# UNIVERSITY OF GUELPH

DEPARTMENT OF MOLECULAR AND CELLULAR BIOLOGY

MBG*2040 Foundations in Molecular Biology and Genetics

Fall 2016

## Midterm Examination: Version 1

Saturday, October 22, 2016

Instructor: Dr. Jim Uniacke

**Surname (print clearly):**

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**YOU ARE WRITING VERSION 1 OF THE MIDTERM. THE EXAM IS WHITE AND THE TEST-SCORE SHEET IS GREY.**

### Midterm Instructions

This midterm consists of 35 questions and you have 90 minutes to complete it.
Mark your answers on the test-score sheet in PENCIL ONLY.
**Please note that only the test-score sheet is graded.**
Additional time will not be given to fill out the test-score sheet.

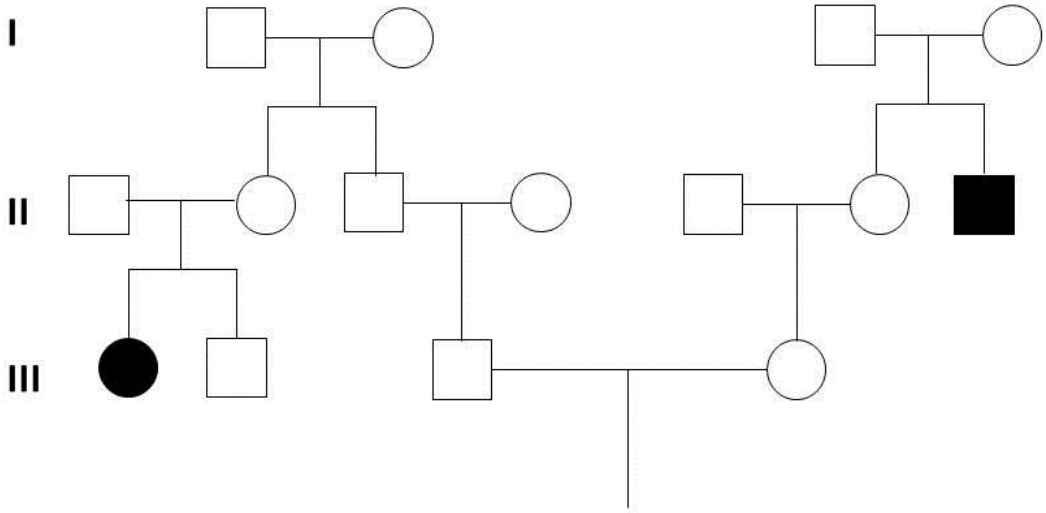
### TEST-SCORE SHEET INSTRUCTIONS

PENCIL ONLY

Include your: **Surname, ID number**

**NOTE**: You will be required to hand in the test-score sheet AND the entire exam booklet

You are a genetic counselor interviewing a phenotypically normal couple III-3 and III-4, each with a deadly autosomal recessive disease in their families. Shaded individuals died at a very young age. Assume that this trait is very rare.




1. What is the probability that III-3 and III-4 will have a child with this deadly disease?

a) 1/48
b) 1/32
c) 1/64
d) 1/16
e) none of the above

2. A variety of limes called “Samoa” is a sterile autotriploid with 3N=45. What could be observed in cells undergoing meiosis I?

a) 4 trivalents, 10 bivalents, and 13 univalents
b) 45 bivalents
c) 1 trivalents, 15 bivalents, and 12 univalents
d) 10 trivalents, 5 bivalents and 5 univalents
e) more than one of the above

3. Under some conditions individuals with a wildtype/normal genotype can express a mutant phenotype; and conversely, individuals with a mutant genotype can be phenotypically normal/wildtype. These are examples, respectively, of the phenomena known as:

a) variable expressivity and incomplete penetrance
b) incomplete penetrance and variable expressivity
c) phenocopy and incomplete penetrance
d) variable expressivity and phenocopy
e) none of the above

