UNIVERSITY OF GUELPH

DEPARTMENT OF MOLECULAR AND CELLULAR BIOLOGY

MBG*2040 Foundations in Molecular Biology and Genetics

Fall 2015

Midterm Examination: Version 1

Saturday, October 31, 2015

Instructor: Dr. Jim Uniacke

Surname (print clearly):

First Name:

ID #:

YOU ARE WRITING VERSION 1 OF THE MIDTERM. THE COVER SHEET IS BLUE AND THE TEST-SCORE SHEET IS GREY.

Midterm Instructions

This midterm consists of 40 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.

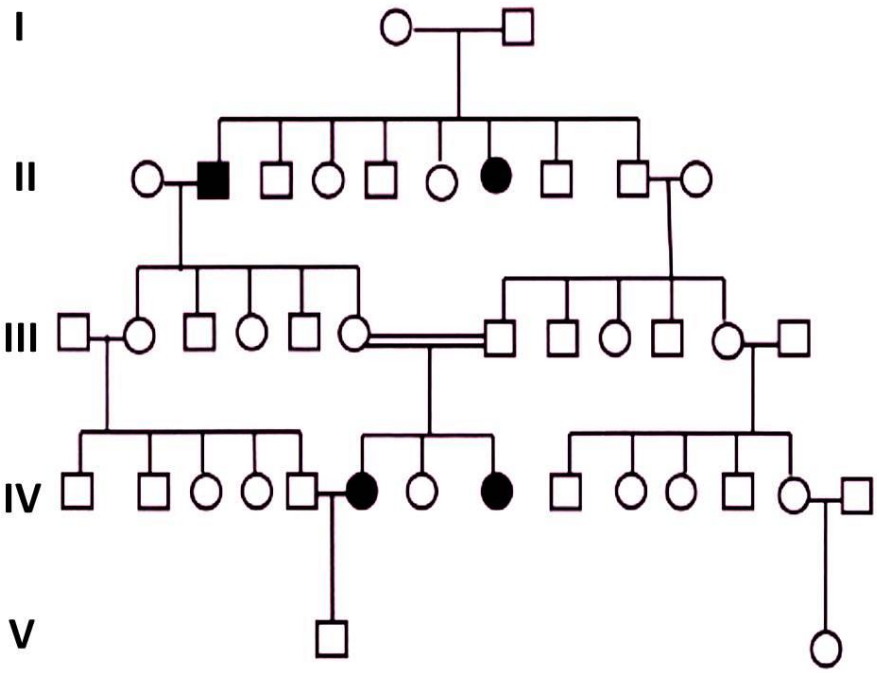
TEST-SCORE SHEET INSTRUCTIONS

PENCIL ONLY

Include your: **Surname, ID number, user ID (email address)**

You are writing version 1.

JEB3 is a rare single gene disorder. The gene responsible for this disorder, LAMA3, maps to chromosome 18 and encodes laminin-3. Laminin-3 is one of many proteins that anchor cells to the basal lamina. Individuals with JEB3 show blistering and shearing of the skin after minor mechanical trauma. The pedigree below represents a hypothetical family affected with JEB3. Shaded individuals are affected. The next two (2) questions refer to this information.



1. Individual V-1 marries V-2. What is the probability that their first child will be affected with JEB3?

a) 1/16
b) 1/24
c) 1/32
d) 1/48
e) none of the above

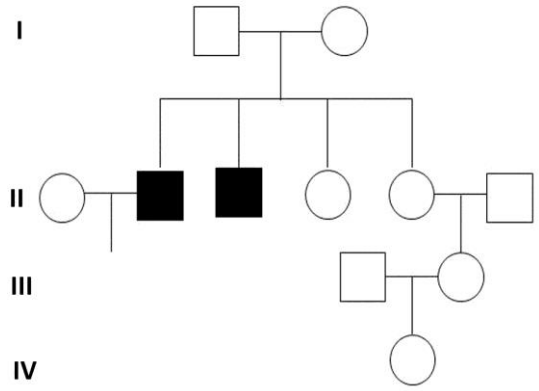
2. A student is asked to determine the proportion of lll-3's gametes that will contain a Y and a chromosome 18 with the normal LAMA3 allele. The student claims the answer is 50%. Is the student correct?

a) The student is correct b) The student is incorrect

3. A calico cat is crossed to an orange cat many times. What are the expected phenotypes of the female offspring?

a) 25% will be black, 25% will be orange and 50% will be calico
b) 50% will be calico and 50% will be black
c) All will be calico
d) 50% will be orange and 50% will be black
e) 50% will be calico and 50% will be orange

Canine Muscular Dystrophy (CMD) is an X-linked recessive disorder that affects many breeds of dogs. Individuals with CMD show progressive muscular weakness and older dogs often have difficulty swallowing and walking. The pedigree below shows the offspring of two Labrador retrievers. Offspring affected with CMD are represented by shaded symbols. These dogs come from a population where the **frequency of males affected with CMD is 1 in 25**. The next three questions refer to this information.



