Introduction to Genetics
FALL 2025
EXAM III

1. In a mating between an F+ donor and an F$^-$ recipient, the recipient

A) receives a stable copy of the F plasmid
B) may incorporate chromosomal genes from the donor into its genome
C) receives a stable copy of the F plasmid that also contains a segment of chromosomal genes
D) remains lysogenic
E) induces the phage's lytic replication cycle

2. The process occurring above is referred to as

A) transformation B) transjugation C) transduction D) conduction E) conjugation

Questions 3 - 4 refer to the following experiment:

In a generalized transduction experiment, donor *E. coli* cells have the genotype $a^+b^-c^+$, and recipient cells have the genotype $a^-b^+c^-$. Pl-mediated transductants for a^+ were selected, and their total genotypes were determined, with the following results:

Genotype	Number of progeny
$a^+b^-c^+$	390
$a^+b^-c^-$	410
$a^+b^+c^+$	10
$a^+b^+c^-$	190
	1000

3. What is the cotransduction frequency for *a* and *b?*

A) 0.20 B) 0.40 C) 0.60 D) 0.80 E) cannot be determined since they were not selected for

4. What is the cotransduction frequency for *a* and *c?*

A) 0.20 B) 0.40 C) 0.60 D) 0.80 E) cannot be determined since they were not selected for

5. In a generalized P1 transduction experiment using donor a^+ b^+ c^+ d^+ *E. coli* cells and a^- b^- c^- d^- recipients, the following cotransduction frequencies are observed:

Selecting for	Cotransduction percentage
a+ transductants	*b* 30%, *c* 10%, *d* 50%
b+ transductants	*c* 0%, *d* 40%
c+ transductants	*d* 3%

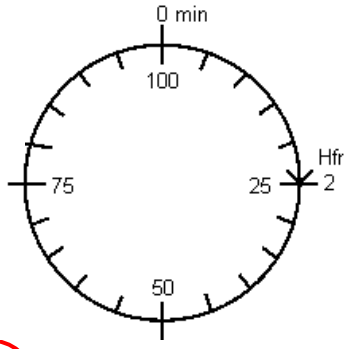
What is the order of the genes on the chromosome?

A) abcd B) bdac C) cdab D) dabc E) bacd

Questions 6 - 9 refer to the following experiment:

An *E. coli* F^- strain has the following genotype: $A^- B^- C^- D^- E^-$. Three different Hfr strains, all carrying $A^+ B^+ C^+ D^+ E^+$ markers are mated with the F- strain in separate matings. The interrupted-mating results are given below. The numbers indicate time (in minutes) when different donor markers appeared in F^- cells after mating began. Assume that the *E. coli* map consists of 100 minutes. Hfr 2 is known to have integrated at the 25min location on the chromosome and transfers in a counterclockwise direction.

Markers	Hfr 1	Hfr 2	Hfr 3
A	10	20	–
B	45	–	20
C	25	5	40
D	–	60	–
E	–	–	5



6. The gene order, starting from *A* and going clockwise is

A) *ACBDE* B) *ADEBC* C) *AEDCB* D) *ABCED* E) *ACBED*

7. What is the location of the origin for Hfr 1and Hfr 3?

A) 95min; 30min B) 95min; 60min C) 15min; 35min D) 5min; 40min E) 85min; 30min

8. What is the direction of transfer for Hfr 1and Hfr 3?

A) Both transfer in a clockwise direction
B) Both transfer in a counterclockwise direction
C) Hfr 1 transfers clockwise, Hfr 3 transfers counterclockwise
D) Hfr 1 transfers counterclockwise, Hfr 3 transfers clockwise
E) Hfr 1 transfers counterclockwise, but Hfr 3 cannot be determined

9. What is the map location of the *E* marker?

A) 55min B) 35min C) 95min D) 5min E) 70min

=====**********=====

Questions 10 - 11 refer to the following population:

A human virus has a mutation rate of $5*10^{-3}$. Gene D, encodes a capsid protein that is recognized by the immune system and important for clearing viral infections. Assume that 90% of the population of viral genomes have a wild type copy of D at the time of infection.

10. Assuming there is no selection, what fraction of the viral population would have the wild type copy of the D gene after it replicates once (ie one generation)?

A) 0.0045 B) 0.0050 C) 0. 8955 D) 0.8995 E) 0.9995

11. Assuming there is no selection, what fraction of the viral population would have the wild type copy of the D gene after 1,000 rounds of replication (ie 1,000 generations)?

A) 0.0045 B) 0.0060 C) 0.0067 D) 0.0452 E) 0.4520

Questions 12 - 15 refer to the following experiment:

You identify a population of rabbits from a dark forest whose coat color is controlled by a single gene: *BB* rabbits are black, *Bb* rabbits are gray, and *bb* rabbit are white. You take a census of the population and record the following numbers of rabbits:

Black	490
Gray	420
White	90

12. What are the allele frequencies of B and b?

A) f(*B*)=0.490, f(*b*)=0.090
B) f(*B*)=0.700, f(*b*)=0.300
C) f(*B*)=0.465, f(*b*)=0.255
D) f(*B*)=0.910, f(*b*)=0.510
E) f(*B*)=0.900, f(*b*)=0.100

13. A rare snow hits the region making it advantageous to have white fur. Before the spring mating season arrives, 245 black rabbits and 105 gray rabbits have been eaten by wolves. All the other rabbits survive. What is the average fitness of the rabbit population in the spring?

