ANSWERS TO Exam Questions from Final Exam – Human Genetics, Nondisjunction, and Cancer, and Cumulative Questions

1. You are working on two different organisms -- the fruit fly *Drosophila* and the yeast *S. cerevisiae*

(a) how to make this strain in yeast: mate C haploid mutants to E haploid mutants.
how to make this strain in *Drosophila*: mate true-breeding C mutants to true-breeding E mutants
list **all** of the possible genetic tests for which this strain could be used: complementation, dominant/recessive, trans

(b) how to make this strain in yeast: mate C mutant haploids to D mutant haploids, induce sporulation of the diploids, look for NPD tetrads (4 spores, 2 normal, 2 double mutant)
how to make this strain in *Drosophila*: can't be made, flies are diploid
list **all** of the possible genetic tests for which this strain could be used: epistasis

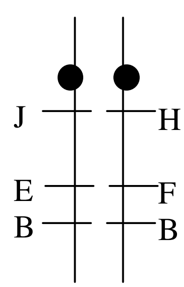
(c) complementation, dominant/recessive, cis, trans

2. On the next page is a pedigree showing a couple that has a child with trisomy of chromosome 21.

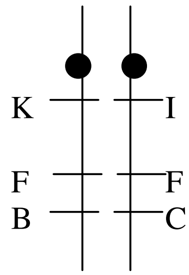
(a)

maternally inherited allele(s) at SSR 53	**C**	**B**
paternally inherited allele(s) at SSR 53	**BB**	**B**
maternally inherited allele(s) at SSR 78	**F**	**F**
paternally inherited allele(s) at SSR 78	**FF**	**E**
maternally inherited allele(s) at SSR 99	**I**	**I**
paternally inherited allele(s) at SSR 99	**HJ**	**H**

(b) Father (individual 1):



Mother (individual 2):



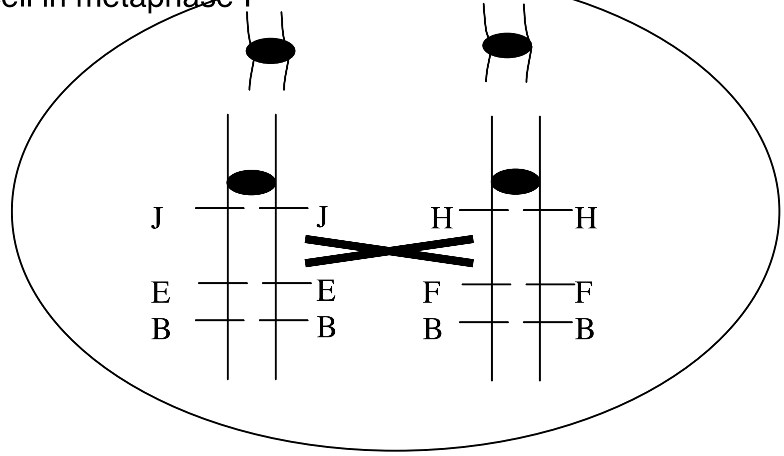
(c) Individual 3

(d) the dad (individual 1)

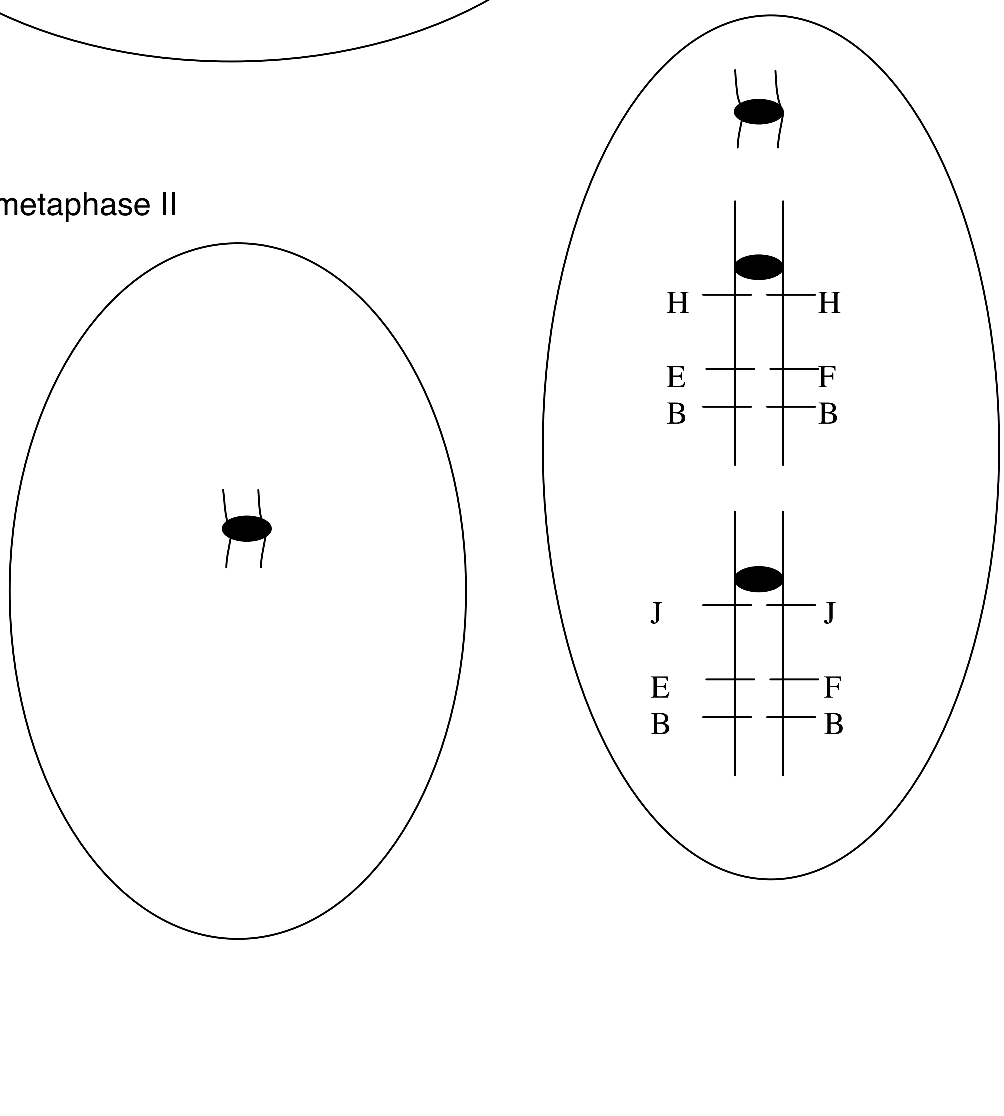
(e) meiosis I

(f)

