \leftarrow C$  would not proceed in the presence of the enzyme.
- d) the reaction in the presence of the enzyme will not proceed any faster if the temperature is raised a few degrees.

I6

Bloom's rank (majority value): Comprehension

The reaction catalyzed by the enzyme hexokinase (Reaction 3 below) can be thought of as the sum of Reactions 1 and 2. Reaction 1 is the breakdown of ATP to ADP, which releases energy. Reaction 2, in which glucose is phosphorylated, requires energy.



When Reactions 1 and 2 are coupled in the enzyme active site, Reaction 3 will occur spontaneously because:

- a) the energy required to form glucose-6-P in Reaction 2 is less than the energy released by ATP breakdown in Reaction 1.**
- b) the energy required to form glucose-6-P in Reaction 2 is greater than the energy released by ATP breakdown in Reaction 1.
- c) both Reactions 1 and 2 can occur spontaneously.
- d) neither Reaction 1 or 2 can occur spontaneously alone, but both can occur spontaneously when coupled in the active site of the enzyme.

B2

Bloom's rank (majority value): Comprehension

In which way are plants and animals different in how they use energy?

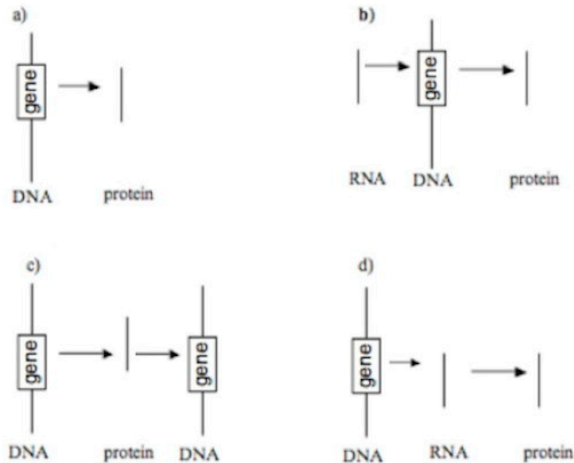
- A. Plants use energy to build molecules; animals cannot.
- B. Animals use energy to break down molecules; plants cannot.
- C. Animals use energy to move; plants cannot.
- D. ✓ Plants use energy directly and transform it, animals must transform it.**

M1

Bloom's rank (majority value): Knowledge

Which of the following diagrams best represents the flow of genetic information in cell?

- a)
- b)
- c)
- d)**



I7

Bloom's rank (consensus value): Application

The human hexokinase enzyme has the same function as the bacterial hexokinase enzyme but is somewhat different in its amino acid sequence. You have obtained a mutant bacterial strain in which the gene for hexokinase and its promoter are missing. If you introduce into your mutant strain a DNA plasmid engineered to contain the coding sequence of the human hexokinase gene, driven by the normal bacterial promoter, the resulting bacteria will now produce:

- a) the bacterial form of hexokinase.
- b) the human form of hexokinase.**
- c) a hybrid enzyme that is partly human, partly bacterial.
- d) both forms of the enzyme.

I8

Bloom's rank (consensus value): Application

In a certain mutant strain of bacteria, the enzyme leucyl-tRNA synthetase mistakenly attaches isoleucine to leucyl-tRNA 10% of the time instead of attaching leucine. These bacteria will synthesize:

- a) proteins in which leucine is inserted at some positions normally occupied by isoleucine.
- b) proteins in which isoleucine is inserted at some positions normally occupied by leucine.**
- c) no abnormal proteins, because the ribosomal translation machinery will recognize the inappropriately activated tRNAs and exclude them from the translation process.
- d) no proteins, because the inappropriately activated tRNAs will block translation.

### Questions Groups by Topic

Biological Membranes: MI3a, I3b, B1, I10,

Energetics: I5, I6, B2, I11, B3

Genetics and DNA: I1, I2, M1, I7, I8, I12, I13, B4

**FLC participant Survey:**

1. How do you interpret the data comparing student knowledge at the beginning and end of Biology 212? Does this information about what students know at the beginning of the course, and what they gain from Biology 212, affect how you plan to teach this course in the future? How so?
2. Specifically, how do you interpret the difference in student learning comparing the results of CA1 and CA2? Does this difference in learning inform how you plan to teaching Biology 212 in the future? How so?
3. How do you interpret the data about student attitudes towards biology (CLASS)? Does this data give you some insight into the students in your biology 212 class(es)? Does it affect how you plan to teach in the future, and how so?
4. How has this information about the students in Biology 212 affected how confident you are in the effectiveness of active learning in this course?

Much less confident  
Less confident  
Neither more nor less confident  
More confident  
Much more confident

5. How has this information about the students in Biology 212 affected your confidence in your ability to effectively use active learning techniques in Biology 212?