A) 0. 245 B) 0.403 C) 0.620 D) 0.650 E) 0.750

14. What will be the frequency of the *B* allele among rabbits born in the spring?

A) 0. 245 B) 0.403 C) 0.620 D) 0.650 E) 0.750

15. If it doesn't snow anymore and all rabbits are again equally fit, what will the new Hardy-Weinberg frequencies be for the offspring of the spring generation of rabbits?

A) Black 245, Gray 315, White 90
B) Black 377, Gray 485, White 138
C) Black 384, Gray 471, White 145
D) Black 245, Gray 315, White 440
E) Black 490, Gray 420, White 90

Questions 16 - 17 refer to the following experiment:

In beetles, red eye color is determined by a single dominant allele (R). A large population is created by mixing 50% (RR) red-eyed beetles with 50% (rr) white-eyed beetles. If all the conditions of Hardy-Weinberg equilibrium are met,

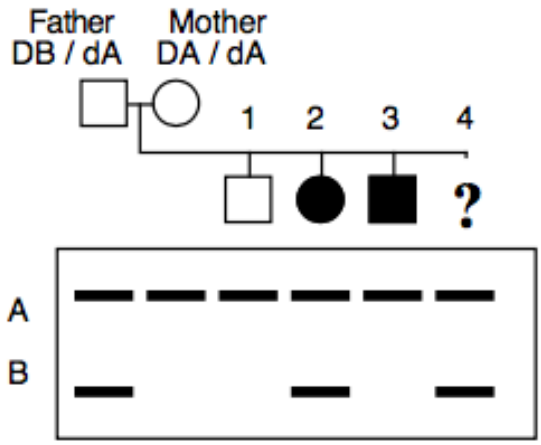
16. What fraction of beetles will have red eyes in the next generation?

A) 25% B) 50% C) 62.5% D) 75% E) 100

17. What fraction of beetles will have red eyes when the population reaches Hardy-Weinberg equilibrium?

A) 25% B) 50% C) 62.5% D) 75% E) 100

Questions **18-22** refer to the following cross.
A common recessive gene is associated with heart defects in dogs (d). The d locus is 90% linked to the SSR marker used in the analysis below. Two carriers of known genotypes had a litter of puppies and the puppies were tested for the linked marker as shown.



18. With respect to the SSR marker, puppy #1 inherited

A) Allele A from the father and Allele A from the mother
B) Allele B from the father and Allele A from the mother
C) Both Allele A's came from the mother
D) An "A" Allele from the father but it is ambiguous in the mother
E) An "A" Allele from the mother but it is ambiguous in the father

19. With respect to the SSR marker, puppy #2 inherited

A) Allele A from the mother and Allele A from the father
B) Allele B from the mother and Allele A from the father
C) Allele A from the mother and Allele B from the father
D) An "A" Allele from the father but it is ambiguous in the mother
E) Allele B from the father and Allele A could have been donated by either the mother or the father

20. If puppy #4 has not yet been tested for the heart defect, what is the probability that the mother passed on the disease allele to puppy #4?

A) 10% B) 25% C) 50% D) 81% E) 90%

21. If puppy #4 has not yet been tested for the heart defect, what is the probability that the father passed on the disease allele to puppy #4?

A) 10% B) 25% C) 50% D) 81% E) 90%

22. Which puppy(s) *must* be a recombinant with respect to the marker and disease locus?

A) #1 B) #2 C) #3 D) #4 E) #3 & #4

Questions **23-25** refer to the following cross
Neorospora contain ordered tetrads. A cross is made between strains of genotype **Ab** and **aB** and the following ascii are observed.

Ascii	Genotypes of ascii	# of tetrads
Type 1	*ab ab aB aB Ab Ab AB AB*	160
Type 2	*aB aB AB AB Ab Ab ab ab*	60
Type 3	*aB aB aB aB Ab Ab Ab Ab*	180
	Total	400

23. Gene A is how far from its centromere
A) 7.5 map units
B) 15 map units
C) 20 map units
D) 22.5 map units
E) 27.5 map units

24. Gene B is how far from its centromere
A) 7.5 map units
B) 15 map units
C) 20 map units
D) 22.5 map units
E) 27.5 map units

25. Genes A and B are
A) 15 map units apart
B) 20 map units apart
C) 22.5 map units apart
D) 27.5 map units apart
E) unlinked

26. The order of the three genes is
A) A-centromere-B
B) centromere-A-B
C) centromere-B-A
D) A and B are on different chromosomes
E) unable to be determined since all three markers are unlinked

Questions 27 - 28 refer to the following population:
A population of frogs in a large pond is in Hardy-Weinberg equilibrium for an autosomal locus that determines the presence or absence of a forked tongue. The frequency of forked tongues (*ff*) in the population is 5 in 1,000.