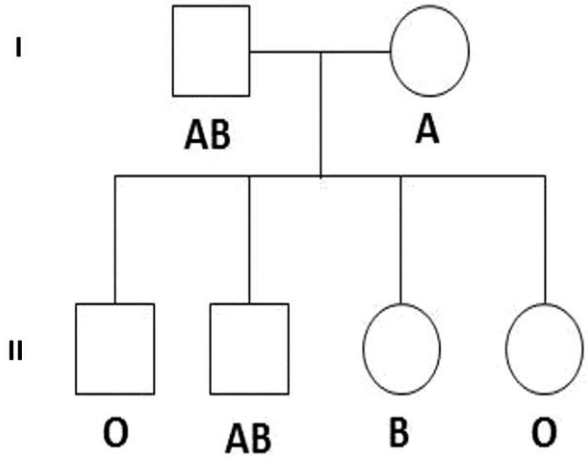
4. In a species of mouse, the *Y* allele produces yellow fur and is dominant to the *y* allele that produces white fur when homozygous. When you cross two yellow mice, you always observe roughly twice as many yellow progeny than white. Your knowledge of Mendelian genetics suggests that you should be observing three times as many yellow mice. What could be a possible explanation?

a) Recessive epistasis
b) A dominant negative allele
c) Two genes are affecting fur color in this species
d) Variable expressivity
e) Recessive lethal allele

5. A single gene can be responsible for a number of distinct clinical symptoms. This is an example of:

a) phenocopy effect
b) penetrance
c) pleiotropy
d) incomplete expressivity
e) genetic anticipation

A small number of type O individuals have the Bombay blood phenotype. Individuals with the Bombay blood phenotype always appear to have type O blood because they are homozygous recessive for the gene, H, which is epistatic to gene I. As long as at least one dominant H allele is present, the ABO blood type associated with the person's ABO genotype will be expressed. Individuals who are homozygous hh always have type O blood. The pedigree below includes two individuals with the Bombay blood phenotype.




Use the above information to answer the next two questions.

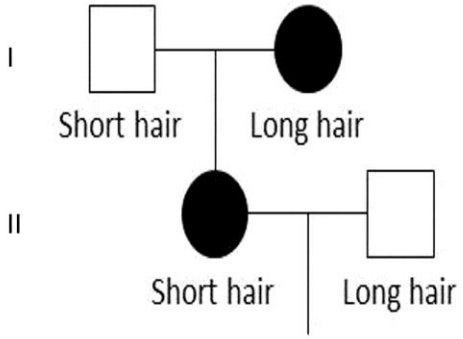
6. The genotype of I-2 is:

a) $I^AI^A$ Hh
b) $I^A$i hh
c) $I^A$i HH
d) $I^A$i Hh
e) more than one of the above is possible

7. What is a possible genotype for II-1?

a) $I^AI^A$ Hh
b) $I^BI^B$ Hh
c) ii hh
d) $I^B$i Hh
e) $I^AI^A$ hh

In cavies (guinea pigs) solid-colored coats (W) are dominant to white-spotted coats (w) and short hair (L) is dominant to long hair (l). Imagine genes W and L are 18 map units apart on chromosome 5. Examine the pedigree below. Note that solid-colored cavies are indicated by solid symbols and white-spotted cavies are indicated by open symbols. The next two questions refer to this information.




8. What proportion of the gametes produced by II-1 will be L w gametes?

a) 18%
b) 41%
c) 9%
d) 82%
e) none of the above

9. The first offspring of II-1 and II-2 has a white-spotted coat. What is the probability this offspring will also have long hair?

a) 18%
b) 41%
c) 9%
d) 82%
e) none of the above

10. If genes A and B are tightly linked on chromosome 12, a dihybrid, Ab//aB, will produce the following gametes:

a) AB, aB, Ab and ab in a 1:1:1:1 ratio
b) ab and AB in a 1:1 ratio
c) Ab and aB in a 1:1 ratio
d) Ab//ab and aB//ab in a 1:1 ratio
e) AaBb, aaBb, Aabb and aabb in equal frequencies

A breeder of morning glory plants has plants which produce three different flower color phenotypes - red, pink, and white. The breeder makes a number of crosses and produces the following table:

| Parents | F1 Phenotypes |
|---|---|
| pink X pink | 1/4 red, 1/2 pink and 1/4 white |
| pink X white | 1/2 pink and 1/2 white |
| pink X red | 1/2 red and 1/2 pink |
| red X white | all pink |

The next question refers to the above information.