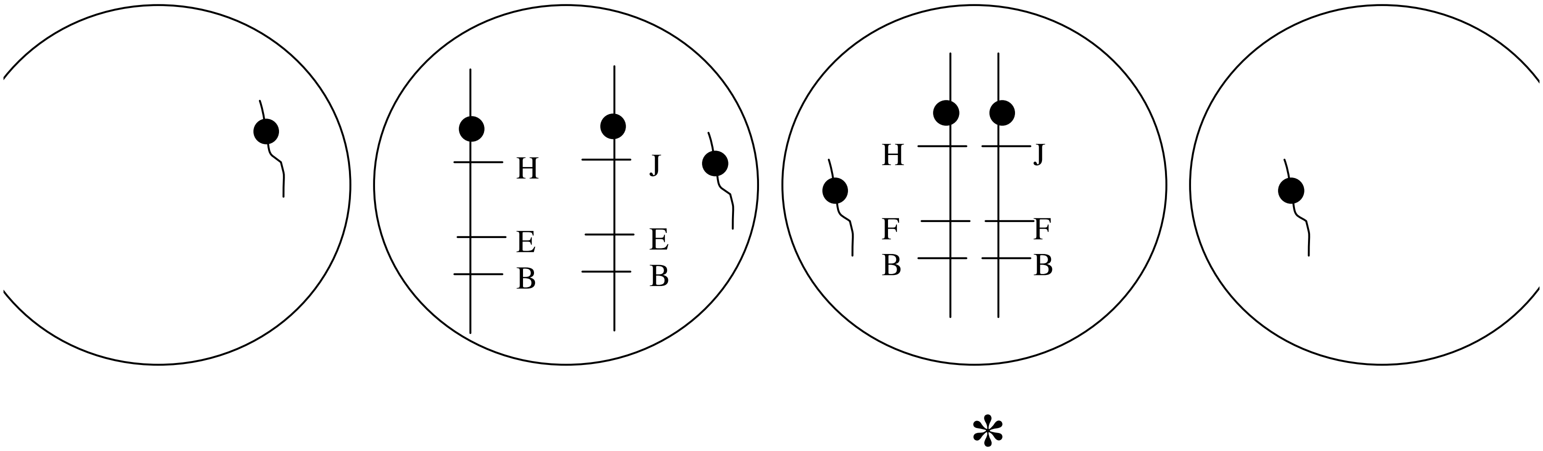
i) the cell in metaphase I



ii) the two cells in metaphase II



iii) the four final products of the meiosis



3. After extensive genetic linkage studies, you map the locus for the ability to taste or not taste the compound PTC to a 2-centiMorgan (cM) region on human chromosome 7.

(a) gene targeting

(b) remove both copies of the Z gene

(c) the Z gene disrupted by a gene that encodes antibiotic resistance. This construct would integrate at the Z locus by homologous recombination.

(d) wild-type ES cell

(e) Mate the chimeric heterozygote that results to wild-type to get a non-chimeric heterozygote. Then mate two non-chimeric heterozygotes together, and 1/4 of their progeny will be the mouse you want.

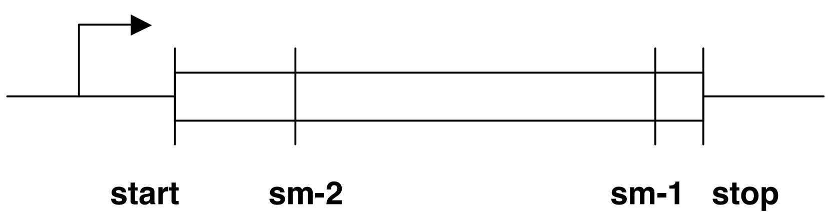
(f) If the mouse will eat PTC-laced food, then gene Z is the locus for PTC tasting. If the mice won't eat the PTC-laced food, then gene Z is not the locus for PTC tasting.

(g) Inject the wild-type human Z DNA as a transgene into the homozygous Z mutant fertilized mouse egg.

4. You have isolated three mutations in phage λ.

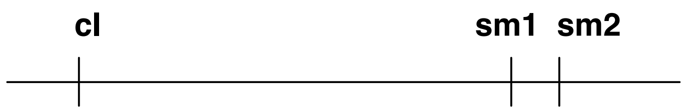
(a) 1.5 m.u.

(b)



(c) 0.6 kb per 1% recombination

(d)



5. A ship carrying 7,000 passengers is about to land on an island that has 33,000 occupants.

(a) q =(21/3500) = 0.006

(b) 2pq = 0.00073

(c) q = 0.00135

(d) (1/2)q = 0.000675

6.

