Supplemental Material

CBE—Life Sciences Education

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Interview protocol

Introduction

In this interview, we are going to show you some problems from your recent midterm exam. We would like you do the problems again and explain your thought process. We are really interested in how you are solving the problems and thinking about the concepts, and we are not looking to see if you know the correct answers at all. Please feel free to articulate and say out loud your thought process as you go through the problems.

Possible follow-up prompts

- What do you mean by [what you just said]? We are curious what made you say that.
- Could you explain how you got to your answer? Could you draw that out? Could you draw an example?
- Could you explain this drawing you have done here? What does this [shape] mean?
- For allele or locus: You drew this here. Does the position have specific meaning?
- For linkage: How can you tell if two genes are linked or not?
- For key terms: Could you define [word]? Could you explain when [word] happens?
  - For example, linkage, nondisjunction, recombination
- For comparisons: Could you explain how [word] is different from [word]?
  - For example, allele vs gene vs genotype, dominant vs recessive, heterozygous vs homozygous, homologous chromosomes vs sister chromatids, meiosis I vs meiosis II, parental vs recombinant
- Are there other ways that you could solve the problem? Is there anything else that you would like to add about this problem?

Wrap-Up

Is there anything that the course could do differently that you think would help you learn better?

Exam problems, set #1

Question 1: A child with Klineflelter Syndrome is colorblind, yet both of his parents have normal color vision.

a. What are the genotypes of his parents?
b. What can you conclude about the chromosome segregation event that gave rise to the syndrome?

Questions 2: You cross a phenotypically wild type polychaete worm with one that is pure breeding for dumpy, white, and curved. The progeny from this cross are as follows:

Wild type	85
Dumpy	15
White	120
Curved	265
Dumpy, white	275
Dumpy, curved	140
White, curved	25
Dumpy, white, curved	75
Total	1000

a. Define the genes indicating which alleles are dominant and which are recessive.
b. Which genes are linked?
c. For the linked genes determine the map distance between them and draw a map with the map distances.
d. Where applicable calculate a value for interference.
e. For the initial wild type polychaete worn that was crossed to the pure breeding worm that was dumpy, white and curved, draw the homologous chromosomes in prophase I of meiosis and crossover(s) that could give rise to wild type progeny. Assume all chromosomes are telocentric. Show the position of the genes and their alleles relative to the crossovers. Do not consider anything more complicated than double crossovers.
f. What are the genotypes of the other three meiotic products?

Question 3: You are studying plant speciation and notice two pure breeding varieties of native maize growing in adjacent valleys of the Andes. One has yellow leaves, short stalks and short tassels while the other has green leaves, long stalks and long tassels. The genes for leaf color and stalk length map to chromosome 4 and are 30 cM apart while the gene for tassel length maps to chromosome 6. You cross the two varieties and all the progeny have green leaves, long stalks and long tassels. You then backcross the hybrids to the homozygous recessive parent and get the following progeny:

yellow leaves, short stalks, short tassels	220
green leaves, long stalks, long tassels	230
yellow leaves, short stalks, long tassels	225
green leaves long stalks, short tassels	225
yellow leaves, long stalks, short tassels	26
green leaves, short stalks short tassels	24
yellow leaves, long stalks long tassels	27
green leaves, short stalks, long tassels	23
Total	1000

a. Define the genes
b. Calculate map distances for any linked genes
c. Draw the two relevant pairs of chromosomes in the initial hybrid at metaphase I of meiosis. Position the genes and include any map distances. Draw the crossover(s) that would result in progeny with green leaves, short stalks, long tassels. Draw an arrow from each centromere to the appropriate spindle pole that will give rise to the green leaves, short stalks, long tassels gamete.
d. What would be the genotypes of the other three gametes?
e. You look at the cobs on your hybrid maize plant and observe that roughly 1/5 of the kernels failed to develop. Why did that happen?
f.

Exam problems, set #2

Use the following information for the next three questions.

You cross pure breeding black bodied beetles with green eyes to pure breeding brown bodied beetles with orange eyes. The progeny are all black bodied with green eyes.

Question 1: From this you conclude that:

a) Black bodies and green eyes are dominant to brown bodies and orange eyes
b) Black bodies and green eyes are recessive to brown bodies and orange eyes
c) There is not enough information to draw a conclusion.