4. What is the probability that the first offspring of II-1 and II-2 will be affected with CMD?

a) less than 1%
b) between 1% and 5%
c) between 5% and 10%
d) between 10% and 20%
e) greater than 20%

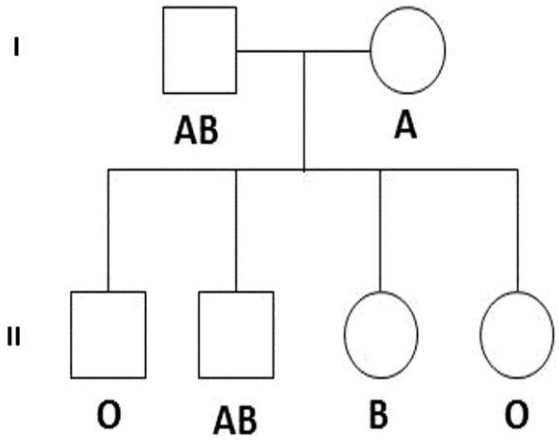
5. What is the probability that IV-1 is homozygous for the normal allele?

a) 7/8
b) 1/4
c) 1/8
d) 3/4
e) none of the above

6. When researchers thoroughly examined female II-4 they noticed she had some muscular weakness confined to her right shoulder. They wondered if this was due to an injury or to CMD. Tissue analyses of II-4 indicated that the protein encoded by the CMD gene was not present in the muscle cells of her right shoulder. Muscle cells from her left shoulder and hip regions had normal amounts of functional CMD protein. What can you conclude from this information?

a) All the muscle cells in the right shoulder of II-4 must be homozygous for the normal allele.
b) The disease-causing CMD allele is located on the transcriptionally active X chromosome in the muscle cells of ll-4's right shoulder.
c) The Barr Body found in the cells of ll-4's right shoulder is the X chromosome with the disease-causing CMD allele.
d) A mutation must have occurred in the germ-line cells of II-4. This resulted in the presence of two disease-causing CMD alleles in her right shoulder muscle cells.
e) The muscle cells in the left and right shoulder of II-4 must be homozygous for the disease-causing CMD allele.

A small number of type 0 individuals have the Bombay blood phenotype. Individuals with the Bombay blood phenotype always appear to have type 0 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 have type 0 blood. The pedigree below includes two individuals with the Bombay blood phenotype.



Use the above information to answer the next two questions.

7. The genotype of I-2 is

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

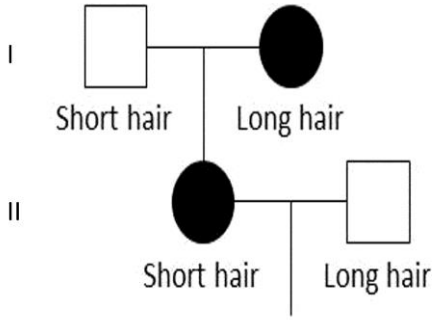
8. What is a possible genotype for II-1?

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

9. In a Southern region of Yemen, the carrier frequency of PKU (an autosomal recessive disease) is 1 in 10. Two phenotypically normal individuals from this region marry. What is the approximate probability that their first child will be phenotypically normal?

a) 1/400
b) 3/400
c) 399/400
d) 300/400
e) none of the above

In cavies (guinea pigs) solid-coloured 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 22 map units apart on chromosome 5. Examine the pedigree below. Note that solid-coloured cavies are indicated by solid symbols and white-spotted cavies are indicated by open symbols. The next two questions refer to this information.



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

a) 22%
b) 39%
c) 11%
d) 78%
e) none of the above

11. 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) 22%
b) 39%
c) 11%
d) 78%
e) none of the above

A breeder of morning glory plants has plants which produce three different flower colour 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.

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

a) Three alleles of one gene control the above flower colour 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 colour phenotypes in morning glory plants.
e) The red allele is incompletely dominant to the pink allele.

13. How many Barr bodies are present in somatic cells of an XXYY individual?

a) 0
b) 1
c) 2
d) one or two depending on the cell
e) none of the above

Rats of the "Dumbo" breed have large, flat ears. There are two varieties of "Dumbo" rats ---one with "tulip" ears and one with "saucer" ears. The saucer-ear phenotype is due to a recessive allele, *sa.* The tulip-ear phenotype is due to another recessive mutation, called *tu.* Alleles *sa* and *tu* could be alleles of the same gene or they could be alleles of two different genes. To answer this question, rats homozygous for the *sa* allele were crossed to rats homozygous for the *tu* allele. A student predicts possible outcomes for this cross and comes up with the following :

Possible Outcome	**F1**	**F2**
a)	All have intermediate ears (similar to both saucer and tulip)	1 saucer: 2 normal :1 tulip
b)	All have tulip ears	3 tulip: 1 normal
c)	All have saucer ears	3 normal : 1 saucer
d)	All have tulip ears	3 tulip : 1 saucer
e)	All have normal ears	9 normal:3 tulip:3 saucer: 1 reduced ears

Use the above information to answer the following 2 questions.

