



Midterm 2019, questions

Introduction to Molecular and Cellular Biology (University of Guelph)

Student Name: _____

Student ID#: _____

BIOL*1090
Introduction to Molecular and Cellular Biology
Midterm Examination Winter 2019

2 March 2019

Examiner: Dr. Van Raay

VERSION # 1: WHITE Cover Page, GREY Scantron

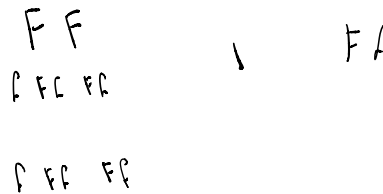
45 Multiple Choice Questions

Total time: 90 minutes

1. **PRINT your name and student number** in the spaces provided at the top left corner of this page AND on the Test Scoring Answer Sheet.
2. This examination consists of **13 pages** containing an extra page at the back that you can use to work on. These will not be marked.
3. Answer **IN PENCIL** on the provided **Test Scoring Answer Sheet**.
ONLY Test Scoring Answer Sheets will be marked.
4. This examination terminates after **exactly 90 minutes**.

1. What happens during **pro-metaphase of mitosis**?
- A) Nuclear envelope reforms and cells divide
 - B) Nuclear envelope starts to break down
 - C) Centrosome duplicates, chromosomes begin to condense
 - D) Sister chromatids separate
 - E) DNA is synthesized
2. During **meiosis**, sister chromatids move towards opposite poles of the spindle during:
- ~~A) Anaphase I~~
 - ~~B) Metaphase I~~
 - C) Metaphase II
 - D) Anaphase II
 - E) Prophase II
3. In a monohybrid cross, if the P generation consists of plants that are **true breeding**, one for a dominant trait and the other for the recessive trait, then the F₂ generation will consist of organisms that exhibit what ratio of homozygous dominant individuals to heterozygous individuals to homozygous recessive individuals?

- A) 1:2:1
- B) 3:2:1
- C) 2:1
- D) 3:1
- E) None of the above

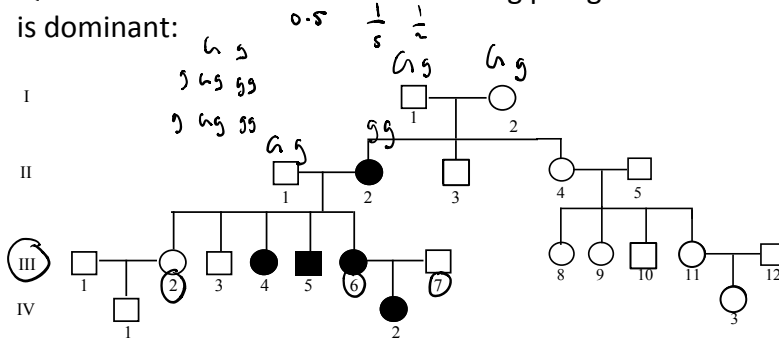


4. A newlywed couple knows they are each heterozygous for the attached earlobe gene (Aa), each displaying beautiful, free flowing earlobes. They are planning on having **3** children but want some idea of the chances of having only one child with attached earlobes. Using the following binomial equation, what is the overall probability that they have only 1 child with attached earlobes?

$$\left[\frac{n!}{x! y!} \right] p^x q^y$$

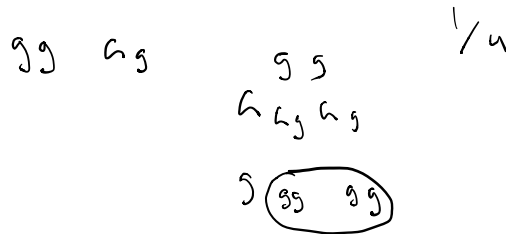
- A) 9/64 or 0.14
- B) 27/256 or 0.11
- C) 81/128 or 0.63
- D) 9/128 or 0.32
- E) 27/64 or 0.42

Question 5 and 6 refer to the following pedigree. Assume that the mode of inheritance is dominant:



5. From the pedigree above, what is the probability that the next child born to individuals III-6 and III-7 is affected?

- A) 0
- B) 0.5
- C) 0.75
- D) 0.25
- E) 1.0

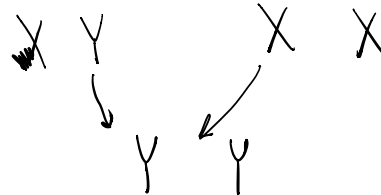


6. From the pedigree above, what is the probability that individual III-2 is a carrier?

- A) 0
- B) 0.5
- C) 0.75
- D) 0.25
- E) 1.0

7. Colour blindness is an X-linked trait. A color blind male mates with a woman who has normal vision. The woman has no history of colorblindness in her family. What percentage of their sons will be colorblind?