Genotype of strain	Will *cheX* be expressed when chemoattractants are absent?	Will *cheX* be expressed when chemoattractants are present?
wild-type	**No**	**Yes**
cheC1	**Yes**	**Yes**
cheB2 **/ F'** P_X^- ***cheX+***	**Yes**	**Yes**
cheA3 **/ F'** ***cheC1***	**No**	**No**
cheX+ cheB2 cheA3	**No**	**No**
P_X^- ***cheX+*** **/ F'** ***cheC1*** P_X^+ ***cheX+***	**No**	**Yes**

7. You are studying cancer progression in mice.

(a) constitutive

(b) recessive

(c) tumor suppressor

(d) to inhibit cell division whenever nutrients are absent

(e) constitutive

(f) dominant

(g) proto-oncogene

(h) to promote cell division whenever nutrients are present.
(i) yes because of loss of heterozygosity
(j) one wild-type allele
(k) two mutant alleles

8. You are mapping a certain rare disorder that is caused by an allele at the N locus.

maternally inherited allele at SSR112	**C**	**A**	**A**	**A**	**C**	**C**	**A**
paternally inherited allele at SSR112	**B**	**C**	**C**	**B**	**B**	**C**	**B**

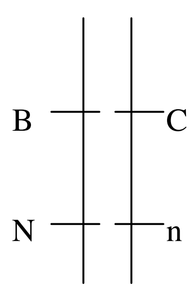
maternally inherited allele at the N locus	**n**	**n**	**n**	**n**	**n**	**n**	**n**
paternally inherited allele at the N locus	**N**	**n**	**N**	**N**	**N**	**n**	**n**

<u>**IF**</u> the condition is autosomal recessive [parts **(a)** and **(b)**] (Individual 2 is “nn”)

maternally inherited allele at the N locus	**n**	**N**	**n**	**n**	**n**	**N**	**N**
paternally inherited allele at the N locus	**n**	**n**	**n**	**n**	**n**	**n**	**n**

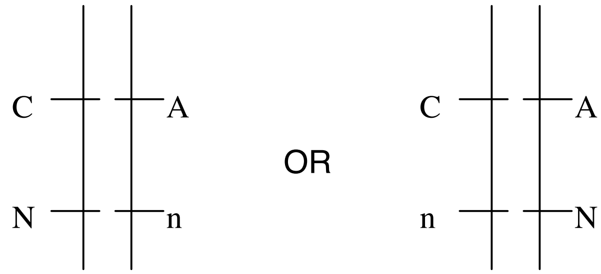
<u>**IF**</u> the condition is autosomal dominant [parts **(c)** - **(e)**] (Individual 2 is “Nn”)

(a) father – individual one
(b)



(c) mother – individual two

(d)

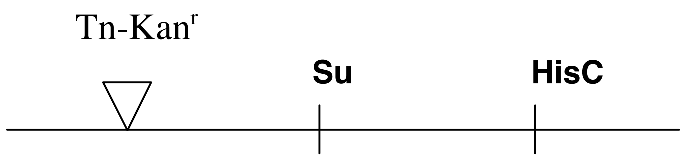


(e) $\frac{(1/2)\,(0.4)^3\,(0.1)^4 + (1/2)\,(0.4)^4\,(0.1)^3}{(0.25)^7} = 0.262$

9. You have isolated an *E. coli* mutant that carries both an amber mutation in the HisC gene (HisC-am) and an amber suppressor mutation in a gene encoding a tRNA gene (Su^+).

(a) 20% is the distance between the Su locus and the transposon insertion

(b)



10. Mendel's concept of the gene was first applied to a human trait in Archibald Garrod's landmark 1902 paper entitled "The Incidence of Alkaptonuria: A Study in Chemical Individuality."

(a) autosomal recessive

(b) q = 0.0014

(c) 2pq = 2* (0.9986)(0.0014) = 0.0028

(d) F = (1/16)

(e) 2.3% of matings are between 1st cousins

11. Consider the following mouse pedigree in which the indicated male exhibits a distinctive rare trait.

(a) (1/3)

(b) (1/4)

(c) (1/4)

(d) 45%

12. The **cI** gene of phage lambda encodes a repressor protein that has a molecular weight of 24 kDa.

(a) an amber nonsense mutation 2/3 of the way into the coding region

(b) a +1 or –1 frameshift mutation that lies shortly before the nonsense mutation

(c) 5'-TGG-3'

(d) 5'-TAG-3'

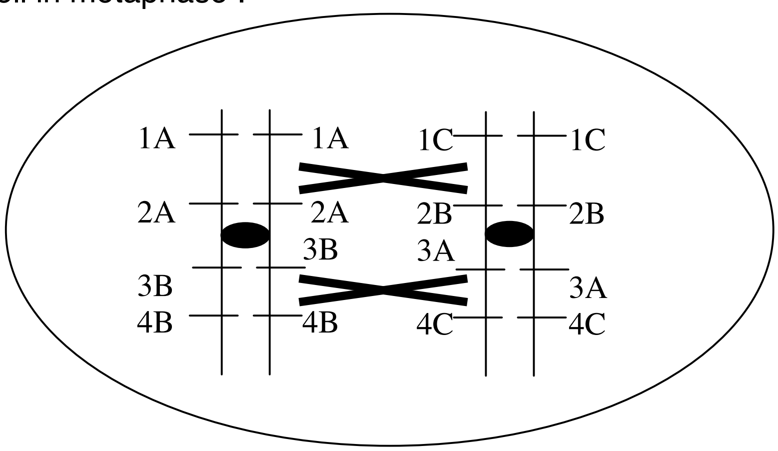
13. Your colleague, who is a medical geneticist, seeks your help in interpreting a patient: an XXY girl.

