Exam II

Biology 110: Biological Exploration
Fall 2022

This exam is worth 120 points,
and is comprised of 20 questions on 7 pages.

This is a CLOSED BOOK exam --
NO resources (electronic, paper or human) may be consulted;
calculators ARE permitted.

Answers must be written legibly
and be confined to the space provided;
answers that exceed this space will not be read or graded.

GOOD LUCK!

name: _____

lecture section: 10 am _____ 11 am _____

You have **90 minutes** to complete the exam.

date taken: _____

exam start time: _____

exam end time: _____

Multiple Choice (3 points each). Using capital letters, indicate the SINGLE BEST answer to each question.

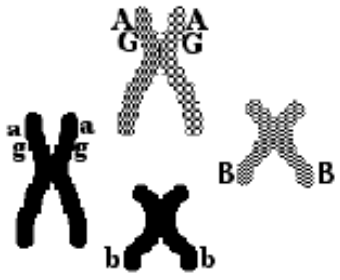
_____ 1. A woman with type O blood has a child with a man with type AB blood. What are the possible blood types for the child?
A. O
B. AB or O
C. A, B, or O
D. A or B
E. AB, A, B, or O

_____ 2. A male patient has red-green color blindness, which is a rare X-linked recessive trait in humans. His family has a history of red-green color blindness, although both of his parents have normal color vision. Which of the male's grandparents is most likely to be red-green colorblind?
A. maternal grandfather
B. maternal grandmother
C. paternal grandfather
D. paternal grandmother
E. either grandfather is equally likely

_____ 3. In a certain species of bird, a single pair of alleles at one gene controls feather color; feathers can be green, blue, or yellow. The genetic explanation for this is most likely an example of:
A. codominance
B. incomplete dominance
C. variable expressivity
D. incomplete penetrance
E. epistasis

_____ 4. Which of the following has occurred at the end of meiosis I?
A. Homologous chromosome pairs are separated into separate daughter cells.
B. The chromosome number in each daughter cell is the same as the mother cell.
C. Sister chromatids are separated into separate daughter cells.
D. Four daughter cells are formed.
E. One copy of each gene is present in each cell.

_____ 5. Meiosis of a cell containing the chromosomes illustrated to the right would **most likely** produce a gamete with the genetic makeup:
A. AaGgBb
B. AgB
C. AGBb
D. AG
E. AGb



_____ 6. Which of the following statements is **not** true about genes that are linked?
A. Linked genes are located on the same chromosome.
B. Linked genes always segregate together during meiosis.
C. Recombination frequencies represent the distance between linked genes.
D. Linked genes fail to display a 1:1:1:1 ratio among the offspring produced from a testcross.
E. Linked genes may be separated by crossing over.

_____ 7. In *Drosophila*, the genes *spineless* and *ebony* are located 12 map units away from each other. These recessive mutations cause spineless & black body phenotypes, respectively. A cross between a wild-type fly and a fly homozygous for both mutations produces heterozygous F_1 hybrids. If a heterozygous female is crossed to a doubly homozygous mutant male, what fraction of the offspring will be spineless with a wild-type body color?
A. 0%
B. 6%
C. 12%
D. 25%
E. 50%

_____ 8. ABO blood type is influenced by two independently assorting genes: the *I* gene, which has three alleles (I^A, I^B and *i*), and the *H* gene, which has two alleles (*H* and *h*). Individuals with the genotype *hh* always have type O blood, regardless of their genotype at the ABO gene. If a man and woman who both have the genotype $I^Ai; Hh$ have children, what fraction of their children will have type O blood?
A. 1/16
B. 1/4
C. 7/16
D. 3/4
E. 9/16

_____ 9. In humans, brachydactyly (shortened fingers and/or toes) is an autosomal dominant condition. In a population of 10,000 individuals that is at Hardy-Weinberg equilibrium, 6400 people have brachydactyly. What is the frequency of the wild-type allele?
A. 0.2
B. 0.4
C. 0.48
D. 0.6
E. 0.8

_____ 10. Which of the following is **not** one of the assumptions of the Hardy-Weinberg law?
A. The population is very large.
B. Non-random mating occurs within the population.
C. Mutations do not occur.
D. No alleles migrate into or out of the population.
E. The ability of individuals with all genotypes to survive and reproduce is the same.