14. Which of the above possible outcomes (a, b, c, d, or e) would convince you that sa and tu **are alleles of the same gene?**

    d)

15. Which of the above possible outcomes (a, b c, d, e) would best convince you that sa and tu **are alleles of two different genes?**

    e)

16. 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/lab and aB/lab in a 1:1 ratio
e) AaBb, aaBb, Aabb and aabb in equal frequencies

The fescue grass, F. sativa (2N=16) 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 two questions refer to this information.

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

a) 14
b) 7
c) 16
d) 28
e) none of the above

18. 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) 22
b) 28
c) 20
d) 44
e) none of the above

19. A phenotypically normal female (with no family history of colourblindess) and a red-green 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

20. 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

21. 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.

22. 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

23. 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

24. 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.

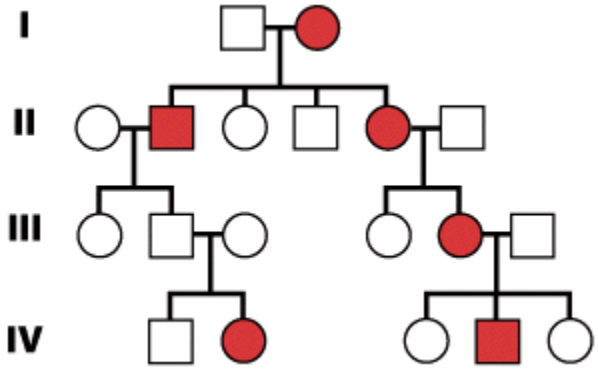
25. Each nucleosome core:

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 histone H3 for stabilization.

26. 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.



27. Individual III-2 is an example of:

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

28. Multiple crosses were made between true-breeding lines of black and yellow Labrador retrievers. All the F1 progeny were black. When these progeny were intercrossed, they produced an F2 consisting of 91 black, 39 yellow, and 30 chocolate. Propose an explanation for the inheritance of coat color in Labrador retrievers.

a) Complementation
b) Recessive epistasis
c) Recessive lethal mutation
d) Inbreeding
e) None of the above

29. A man who has color blindness and type O blood has children with a woman who has normal color vision and type AB blood. The woman's father had color blindness. Color blindness is determined by an X-linked gene, and blood type is determined by an autosomal gene. What proportion of their children will have color blindness and type A blood?

a) 1/2
b) 1/8
c) 0
d) 1/4
e) 3/16

30. 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 F_1 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% $a\ b^+/a\ b$

31. A phenotypically wild-type female fruit fly that was heterozygous for genes controlling body color and wing length was crossed to a homozygous mutant male with black body (allele *b*) and vestigial wings (allele *vg*). The cross produced the following progeny: gray body, normal wings 126; gray body, vestigial wings 24; black body, normal wings 26; black body, vestigial wings 124. What is the frequency of recombination?

a) 0.2
b) 0.167
c) 0.08
d) 0.087
e) none of the above

32. 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

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

a) 12 bivalents
b) 12 tetravalents
c) 20 bivalents and 1 tetravalent
d) 8 trivalents
e) none of the above

34. 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

Red-green colourblindness is due to a sex-linked recessive gene. About 64 women out of 10,000 are colourblind. Using the Hardy-Weinberg equation $p^2 + 2pq + q^2 = 1$, determine:

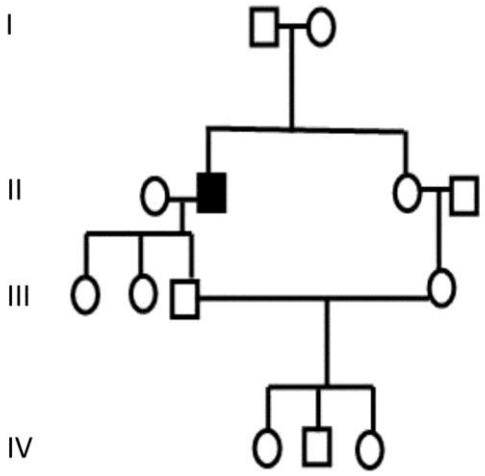
35. What percentage of men from this population would be colourblind?

a) 64%
b) 4%
c) 8%
d) 0.64%
e) none of the above

36. What percentage of females from this population would be carriers?

a) 50%
b) 7%
c) 15%
d) 25%
e) none of the above

37. 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 colour with white fat	32
Himalayan with yellow fat	36
Full colour with yellow fat	212

Use the above information to answer the following 2 questions.

38. 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

39. 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

40. 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