- A) 50%
- B) 75%
- C) 100%
- D) 0%
- E) 25%



8. Two possible mutations that could result in a prematurely truncated protein are:

- A) Random mutation; Silent mutation
- B) Deletion of 3 nucleotides; temperature sensitive mutation
- C) Neutral mutation; Insertion of 1 nucleotide
- D) Nonsense mutation; Insertion of 2 nucleotides
- E) Silent mutation; Deletion of 4 nucleotides

9. When fruit flies do not show a trait even though they have the appropriate genotype, the trait is said to exhibit:

- A) Codominance
- B) Incomplete penetrance
- C) Variable expressivity
- D) Dominant Loss-of-Function
- E) Incomplete dominance

10. Which of the following equations would be most useful if you are trying to determine if an autosomal recessive trait will be inherited in an individual in the next generation.

A) $\left[\frac{n!}{x! \times y!} \right]$

B) $p^x q^y$

C) $\sum \frac{(o-e)^2}{e}$

D) $P_k(gg) = P_H(Gg) \times P_H(g) \times P_I(g)$

E) None of these would be useful.

11. In a mitotically dividing cell, will an allele on one sister chromatid match the allele on the other sister chromatid?

- A) Yes, but only if both sister chromatids are inherited from the same parent.
- B) Yes, or the chromatids won't disjoin during anaphase.
- C) Yes, if no errors have been made during DNA synthesis.
- D) Yes, but only when an individual is homozygous for that allele.
- E) No, alleles only match up during meiosis.

12. At which stage of meiosis are cells haploid?

- 1. prophase I
- 2. prophase II
- 3. Interphase I
- 4. telophase II

- A) 1, 2
- B) 1, 3
- C) 2, 3
- D) 2, 4
- E) 1, 2, 4

13. Which of the following can be true regarding alleles?
- 1) Alleles are alternate forms of two different genes.
 - 2) Alleles are assigned according to the dominant trait.
 - 3) Upper case refers to the dominant allele; lower case refers to the recessive allele.
 - 4) For a multi-allelic gene, a diploid organism can only possess two of the alleles.
 - 5) Allelic combination is referred to as the genotype.
- A) 2, 3, 4, 5
 B) 1, 2, 4, 5
 C) 1, 2, 3, 4
 D) All
 E) None

14. According to the multiplication rule of probability, what is the probability of having 4 offspring with no recessive phenotype from a heterozygote cross?

- A) $\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4}$
 B) $\frac{3}{4} \times \frac{3}{4} \times \frac{3}{4} \times \frac{3}{4}$
 C) $(\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4}) + (\frac{3}{4} \times \frac{3}{4} \times \frac{3}{4} \times \frac{3}{4})$
 D) $\frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4}$
 E) None of the above.
- a g
g

15. Consider the following cross to answer the following 2 questions. Assume each gene is located on a different chromosome:

Parent 1: AABBCcDDEe X Parent 2: AaBbCCDdee.

$$\left(\begin{array}{cccc} 1 & 1 & \frac{1}{2} & \frac{1}{2} \\ & & & \end{array} \right) \times \left(\begin{array}{cccc} \frac{1}{2} & \frac{1}{2} & 1 & 1 \\ & & & \end{array} \right)$$

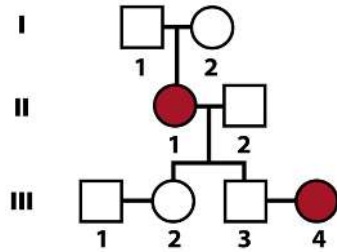
How many different kinds of gametes will be produced in total?

- A) 20
 B) 14
 C) 16
 D) 12
 E) 18
- $\left(\frac{1}{2} \right) \times \left(\frac{1}{9} \right)$

16. Using the cross in Question 15, what is the probability of generating the following offspring: AABBCcDDee?

- A) 1/ 64 or 0.0156
 B) 1/48 or 0.021
 C) 1/32 or 0.0313
 D) 1/16 or 0.0625
 E) 1/2 or 0.5

The following pedigree shows the inheritance of a rare condition. Use for questions 17 and 18.