(a) mother

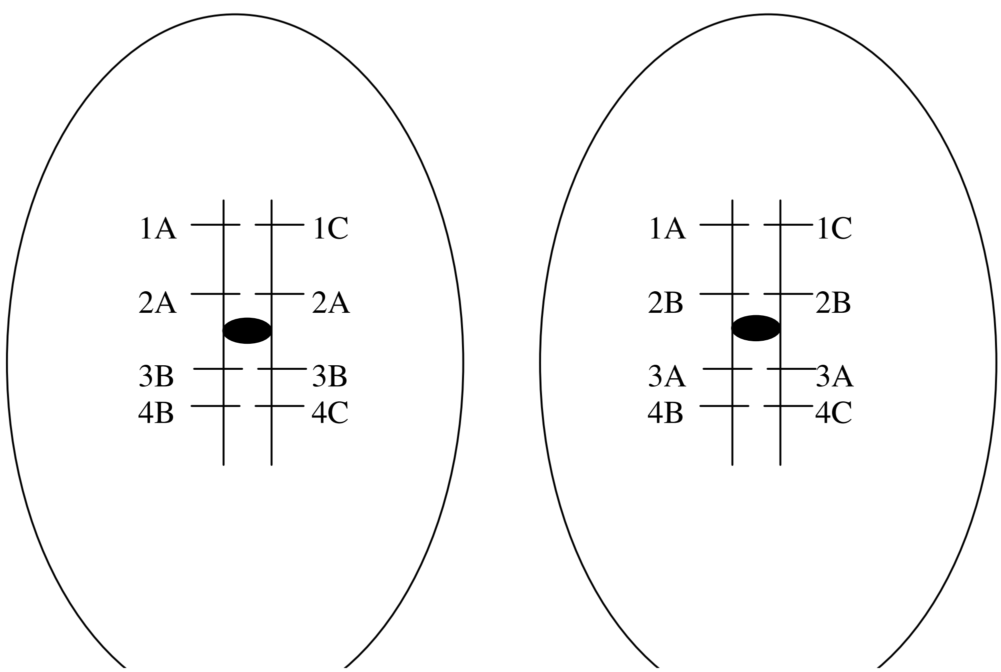
(b) meiosis II

(c)

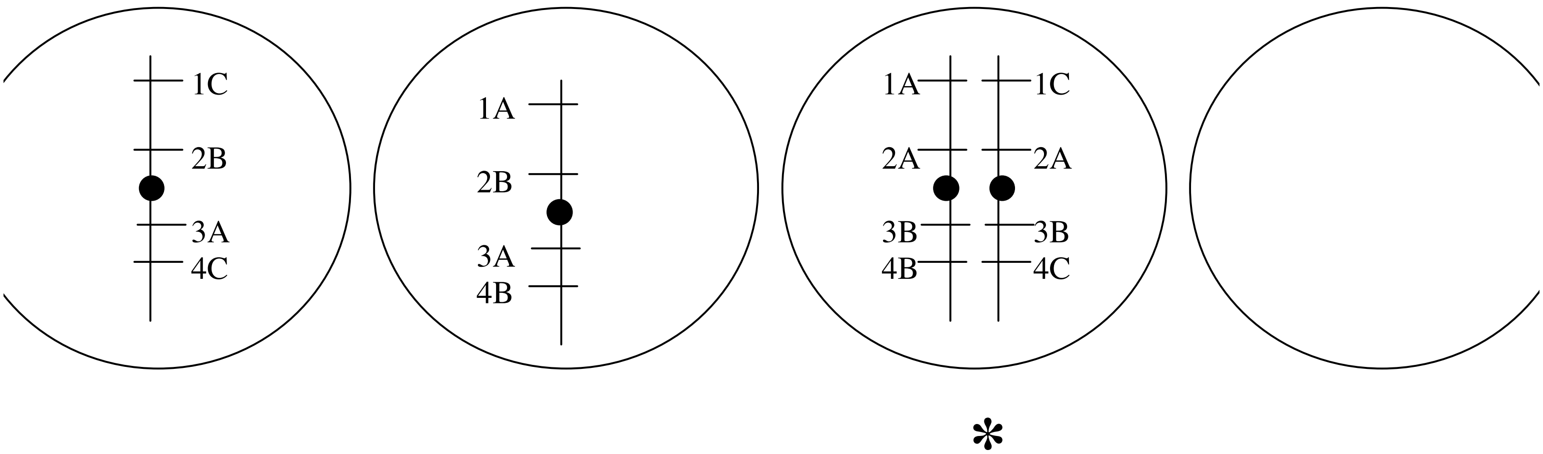
i) the cell in metaphase I



ii) the two cells in metaphase II



iii) the four final products of the meiosis



(d) a translocation during the development of the sperm in the father, so that the Sry gene went to the X chromosome, and SSR1 went to the Y chromosome

14. Your colleague seeks your advice regarding a family in which several individuals (filled circles or squares below) developed colon cancer in their 30's or 40's.

(a) if you see SSR instability in the tumor cells, then it is most likely HNPCC

(b) $\log \dfrac{(0.5)^7}{(0.25)^7} = 2.1$

(c) yes, it becomes:

$$\log \frac{(0.5)^6}{(0.25)^6} = 1.8$$

(d) yes

(e) no, child #2 is a recombinant

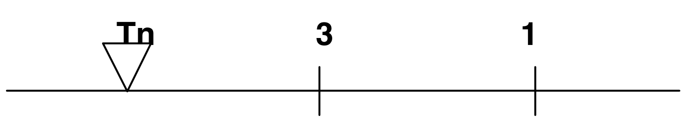
(f) yes

15. Wild-type *E. coli* bacteria are motile (that is, they can swim around).

(a) 70%

(b) unlinked (more than 100kb away)

(c)



16. In order for yeast cells use the amino acid arginine as a nitrogen source, arginine is broken down by the enzyme arginase.
(a) it is in a different gene than Arg1 and thus must act in trans
(b) activator
(c) yes, at 50cM
(d) constitutive
(e) Type Five
(f) arginine → Arg2 --] Arg3 --] Arg1

17. One in 20,000 human males is an (infertile) XX male (due to a translocation that moves the sex-determination gene Sry onto an X chromosome).
(a) DZ = (1/2) (1/20,000)
(b) MZ = 100%
(c) DZ = 50%
(d) MZ = 100%
(e) DZ = (1/885)
(f) MZ = 100%

18. Consider a codominant blood antigen where individuals homozygous for one allele express only antigen M, individuals homozygous for the other antigen express only antigen N, and heterozygous individuals express both N and M antigens. **(a)**

	Frequency expressing		Allele frequencies		
Population	**M only**	**N only**	**M**	**N**	**H-W equilib (yes or no)?**
1	0.25	0.25	0.5	0.5	yes
2	0.36	0.16	0.6	0.4	yes
3	0.01	0.64	0.185	0.815	no

(b) $q^2 + 0.1q - 10^{-5} = 0$
so $q = 10^{-4}$
(c) Fq= 0.004

19. HNPCC (Hereditary Non-Polyposis Colon Cancer) shows autosomal dominant inheritance in humans.

(a) knockout of the mouse MSH2 gene

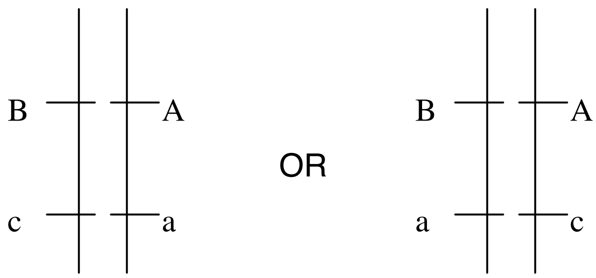
(b) more quickly

20. Your project is to genetically map the locus for color blindness, an X-linked recessive trait, with respect to SSR markers.

