

Supplemental Material

CBE—Life Sciences Education

Kalas et al.

APPENDIX

Question 1 [select the best answer]

One of the characteristics that differentiates all haploid cells from all diploid cells is that

- a) haploid cells have half as many chromosomes than diploid cells.
- b) haploid cells have one full set of chromosomes while diploid cells have two.
- c) haploid cells' chromosomes have a different structure/shape from diploid cells' chromosomes.
- d) haploid cells have half the amount of DNA as diploid cells.

Expert answer: b

- Alternatives/misconceptions²:
- a)
 - i) The absolute number of chromosomes determines ploidy.
 - ii) Diploid cells always have more chromosomes than haploid ones, regardless of what species they come from; being haploid implies having fewer chromosomes.
 - c)
 - i) Haploid cells' chromosomes have an "I" shape/structure, diploid cells' chromosomes have an "X" structure (confusion between replicated vs. unreplicated chromosomes and ploidy).
 - d)
 - i) Total amount of DNA must be higher in $2n$ than in $1n$ cells.
 - ii) Unsure about what a "set of chromosomes" is, but convinced that the absolute amount of DNA or the number of chromosomes does not define ploidy.

Concept:	ploidy
Bloom level:	II
Difficulty index ¹ :	0.37
Discrimination index (D) ¹ :	0.38
D.E. ¹ :	0.50
Common incorrect answer ²	a (31%) ³

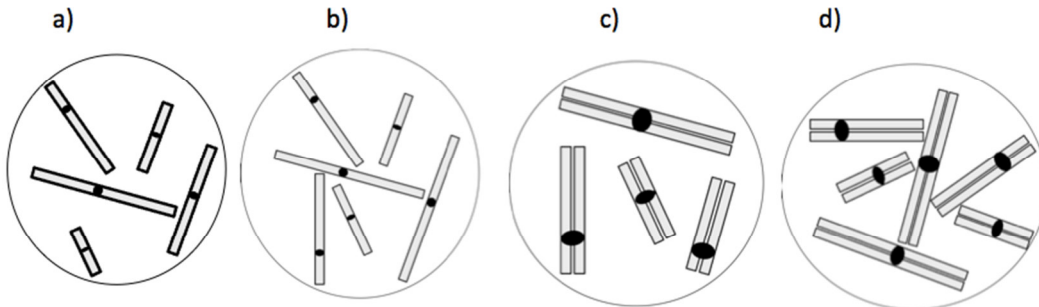
¹Based on the answers of 193 1st year students when the item was used in a post-test.
D.E.: discrimination efficiency.

²Compiled from 28 individual student interviews conducted as described by Adams and Wieman (2010).

³Percentage of students selecting this answer in our sample (N=193).

Question 4 [select all that apply]

One or more of the cells represented below are haploid. Which one is it/which ones are they?



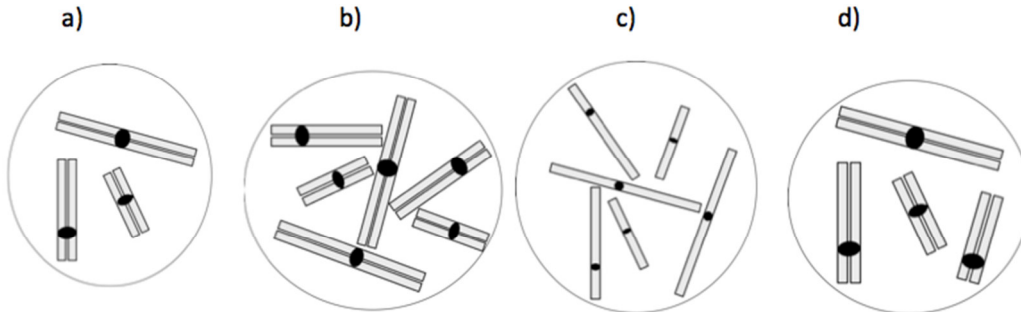
Expert answer: a+c

- Alternatives/misconceptions:
- a) i) Cells with an odd number of chromosomes are always haploid, uncomfortable/unsure with all the others.
NOTE: if students don't pay attention to the instructions ("check all that applies"), this is usually the answer they choose.
 - b) i) [RARE] Haploid cells can't have chromosomes composed of two sister chromatids, and cells should not have odd numbers of chromosomes.
 - a+b) i) Haploid cells can't have chromosomes composed of two sister chromatids.
ii) Confusion between sister chromatids and homologous chromosomes (if there are sister chromatids, then the cell must be diploid).
 - a+b+c) i) A cell is haploid if its chromosomes are not composed of sister chromatids, but also if there aren't chromosome pairs. [As long as there are even numbers of each chromatid, the cell is diploid].

Concept: ploidy
 Bloom level: III
 Difficulty index²: 0.54
 D: 0.77
 D.E.²: 0.83
 Common incorrect answers² a+b (23%)³

Question 5 [select all the answers that apply]

One or more of the cells represented below are diploid. Which one is it/which ones are they?



Expert answer: b+c

- Alternatives/misconceptions:
- b) i) Diploid cells have pairs of homologous chromosomes (\surd), chromosomes always have an “X” structure.
 - c) i) Diploid cells have pairs of homologous chromosomes (\surd), but when chromosomes have sister chromatids “they don’t count” because otherwise “cells would always be diploid” [ploidy can only be determined when there are no sister chromatids].
 - b+d) i) A diploid cell is one where chromosomes are composed of sister chromatids, but it can’t have an odd number [of chromosomes].
 - a+b+d) i) A cell is diploid if its chromosomes are composed of sister chromatids.
 - b+c+d) As long as there are pairs of “matching chromatids”, the cell is diploid [“matching chromatids” can be two sister chromatids or two pre-replication homologous chromosomes; students refer to what I called “matching chromatids” as “matching chromosomes” in both cases].

Concept: ploidy
 Bloom level: III
 Difficulty index: 0.48
 D: 0.81
 D.E.: 0.84
 Common incorrect answers²

a+b+d (20%)³, b+c+d (13%)³, overall 41%³ of the answers included “d”.