11. What statement best explains the results shown in the above table?

a) Three alleles of one gene control the above flower color phenotypes in morning glory plants.
b) The pink allele is incompletely dominant to the white allele.
c) Pink flowered plants must be monohybrids.
d) Two genes control the above flower color phenotypes in morning glory plants.
e) The red allele is incompletely dominant to the pink allele.

12. Bacterial transformation:

a) is a process whereby bacteria swap genetic information, akin to eukaryotic mating.
b) occurs when bacterial genes are carried by a phage.
c) is a process by which the bacteria take up nutrients from the environment.
d) is a process by which bacteria take up DNA from their environment.
e) occurs when a phage carries the F plasmid.

13. Which of the following matings would most likely produce an F- cell with a new genetic makeup after conjugation?

a) F+ donor and F- recipient
b) Hfr donor and F- recipient
c) F- donor and F+ recipient
d) Hfr donor and F+ recipient
e) F+ donor and Hfr recipient

The fescue grass, F. sativa (2N=20) was pollinated by F. punctoria (2N=12) and this cross produced many hybrid plants. Most of the hybrids were infertile except for a few plants which were very robust with long leaves, long stems and large seeds. Breeders decided that the fertile hybrids were polyploids and gave them the name F. titanica.

The next three questions refer to this information.

14. How many bivalents would be observed in F. titanica cells during Prophase I?

a) 16
b) 8
c) 18
d) 32
e) none of the above

15. In the laboratory, F. titanica plants were back-crossed to F. sativa to produce an infertile hybrid. How many chromosomes would be found in the somatic cells of the infertile hybrid?

a) 26
b) 32
c) 24
d) 48
e) none of the above

16. Germ cells from the infertile hybrid produced in question 15 do attempt meiosis. What would you expect to see at Prophase I?

a) There are no homologous chromosomes so pairing would not be seen
b) 20 bivalents and 8 univalents
c) 10 bivalents and 6 univalents
d) 8 bivalents and 8 univalents
e) 10 bivalents and 12 univalents

17. Genetic elements that can replicate independently or integrate with the main chromosome in bacteria are known as:

a) fragments
b) plasmids
c) episomes
d) chromatids
e) none of these

18. Which of the following is true about double stranded DNA?

a) 50% of the bases are purines
b) 50% of the composition of DNA is C.
c) It is 25% A, 25% T, 25% G, and 25% C.
d) [A+T] = [G+C].
e) It will always be 25% T.

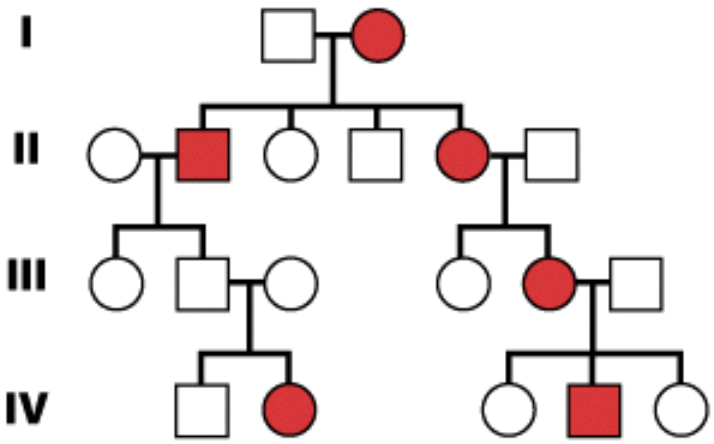
19. Each nucleosome core:

a) also uses protamines for 30 nm fiber formation.
b) has 146 nucleotide pairs of DNA wrapped around the octamer of histones.
c) consists of the 30 nm fiber.
d) holds one negative supercoil.
e) must use histones H2, H3a, H3b, and H4 for stabilization.