(a) AB

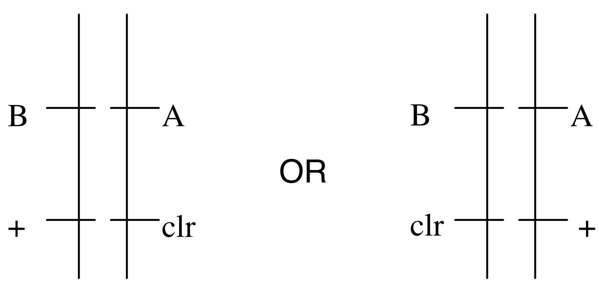
(b) ac

(c)



(d) $$\log \frac{(1/2)\,(0.4)^{1}\,(0.1)^{9} + (1/2)\,(0.4)^{9}\,(0.1)^{1}}{(0.25)^{10}} = 1.14$$

(e)



(f) $$\log \frac{(1/2)\,(0.45)^{1}\,(0.05)^{9} + (1/2)\,(0.45)^{9}\,(0.05)^{1}}{(0.25)^{10}} = 1.30$$

(g) the SSR72 would be in the middle

21. The following three crosses involve mice from either true-breeding mutant strains or true-breeding wild-type strains.

(a) X-linked recessive only

(b) X-linked recessive and autosomal recessive

(c) autosomal recessive only

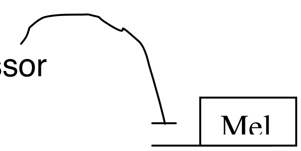
22. *E. coli* can utilize the sugar melibiose after induction of the enzyme melibiase.

(a) yes, at 95%

(b) it gives a dominant phenotype

(c) It works in cis

(d) melibiose --] repressor



Mut1

(e) the mutant repressor can't bind to the operator any more

23. The sequence of the amber stop codon is $^{5'}$UAG$^{3'}$.

(a) the gln-tRNA gene and the trp-tRNA gene

(b) gln: 5'-CAG-3' ← this strand is used as a template during transcription
3'-GTC-5'

trp: 5'-TGG-3' ← this strand is used as a template during transcription
3'-ACC-5'

(c) 5'-TAG-3' ← this strand is used as a template during transcription
3'-ATC-5'

24. You are studying the yeast genes needed to metabolize organic phosphates.

(a) an unlinked suppressor mutation that has no phenotype on its own – for instance, a tRNA suppressor allele

(b) this suppressor mutation is very close to the original mutation, and thus might be an intragenic suppressor mutation (and even may be a back mutation to revert the gene to its original sequence)

(c) an unlinked suppressor mutation whose phenotype on its own is recessive and constitutive; it could be a mutation in a gene encoding a repressor protein that works downstream from Pho4 in the pathway that regulates the expression of phosphatase

25. Shown below is a hypothetical scheme for the formation of eye pigment in *Drosophila*.

(a) purple eyes

(b) because the double mutant flies (bl pr mutants) have blue eyes

(c)

	Number
Purple-eyed males:	42
Blue-eyed males:	50
Red-eyed males:	8

26. When setting out to determine the chromosomal location of a rare human disease gene by genetic linkage analysis (LOD scores), it is useful to calculate the theoretical maximum LOD score that a family of a given size and structure might contribute.

(a) $\log \dfrac{(1/2)\,(0.5)^{10}}{(0.25)^{10}} = 2.7$

(b) $\log \dfrac{(0.5)^{10}}{(0.25)^{10}} = 3.01$

(c) $\log \dfrac{(0.5)^{10}}{(0.25)^{10}} = 3.01$

(d) $\log \dfrac{(1/2)\,(0.5)^{2}}{(0.25)^{2}} = 0.301$

(e) $\log \dfrac{(1/2)\,(0.5)^{1}}{(0.25)^{1}} = 0$

(f) $\log \frac{(0.5)^1}{(0.25)^1} = 0.301$

(g) $\log \frac{(1/2)\ (0.5)^1}{(0.25)^1} = 0$

27. You discover a frame-shift mutation in an X-linked gene called SPG in a man who is infertile because of poor sperm production.

(a) Yes it is possible, because the mutation can be passed on by females indefinitely.

(b) i) pronuclear injection

ii) wt human SPG

iii) fertilized egg

iv) a fertilized egg that is XY and carries a mutant form of SPG on the X chrom

v) randomly

vi) no

vii) none

viii) if the male mouse is fertile, then the human and mouse SPG genes are interchangeable. If the male mouse is sterile, then the human and mouse genes are not interchangeable.

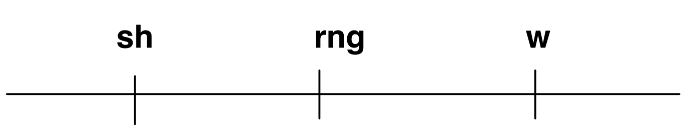
28. You have isolated two different X-linked mutations in *Drosophila* that affect eye color.