Much less confident  
Less confident  
Neither more nor less confident  
More confident  
Much more confident

6. How likely are you to use active learning strategies in Biology 212 in the future?

Very Unlikely  
Unlikely  
Undecided  
Likely  
Very Likely

7. Overall, how valuable did you find this process of investigating student learning and perception of biology in this course for informing your own teaching?

1: Not Valuable. It has not informed how I plan to teach

2

3

4

5: Very valuable. This process has definitely informed my teaching

8. Looking forward, what information about the students and/or Biology 212 would you like to know?

9. Do you have any further comments about what you are taking away from this process of collecting data from student?

10. How helpful have you found FLC meetings to the process of preparing to teach and teaching Biology 212?

Very Unhelpful

Unhelpful

Undecided

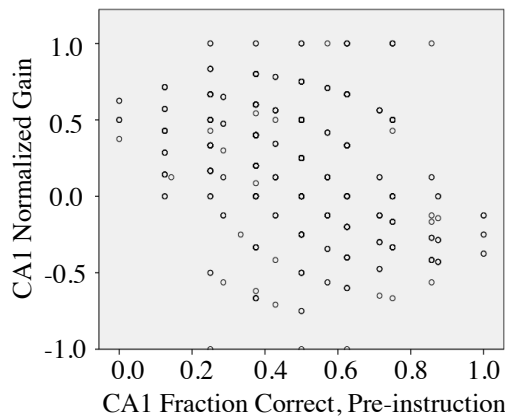
Helpful

Very Helpful

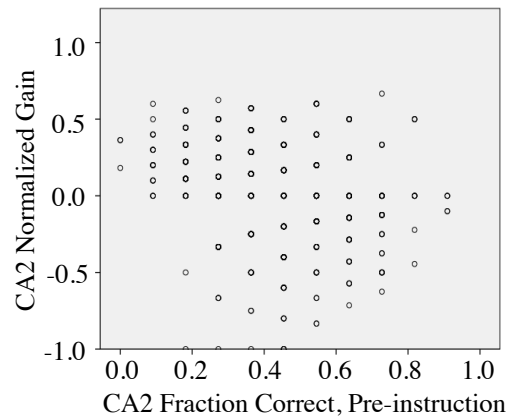
11. What about FLC meetings did you find most helpful to your teaching? Which types of discussions did you find most valuable?

**Supplemental Figures:**

**A**

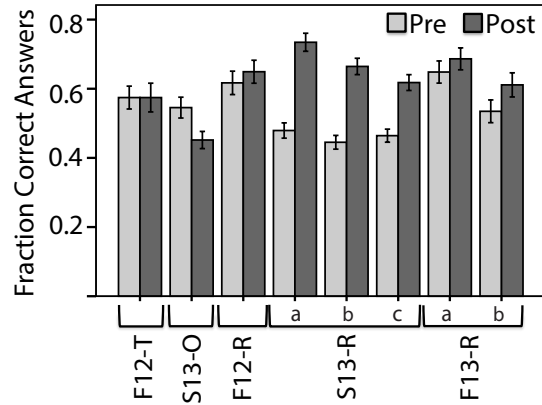


**B**

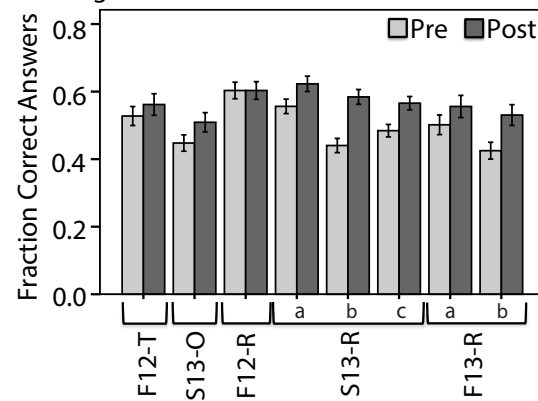


Supplemental Figure 1: Relationship between pre-instruction scores and normalized score gain for CA1 (A) and CA2 (B).