27. What is the frequency of the *f* allele in the population?

A) $2.5*10^{-5}$ B) 0.00498 C) 0.00500 D) 0.07070 E) 0.00995

28. What is the frequency of carriers of the forked tongue allele in the population?

A) 0.0050 B) 0.0010 C) 0.0657 D) 0.07070 E) 0.1314

Questions **29-32** refer to the following cross
A female drosophila inherits a chromosome 12 that contains a paracentric inversion from their mother and a normal chromosome from their father. The inversion spans approximately one fourth of the total length of the chromosome.

29 A cross-over event occurring outside of the inversion on these chromatids during meiosis would result in

A) a Robertsonian translocation.
B) a dicentric and an acentric chromatid.
C) two monocentric chromatids with deletions and duplications.
D) two chromatids containing inversions
E) two viable chromatids- one normal and one containing the inversion

30. A cross-over event occurring within the inversion region on these chromatids during meiosis would result in

A) a Robertsonian translocation.
B) a dicentric and an acentric chromatid.
C) two monocentric chromatids with deletions and duplications.
D) two chromatids containing inversions
E) two viable chromatids- one normal and one containing the inversion

31. If each chromatid averages one crossover event per meiosis, what fraction of the total gametes produced would be expected to be viable?

A) None of them B) 12.5% C) 75% D) 87.5% E) All of them

32. In male drosophila, crossovers (ie recombination between homologous chromosomes) do not occur during meiosis. What fraction of the total gametes produced by the male having these chromosomes would be expected to be viable?

A) None of them B) 12.5% C) 75% D) 87.5% E) All of them

33. A diploid strain of watermelon 2n=44 is crossed with a tetraploid strain of watermelon. The progeny are viable, grow well, and produce tasty fruit. Which of the following is true?

A) Half the progeny are diploid, half are tetraploid.
B) All the progeny are triploid, and must be crossed with other triploid plants to reproduce
C) All the progeny are triploid, but sterile.
D) Half the progeny are diploid but their fertility would be reduced by ~50%.
E) Half the progeny are triploid but their fertility would be reduced by ~50%.

Potentially Useful formulas

the probability that, in n trials, A is realized s times and B is realized t times is equal to (n!)/(s!t!) x ($p^s q^t$)

% Recombinants = (# recombinants) / (# total progeny) x 100%
map distance = (# recombinants) / (# total progeny) x 100
map distance = 1/2 x (# tetratype tetrads) / (# total tetrads) x 100
map distance = 1/2 x (# ascii with 2nd division segregation) / (# total ascii) x 100
Coeff. of coinc. = Observed double recomb. / Expected double recomb.
Interference = 1 – Coefficient of coincidence
$Chi^2 = \sum$ (observed – expected)^2 / expected

if p = frequency of a dominant allele *A and* q = frequency of a recessive allele *a*, then p + q =1 and if the population is at Hardy-Weinberg equilibrium, $p^2 : 2pq : q^2$

For a gene with a mutation rate μ over n generations $p_{(n)} = (1-\mu)^n p_{(0)}$
Average fitness of a population under selection, $\overline{W} = W_{(AA)}p^2 + W_{(Aa)}2pq + W_{(aa)}q^2$
For an (i)sland population, where m fraction of the population has migrated in from the (m)ainland, $p_{(i)}' = (1-m)p_{(i)} + mp_{(m)}$
Chance a new mutation becomes fixed 1/2n or lost (2n-1)/2n from a pop. of size n

Where F= the proportionate reduction in heterozygousity due to inbreeding
f(AA) = $p^2(1-F) + pF$
f(Aa) = $2pq(1-F)$
f(aa) = $q^2(1-F) + qF$

Mean = $\bar{x} = \sum x_i / N$
Variance = $s^2 = \sum (x_i - \bar{x})^2 / N-1$
Standard deviation = $s = \sqrt{s^2}$
Covariance = $Cov(x,y) = \sum f_i (x_i - \bar{x})(y_i - \bar{y}) / N-1$

For a normal distribution,
~68% of the population falls within 1 standard deviation (*s*) of the mean
~95% of the population falls within 2 standard deviation (*s*) of the mean
~99.7% of the population falls within 3 standard deviation (*s*) of the mean

$s_p^2 = s_g^2 + s_e^2$
where p= phenotype g= genotype e= environment

For additive alleles where n= # of additive loci,
$1/4^n$= fraction in the population with the most extreme phenotype
2n+1= the number of different phenotypes

Formulas cont…

$n = D^2/8s_g^2$
where n= number of genes, D= phenotypic difference between parental strains

$s_p^2 = s_g^2 + s_e^2$
$H^2 = s_g^2 / s_p^2$
where H^2=broad-sense heritability p=phenotype g= genotype e= environment

$s_p^2 = s_a^2 + s_d^2 + s_e^2$
$h^2 = s_a^2 / s_p^2 = (M_N - M_O)/(M_E - M_O)$
where h^2=narrow-sense heritability, d=dominant alleles, a= additive alleles, e= environment,
M_O= original mean, M_N= new mean, M_E= mean of the bred population