(a) orange

(b) same gene

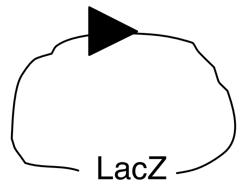
(c) 1 cM

(d)

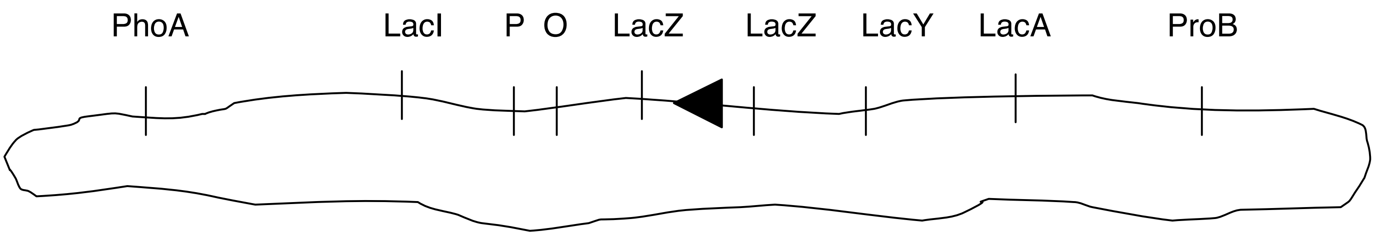


29. You have constructed an **F'** plasmid that carries the **LacZ** gene.

(a) The **F'** plasmid



(b) the Hfr:



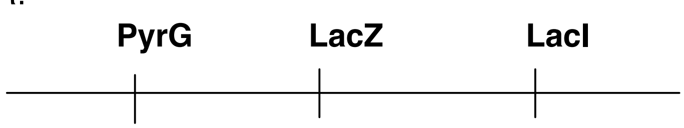
(c) no; it won't express LacY because the gene is disjointed from its promoter

(d) late

30. The **PyrG** gene is found to lie about 40 kb away from the group of **Lac** genes on the *E. coli* chromosome.

Draw a diagram of this region of the chromosome that shows where the **PyrG** gene maps relative to **LacZ** and **LacI**.

ANSWER:



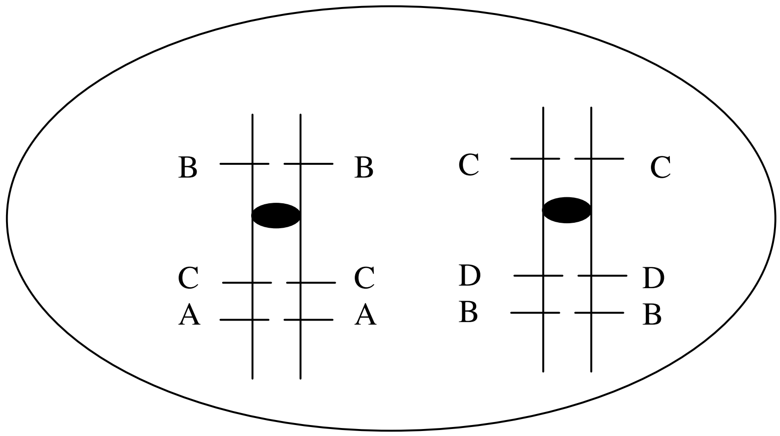
31. Only a small fraction of human fetuses with trisomy 18 survive to birth, and most of those surviving to birth die in infancy.