You then back cross these F1 progeny to the brown bodied parent with orange eyes to generate the following F2: 230 black bodies green eyes, 20 black bodies orange eyes, 30 brown bodies green eyes, 220 brown bodies orange eyes

Question 2: What is the probability of having a crossover between the genes for body color and eye color?

a) 0%
b) 5%
c) 10%
d) 20%
e) 50%

Question 3: A single crossover between these two genes on homologous chromosomes in the F1 dihybrid will produce the following products at the end of meiosis II.

a) One brown bodied green eyed gamete and one black bodied orange eyed gamete
b) Two brown bodied green eyed gametes and two black bodied orange eyed gametes
c) Two brown bodied orange eyed gametes and two black bodied green eyed gametes
d) One brown bodied green eyed gamete, one black bodied orange eyed gamete, one brown bodied orange eyed gamete, and one black bodied green eyed gamete

Question 4: In a cell with a diploid number of six (2n=6), how many chromosomes will be in each of the four gamete cells if one pair of homologous chromosomes experiences nondisjunction during meiosis I?

a) Two cells will have 6 chromosomes, and two cells will have none.
b) Two cells will have 4 chromosomes and two cells will have 2 chromosomes.
c) Two cells will have 5 chromosomes, and two cells will have 1 chromosome.
d) All four cells will have 3 chromosomes.
e) All four cells will have two chromosomes.

Question 5: A phenotypically male patient with Kleinfelter syndrome (has an XXY genotype) is also afflicted with Norrie disease, a rare X-linked recessive disorder that results in cataracts. His mother and father are not afflicted with Norrie disease. Assuming no crossing over, what event resulted in Kleinfelter syndrome for this individual?

a) Nondisjunction in meiosis I in the patient's mother
b) Nondisjunction in meiosis II in the patient's mother
c) Nondisjunction in meiosis I in the patient's father
d) Nondisjunction in meiosis II in the patient's father
e) Not enough information to know

Exam problems, set #3

Question 1: An individual with trisomy 21 has a genotype of BBb for a gene on chromosome 21. His parents are genotypes Bb and bb. Which stage of meiosis could the nondisjunction have occurred? Assume no recombination.

(A) Meiosis I
(B) Meiosis II
(C) Either (A) or (B)
(D) Not possible

Refer to the following information for the next two questions. A friend gives you a wild type quinoa plant that you cross to a plant that is homozygous recessive for three genes (aabbgg). The progeny are as follow:

Phenotype	Number
a B G	278
A b g	286
a B g	115
A b G	111
A B G	83
a b g	87
A B g	24
a b G	16
Total	1000

Genes/alleles/phenotypes:

A wild type leaf color	a white flowers
B red seeds	b white seeds
G large seeds	g small seeds

Question 2: What is the order of the genes?

(A) A-B-G
(B) A-G-B
(C) B-A-G

Question 3: What is the distance between the A and B genes in cM?

(A) (278 + 286) / 1000 x 100
(B) (115 + 111) / 1000 x 100
(C) (83 + 87) / 1000 x 100
(D) (24 + 16) / 1000 x 100
(E) (115 + 111 + 83 + 87) / 1000 x 100
(F) (115 + 111 + 24 + 16) / 1000 x 100
(G) (83 + 87 + 24 + 16) / 1000 x 100

Question 4: You have identified three genes in Drosophila with two alleles each:

Reduced bristles (rd) - wild type bristles (rd+)
Purple eyes (pr) - wild type eyes (pr+)
Ebony body (e) - wild type body (e+)

You cross an animal heterozygous for each gene with a fly that has reduced bristles, purple eyes and ebony body. You get the following 1000 progeny:

Purple eyes, reduced bristles	220
Ebony body	221
Reduced bristles	219
Purple eyes, ebony body	220
Normal	31
Purple eyes, ebony body, reduced bristles	29
Purple eyes	32
Ebony body, reduced bristles	28

What is the gene order?

(A) rd – pr – e
(B) rd – e – pr
(C) e – rd – pr
(D) e and pr linked, rd on another chromosome
(E) e and rd linked, pr on another chromosome
(F) pr and rd linked, e on another chromosome