Supplemental Material

CBE—Life Sciences Education

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Appendix 1: Sample reading quiz

Mitosis vs. Meiosis Sample Reading Quiz

1. Which of the following is the correct definition of ploidy?

A. The total number of chromosomes present.
B. The number of different types of chromosomes present.
C. Having replicated chromosomes (two chromatids—not one chromosome)
D. The number of each type of chromosome present.

2. Which of the following happens during interphase, before mitosis or meiosis?

A. Chromosomes replicate (each consists of two sister chromatids).

B. The spindle apparatus forms.

C. Chromosomes condense (so that they can move without getting tangled up).
D. The nuclear envelope breaks down (this has to happen so that spindle fibers can contact the chromosomes).

3. Which of the following is the most important difference between the events of prophase in mitosis versus meiosis I?

A. In meiosis I, homologs synapse.

B. In mitosis, crossing over occurs between sister chromatids.
C. In mitosis, the nuclear envelope breaks down and the spindle fiber forms.
D. In mitosis, sister chromatids separate.

4. What does it mean to say that "homologs synapse?"

A. Homologous chromosomes line up on the metaphase plate during metaphase of meiosis I.
B. Pairs of homologous chromosomes physically come together.
C. Homologous chromosomes pull apart during anaphase of meiosis I.
D. When chromosomes replicate, the two sister chromatids are attached (synapsed).

5. Which of the following is correct in a comparison between anaphase of mitosis vs. meiosis?

A. Sister chromatids separate in mitosis and anaphase I of meiosis. Homologous pairs separate only in anaphase II of mitosis

B. Homologous pairs separate in anaphase I and sister chromatids separate at anaphase of mitosis and anaphase II of meiosis

C. Sister chromatids separate in anaphase of mitosis and anaphase I of meiosis.

D. Homologous pairs separate in anaphase of mitosis and anaphase I of meiosis.

E. None of the above is correct

6. Which of the following most completely describes the end products of meiosis vs. mitosis?

A. Meiosis reduces chromosome number by half and produces 4 cells

B. Meiosis reduces chromosome number by half, produces 4 cells and produces cells genetically distinct from parent cells

C. Both processes produce daughter cells identical to parent cells, meiosis produces 4 and mitosis produces 2, meiosis reduces chromosome number by half

D. The only difference is that mitosis produces 2 cells and meiosis produces 4 cells

E. The only difference is that meiosis reduces chromosome number in cells by half

7. As a result of meiosis, a cell with a diploid number of 8 could produce gametes with how many different combinations of maternal and paternal chromosomes?

A. 16

B. 32
C. 64
D. 4
E. 8

8. Crossing over
A. Happens in both mitosis and meiosis
B. Creates genetic recombination of parental alleles
C. Happens between sister chromatids
D. Helps cells repair damaged chromosomes

9. When do homologous pairs come together in mitosis?

A. Never
B. In prophase
C. During S of interphase
D. In metaphase

10. How many chromosomes would be present in a human gamete (sperm or egg)?
A. 12
B. 46
C. 23
D. None of the above is correct

Appendix 2: Comparing exam question type and content coverage

The same 124 questions from the control terms and 142 questions from the experimental terms were used in the Bloom's level analysis reported in the main text and in the question type and content coverage analyses reported here.

Table S1

a. Percentage of question types in control versus experimental terms.

Question type	Control	Experimental
Multiple choice	94	93
Drawing	2	1
Open response	3	5
Fill-in-the-blank	1	2

b. Percentage of questions asked, by topic, in control versus experimental terms.

Topic	Control	Experimental
Animal diversity	16	9
Community ecology	6	9
Conservation biology	2	2
Ecosystem ecology	9	13
Evolution	10	13
Experimental design	2	2
Mendelian genetics	15	12
Metacognition	0	1
Mitosis/Meiosis	9	8
Phylogeny, history of life	15	16
Plant diversity	10	9
Population ecology	6	6

Appendix 3: Checking for impacts of under-represented minority status and gender: model selection.

Stepwise backwards model selection techniques were used to determine if gender (coded as a binary 0 = male; 1 = female) or under-represented minority (URM) status (coded as a factor with 5 levels 0 = White; 1 = URM; 2 = Asian; 3 = International; 4 = Multiracial) moderated the impact of the treatment on student exam performance. We found that including URM interactions terms between URM status and treatment and gender and treatment did not increase the fit of the model to the data (Suppl Table S2). In addition, the models including and not including gender were equivalent in their fit to the data (Suppl Table S2). Thus, following model selection procedures (Burnham and Anderson 2002), we chose to remove gender from the

model. Including URM status as a main effect did increase the fit of the model to the data and so it was retained in the final model (Suppl Table S2). Thus, our final model was: Exam Performance ~ BI.QTR.GPA + URM + Treatment.

Table S2.
Demographic variables did not increase the fit of the model to the data and so were not included in the final model. Backwards model selection was used to determine which demographic variables where important to include in the model to explain variance in the outcome variable. Models with the lowest AIC (in this case the most negative) are considered the best, although models with AIC values within two of each other are considered equivalent. When models are equivalent the model with fewer variables is preferred (Burnham and Anderson 2002). The final selected model is in bold.

	AIC	F-stat	P-value
Full Model: BI.QTR.GPA + gender*treatment + URM*treatment	-363.0		
Reduced Model 1: BI.QTR.GPA + gender + URM*treatment	-363.0	0.09	0.764
Reduced Model 2: BI.QTR.GPA + gender + URM + treatment	-367.7	1.23	0.298
Reduced Model 3: **BI.QTR.GPA + URM + treatment**	-369.7	0.018	0.8933
Reduced Model 4: BI.QTR.GPA + Treatment	-342.6	9.33	< 0.0001

References:

Kenneth, P., Burnham, K.P. and Anderson, D.R., 2002. Model selection and multimodel inference: A practical information—Theoretic Approach.