20. In the fruit fly, recessive mutations in either of two independently assorting genes, *brown* and *purple,* prevent the synthesis of red pigment in the eyes. Thus, homozygotes for either of these mutations have brownish-purple eyes. However, heterozygotes for both of these mutations have dark red, that is, wild-type eyes. If such double heterozygotes are intercrossed, what kinds of progeny will be produced, and in what proportions?

a) 9/16 dark red, 7/16 brownish-purple
b) 3/4 dark red, 1/4 brownish-purple
c) 9/16 dark red, 3/16 brownish-purple, 4/16 white
d) 1/4 dark red, 2/4 dark red-brownish purple blend, 1/4 brownish-purple
e) 12/16 dark red, 4/16 brownish-purple

The following pedigree shows the inheritance of ataxia, a rare dominant neurological disorder characterized by uncoordinated movements.




21. Individual III-2 is an example of:

a) Variable expressivity
b) Complementation
c) Pleiotropy
d) Haplosufficiency
e) Incomplete penetrance

22. A phenotypically normal female (with no family history of X-linked colourblindess) and a colourblind male have a child with Klinefelter Syndrome who is $XX^{cb}Y$. Which of the following statements describes the meiotic event that gave rise to this child?

a) A meiosis I nondisjunction occurred in the female parent.
b) A meiosis II nondisjunction occurred in the female parent.
c) A meiosis I nondisjunction occurred in the male parent.
d) A meiosis II nondisjunction occurred in the male parent.
e) None of the above

23. Genes *a* and *b* are 20 cM apart. An $a^+ b^+//a^+ b^+$ individual was mated with an *a b*//*a b* individual. If the F1 was crossed to *a b*//*a b* individuals, what offspring would be expected, and in what proportions?

a) 30% $a^+ b^+//a\ b$, 30% *a b*//*a b*, 20% $a^+ b//a\ b$, 20% $a\ b^+//a\ b$
b) 40% $a^+ b^+//a^+ b^+$, 40% *a b*//*a b*, 10% $a^+ b//a\ b$, 10% $a\ b^+//a\ b$
c) 40% $a^+ b//a\ b$, 40% $a\ b^+//a\ b$, 10% $a^+ b^+//a\ b$, 10% *a b*//*a b*
d) 40% $a^+ b^+//a\ b$, 40% *a b*//*a b*, 10% $a^+ b//a\ b$, 10% $a\ b^+//a\ b$
e) 30% $a^+ b^+//a^+ b^+$, 30% *a b*//*a b*, 20% $a^+ b//a\ b$, 20% $a\ b^+//a\ b$

24. You are told that two genes are 73.2 map units apart on chromosome 6 of a pea plant. When crossing a dihybrid with a homozygous recessive plant, what proportion of recombinant progeny would you expect?

a) 36.6%
b) 0%
c) 73.2%
d) 18.3%
e) None of the above

25. Of the following aneuploid karyotypes, which could ONLY arise from a nondisjunction event during meiosis II?

a) Klinefelter Syndrome
b) Down Syndrome
c) XYY
d) Turner Syndrome
e) XXX

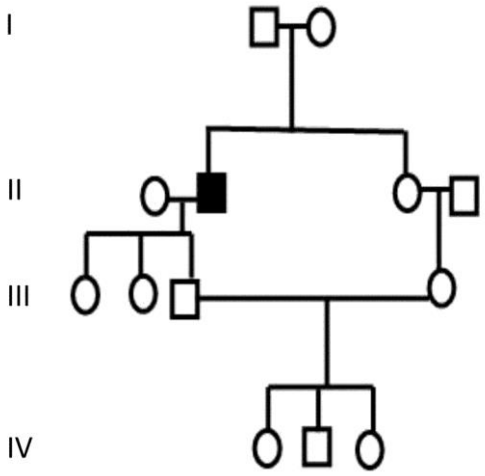
26. An allotetraploid derived from 2 closely related species is 4N=24. What would be observed in cells undergoing meiosis I?