(a) before

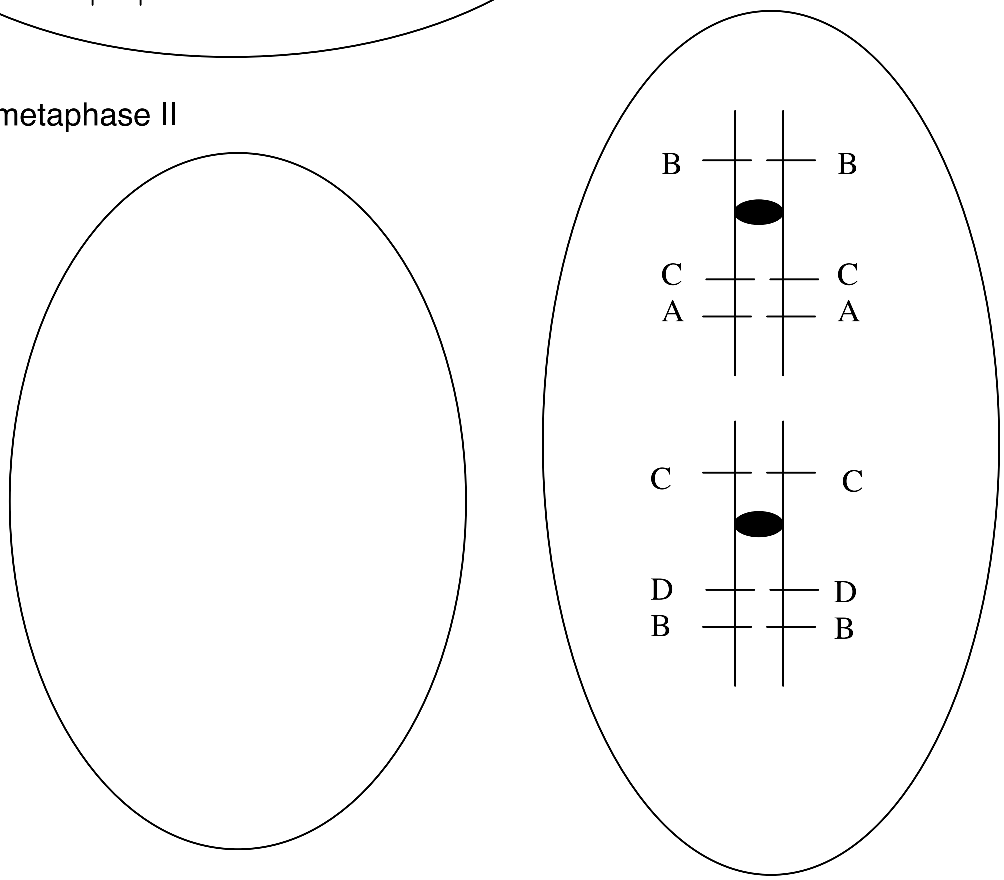
(b) mother

(c) meiosis I

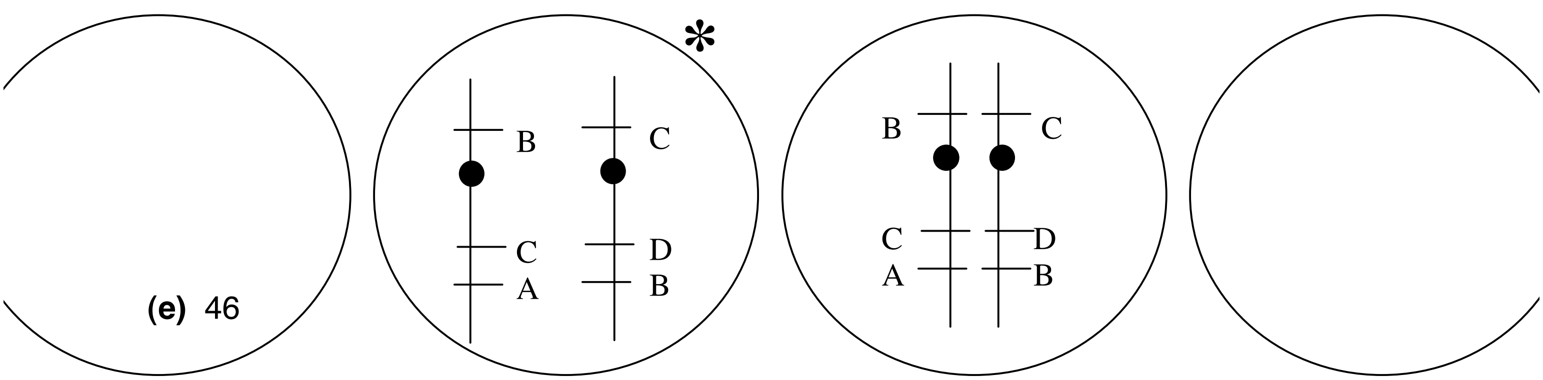
(d) i) the cell in metaphase I



ii) the two cells in metaphase II



iii) the four final products of the meiosis



(e) 46

(f) 23
(g) 44
(h) 24

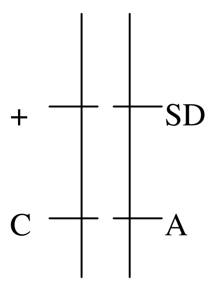
32. In some families, breast cancer displays autosomal dominant inheritance.

(a) $\log \dfrac{(1/2)\,(0.05)^6\,(0.45)^1 + (1/2)\,(0.05)^1\,(0.45)^6}{(0.25)^7} = 0.53$

(b) $\log \dfrac{(0.05)^1\,(0.45)^6}{(0.25)^7} = 0.83$

(c) the cell that develops into a tumor needs to lose the 2nd copy of the gene by loss of heterozygosity
(d) the phenotype caused by a homozygous loss of BRCA is lethality. Perhaps BRCA is necessary for normal fetal development to occur.

33. You are genetically mapping the locus that determines a rare skin disease that shows autosomal dominant inheritance.
(a) the father
(b) A
(c)



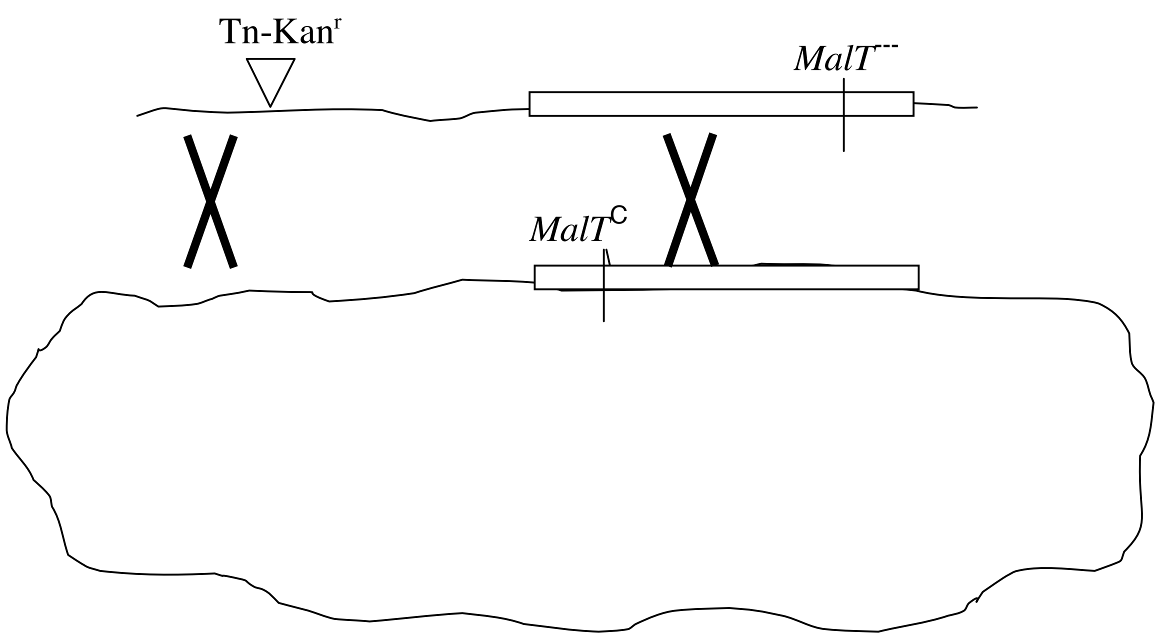
(d) $\log \dfrac{(0.45)^5}{(0.25)^5} = 1.27$
(e) three families

34. Consider an autosomal gene at which a rare allele (call it allele **a**) results in homozygotes (**aa**) having only 20% of the number of offspring as average individuals in the population.

(a) S = 0.8
(b) h = 0.002
(c) f(a) = 0.0025
(d) 2pq = 0.005
(e) new q = 0.00225

35. You have isolated a Tn5 insertion in an otherwise wild-type *E. coli* strain that is linked to the gene encoding the MalT activator protein.