_____ 11. Many human recessive genetic diseases are maintained despite continuing selection against them because:

A. heterozygotes have a higher fitness than either homozygote.
B. the recessive mutant alleles commonly mutate to dominant wildtype.
C. the recessive allele is not transmitted to the offspring.
D. the frequency of the dominant wild-type allele remains the same over generations.
E. genetic diseases are beneficial to human populations.

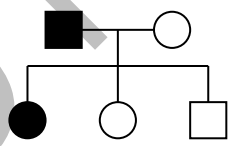
_____ 12. If protein had been the genetic material, what would Avery, MacLeod & McCarty have observed in their experiments?

I. Bacterial extracts treated with proteinase would transform nonvirulent bacteria into the virulent strain.
II. Bacterial extracts treated with proteinase would *not* transform nonvirulent bacteria into the virulent strain.
III. Bacterial extracts treated with DNase would transform nonvirulent bacteria into the virulent strain.
IV. Bacterial extracts treated with DNase would *not* transform nonvirulent bacteria into the virulent strain.

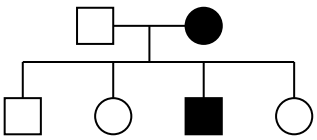
A. Statement I
B. Statement II
C. Statements I and III
D. Statements II and III
E. Statements II and IV

Short answer. Respond to each question in the space provided; answers outside of this space will not be read or graded.

13. (10 points) For each of the following pedigrees, is it possible for the disorder to be caused by an X-linked recessive trait? Explain your answer in 1-2 sentences for each pedigree.

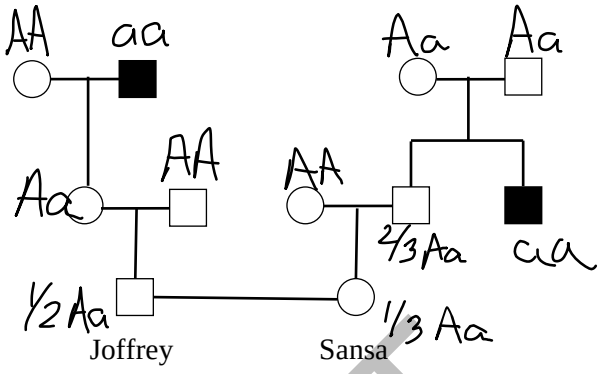


Yes; if I-2 is heterozygous, this could be X-linked recessive. Half of her children would be expected to receive her mutant X.



No. If if was X-linked recessive, individual I-2 could only pass mutant X chromosomes to her offspring. Her daughters would be unaffected because they received a wild-type X from their father, but all of her sons would have to be affected.

14. (12 points) Joffrey and Sansa want to start a family, but they are concerned because both of them have relatives with congenital insensitivity to pain (CIPA), a rare autosomal recessive disorder, as shown in the pedigree to the right. No other family members are known to be affected. Please use the symbol A to represent the wild-type allele and the symbol a to represent the mutant allele.



A. Label each individual in the pedigree with their most likely genotype.

B. What is the probability that Joffrey is heterozygous for the mutant allele?

1/2

C. What is the probability that Sansa is heterozygous for the mutant allele?

1/3

D. What is the probability that Joffrey and Sansa will have an affected child?

1/2 x 1/3 x 1/4 = 1/24

E. Using 1-2 sentences, explain your rationale for Joffrey's father's most likely genotype.

Joffrey's father is almost certainly AA because CIPA is a rare disorder which means that there are very few mutant alleles in the population and therefore very few people are expected to be heterozygous for the mutation.

15. (6 points) The presence of spots on bird eggshells is determined by dominant allele E, while unspotted eggshells are determined by recessive allele *e*. Heterozygotes show incomplete penetrance for the dominant spotted phenotype. If the parental cross is *EE* × *ee*, and the heterozygotes show 90% penetrance, what distribution of phenotypes would be expected in a population of 1000 F_2 eggs?

A lot of students missed this question because they answered for the F_1 generation, not the F_2 generation (partial credit was given in this situation). The F_2 would be expected to have the following distribution: 250 EE (spotted), 500 Ee (with 90% penetrance, 450 spotted, 50 unspotted), 250 ee (unspotted). Therefore, there would be 700 spotted and 300 unspotted.