a) 12 bivalents
b) 6 tetravalents
c) 20 bivalents and 1 tetravalent
d) 8 trivalents
e) more than one of the above

27. A woman is a reciprocal translocation carrier. The chromosomes involved in the translocation are 3 and 7. The following would be observed during prophase I of meiosis:

a) 1 tetravalent and 21 bivalents
b) 23 bivalents
c) 22 bivalents and 1 tetravalent
d) 2 tetravalents and 20 bivalents
e) none of the above

28. The pedigree below illustrates a rare trait controlled by a single gene, gene A. What is the genotype of individual III-4?




a) 2/3 AA ; 1/3 Aa
b) 1/3 AA ; 2/3 Aa
c) 1/2 AA ; 1/2 Aa
d) 1/3 AA ; 1/3 Aa
e) none of the above

Consider two genes in the rabbit. One gene controls pigmentation. Allele *C* produces rabbits with full pigmentation. The recessive allele $c^h$ produces the Himalayan phenotype (pigmentation restricted to the extremities). The second gene controls the color of the fat. Allele *Y* produces rabbits with white fat and the recessive allele, *y*, produces yellow fat. A dihybrid rabbit is crossed to a Himalayan with yellow fat. The following progeny are produced:

| Phenotype | Number |
|---|---|
| Himalayan with white fat | 220 |
| Full color with white fat | 32 |
| Himalayan with yellow fat | 36 |
| Full color with yellow fat | 212 |

Use the above information to answer the following 2 questions.

29. What is the map distance between genes C and Y?

a) 13.6 map units
b) 6.8 map units
c) 27.2 map units
d) more than 50 map units
e) none of the above

30. What is the genotype of the dihybrid?

a) y $c^h$ // Y C
b) y C // Y $c^h$
c) Y y // C $c^h$
d) Y $c^h$ // y $c^h$
e) none of the above

31. In mice, the allele *C* for colored fur is dominant over the allele *c* for white fur, and the allele *V* for normal behavior is dominant over the allele *v* for waltzing behavior, a form of discoordination. Give the genotypes of the parents in the following cross: Colored, normal mice mated with white, normal mice produced 29 colored, normal and 10 colored, waltzing progeny.

a) CC VV and cc Vv
b) Cc Vv and Cc Vv
c) CC Vv and ccVV
d) CC VV and cc vv
e) CC Vv and cc Vv

You cross a white cat with a brown cat and all of the progeny are white colored. Now you cross two of these white cats and in the F2 progeny you see 1013 white colored cats, 450 brown colored cats and now, in addition, you see 338 black colored cats. The parental genotypes are AA BB (white) and aa bb (brown). Use the above information to answer the next two questions.

32. What term best describes the genetic interaction based on the phenotypes in the F2 generation?

a) Complete dominance
b) Recessive epistasis
c) Recessive lethal allele
d) Complementation
e) Dominant epistasis

33. Of the following options, which is NOT a possible genotype of the brown colored cat?

a) aa BB
b) AA Bb
c) aa Bb
e) AA bb
d) More than one of the above

34. What are the possible offspring from a mother with type A blood and a father with type AB blood?

a) A, B, AB, and O
b) A, B, and AB
c) A and AB
d) A only
e) AB only

35. The ability to taste PTC is due to a single dominate allele "T". You sampled 215 individuals in your biology class and determined that 150 could detect the bitter taste of PTC and 65 could not. What is the allele frequency of “T”?

a) 0.45
b) 0.30
c) 0.20
d) 0.55
e) 0.50

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