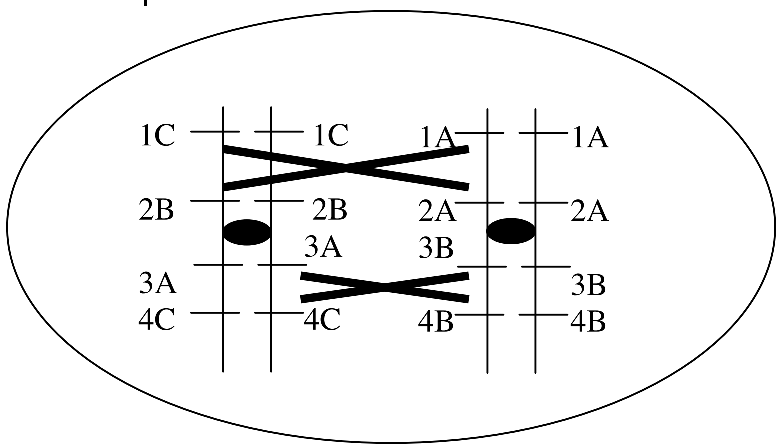
(a) 80%
(b)



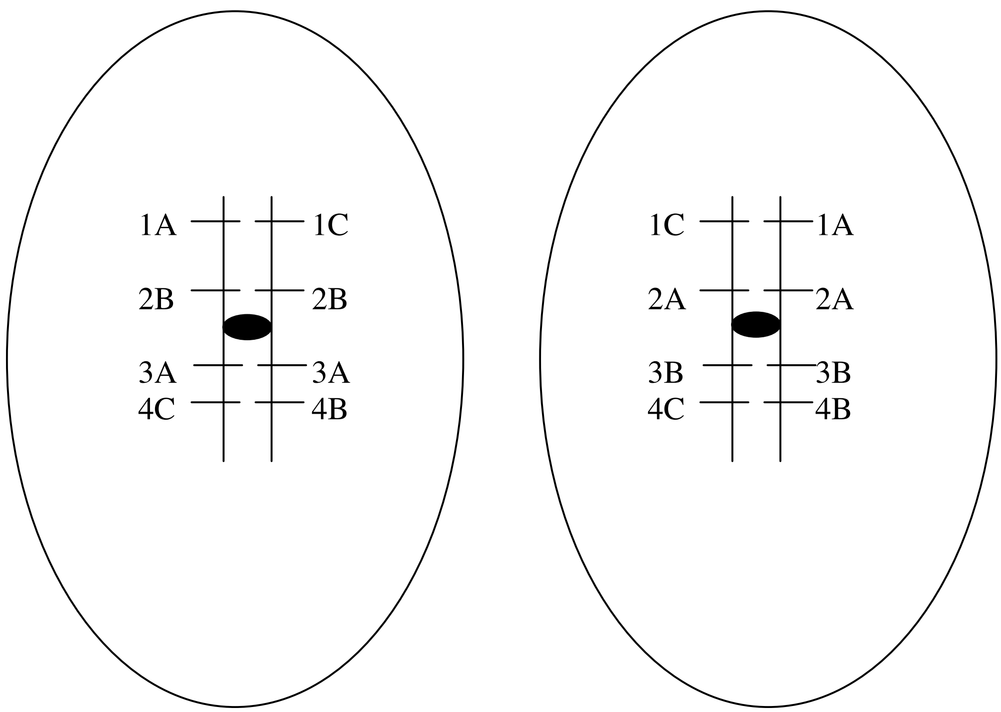
(c) an ochre nonsense mutation
(d) uninducible

36. You are called by your family physician to provide an expert genetic opinion on an unusual patient: an XXX boy.

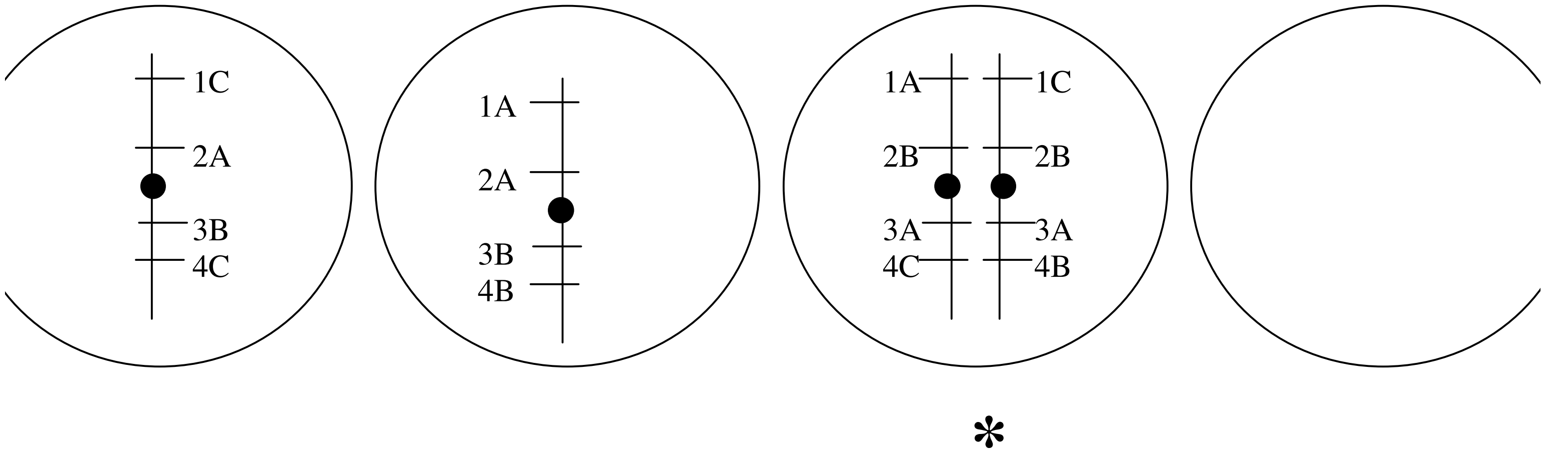
(a) mother
(b) meiosis II
(c)
i) the cell in metaphase I



ii) the two cells in metaphase II



iii) the four final products of the meiosis



(d) the father must have passed on an X chromosome which mistakenly carried the Sry gene that causes maleness
(e) a translocation occurred during the development of that sperm such that SSR1 went to the Y chromosome in exchange for the Sry gene a