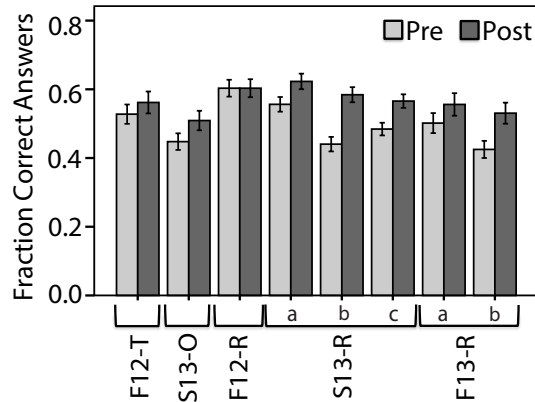
**A. Biological Membranes Scores**



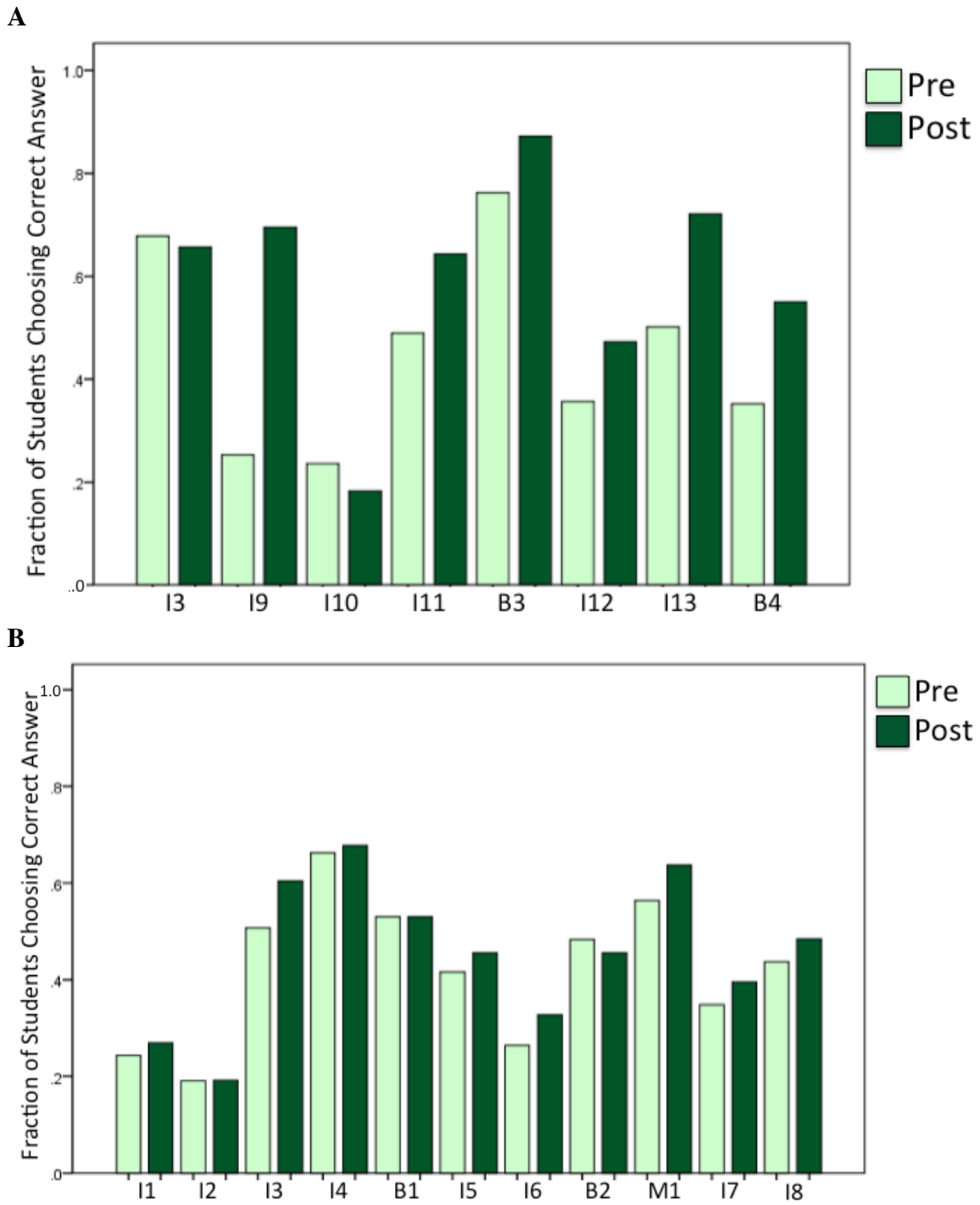
**B. Energetics Scores**



**C. Genetics Scores**



Supplemental Figure 2: Content learning by topic and course section. F12-T represents the traditional Fall 2012 lecture. S13-O represents the Spring 2013 online section. F12-R, S13-R, and F13-R represent reform sections from Fall 2012, Spring 2013, and Fall 2013 respectively. Columns represent student pre-test (light gray) and post-test (dark gray) scores on biological membranes (A), energetics (B), and genetics (C) questions. Error bars = SEM.



Supplemental Figure 3: (A) Student performance on individual questions from CA1. (B) Student performance on individual questions from CA2.