16. (12 points) In humans, a Widow's peak hairline is an autosomal dominant trait, while red-green colorblindness is an X-linked recessive trait. A colorblind man with a Widow's peak (whose mother did not have a Widow's peak) marries a woman with a Widow's peak and normal vision (whose father was colorblind but did not have a Widow's peak).
    A. What are the genotypes of the man and the woman?

    man: Ww; X^cY

    woman: Ww; X^+X^c

    B. What is the probability that among all their possible children there will be a colorblind child with a Widow's peak?

    (3/4 WW or Ww) x (1/2 X^cY or X^c X^c) = 3/8

    C. What is the probability that among all their possible children there will be a son with normal vision and no Widow's peak?

    (1/4 of children will be boys with normal vision) x (1/4 ww) = 1/16

17. (14 points) A homozygous wild-type fruit fly is mated to a fly with two autosomal recessive traits: purple eyes and short legs. The wild type F_1 females are crossed to a purple-eyed, short-legged male to produce the following offspring: 777 wild type; 753 purple eyed, short legs; 242 purple eyed, normal legs; 228 wild type eyes, short legs.
    A. What is the recombination frequency between the genes for eye color and leg size?

    RF = (242+228)/(777+753+242+228) = 470/2000 = 0.235 = 23.5%

    B. In another experiment, a purple-eyed female is crossed to a short-legged male. the wild-type F_1 females are crossed to a purple-eyed, short-legged male. Using the recombination frequency you calculated above, what fraction of the offspring is expected to have purple eyes and normal legs?

    This was a hard one. Notice that the original cross was different: purple-eyed female x short leg male. This means that purple eyes with normal legs is a non-recombinant type. Since the recombination frequency between these genes is 23.5%, non-recombinants must be 76.5%. One non-recombinant class would be found at a frequency of 38.25%.

    C. Recombination frequencies between different pairs of linked genes are used to generate genetic maps. Use the following recombination frequencies to draw a genetic map illustrating the order of genes A, B, C and D and the distances between them: A - B = 8% recombination; A - C = 20%; A - D = 14%; B - C = 12%; C - D = 34%.

    D----------A----------B----------C
    14 mu 8 mu 12 mu

18. (6 points) The autosomal recessive disorder achromatopsia is characterized by a complete absence of color vision. The frequency of achromatopsia world-wide is 1/30,000, but residents of the small Micronesian island of Pingelap are affected at a frequency of 1/20 (total population size, ~250). Using 2-3 sentences, discuss one microevolutionary force that could explain the high frequency of achromatopsia among the Pingelapese as compared to the rest of the human population.

    A variety of answers were acceptable, including:
    founder effect: this mutation was found at a higher frequency among the people who colonized this island than in the population they originated from.

    bottleneck effect: a storm devastated the human population on this island, randomly killing most of the inhabitants; this mutation was found at an extremely high frequency among those who survived (this is what actually happened!).

19. (12 points) In moths collected from a natural population, a researcher found 51 dark specimens and 49 light specimens. The light phenotype is caused by a recessive mutation.
    A. Assuming Hardy-Weinberg equilibrium, what is the frequency of the recessive allele?

    light = homozygous recessive = 49/100

    $0.49 = q^2$; q = 0.7

    B. How many of the moths in this population are expected to be homozygous for the dominant allele?

    if q = 0.7, then p = 0.3

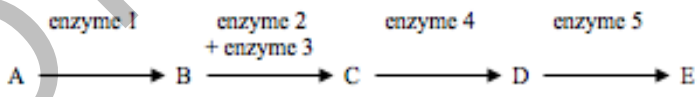
    $p^2 = 0.09$; therefore, 9 moths are expected to be homozygous

    C. What percentage of the dark moths are heterozygous for the mutation?

    2pq = 2 x 0.3 x 0.7 = 0.42; this is the frequency of heterozygotes in the population

    the frequency of heterozygotes among the dark moths is 0.42/0.51 = 0.824 = 82.4%

20. (12 points) The figure to the right illustrates a bacterial metabolic pathway that converts intermediates A, B, C and D to the final product, E.



    A. If there is a mutation in the gene that encodes enzyme 3, list each of the chemical intermediates that could be supplied to the growth medium that would allow chemical E to be synthesized.

    C or D

    B. If chemical C accumulates in cells with a mutation in this pathway, which enzyme(s) is (are) most likely defective?

    enzyme 4

    C. Using 2-3 sentences, explain how you could distinguish between cells that have a mutation in the gene that codes for enzyme 4 from cells that have a mutation in the gene that codes for enzyme 5.

    If there is a mutation in the gene for enzyme 4, then intermediate C would accumulate. If there is a mutation in the genes for enzyme 5, then intermediate D would accumulate.

    Other answers were also possible.