17. Using the pedigree above, what is the chance that couple III-1 and III-2 will have an affected child?
- A) $1/2$
 B) $1/4$
 C) $2/3$
 D) 0
 E) $1/3$
18. Using the pedigree above, what is the probability that couple III-3 and III-4 will have an affected child?
- A) 0
 B) $1/2$
 C) $1/4$
 D) $1/3$
 E) $2/3$
19. An X-linked recessive trait, such as hemophilia A, will:
- A) not be passed from father to son.
 B) be more common in males than in females.
 C) be passed by an affected women to all of her sons.
 D) A and B.
 E) All of the above.
20. A DNA strand has the sequence 5'- GTACGGTATCATAG – 3'. The reverse complementary strand will be:
- A) 5'- CTATGATGTCGTAC -3'
 B) 5'- CTATGATACCGTAC -3'
 C) 5'- GTACGGTATCATAG -3'
 D) 5'- CATGCCATAGTATC -3'
 E) 3'- GTACGGTATCATAG-5'

21. Mutations are important in genetics because:

- A) they are the source of genetic variability for populations.
- B) they allow geneticists to investigate gene function.
- C) they generate unique alleles.
- D) A and B.
- E) All of the above.

22. The ABO blood groups:

- A) Is an example of a multi allelic systems showing both dominance and incomplete Penetrance
- B) Is an example of a 2 allele system (AB) where both are codominant over O
- C) Is an example of a multi allelic system that also shows classic dominant and recessive traits
- D) Is an example of a multi allelic system that has both dominance and co-dominance features.
- E) None of the above.

23. When nutrients are suboptimal for cell growth and division the cell cycle arrests. At which stage of the cell cycle/checkpoint would you predict this arrest to occur?

- A) G₁ checkpoint
- B) G₂ checkpoint
- C) M checkpoint
- D) G₁, G₂ and M checkpoints
- E) The cell cycle would not arrest.

24. In fruit flies, the white eye (w) is recessive to red eyes (W). You perform an incross with heterozygotes. Which of the following best represents the heterozygous offspring?

- A) 0.25 X 0.25
 - B) 0.5 X 0.5
 - C) 0.5 + 0.5
 - D) 0.25 + 0.25
 - E) 0.25 X 0.5
- $$\begin{array}{c} W \\ \downarrow \\ Ww \times Ww \\ \downarrow \\ (1/2 \times 1/2) \text{ or } (1/2 \times 1/2) \end{array}$$

25. The purpose of mitosis is to:

- A) Produce diploid gametes
- B) Produce clonal cells
- C) Produce haploid gametes
- D) Divide the chromosome number by one half
- E) Produce haploid zygote

26. Studies of rapidly dividing embryonic cells revealed:

- A) a cyclic production of certain proteins in sync with the cell cycle.
- B) a cyclic activation of protein kinases in sync with the cell cycle.
- C) that the production of cyclin proteins is followed by activation of CDK enzymes.
- D) that inhibition of protein production blocks mitosis.
- E) All of these choices are correct.

27. Which of the following is/are a characteristic event of Anaphase I?

- 1. Separation of homologues p p m a t b
- 2. Synapsis of homologues
- 3. Crossing over between homologues f

- A) 1, 3
- B) 2
- C) 3
- D) 2, 3
- E) 1

28. You have been analysing many pedigrees for a rare recessive monogenic disorder and have noticed that while it can occur in women it is far more common in men. What conclusions can you make from this information?

- 1. This gene is most likely located on the X chromosome.
- 2. This gene is most likely located on the Y chromosome.
- 3. Men with this disorder have two copies of the recessive allele.
- 4. Women with this disorder have two copies of the recessive allele.

- A) 1 or 2 are both possible.
- B) 1 and 4 are both correct.
- C) 3 and 4 are both correct.
- D) 2 and 3 are both correct.
- E) There is not enough information to determine.

29. Black fur (b) in mice is recessive to white fur (B). Short tails (T) are dominant to long tails (t). What proportion of the offspring from a cross between individuals with the genotypes BbTt and BBtt will have white fur and short tails?

- A) 1/16
- B) 3/16
- C) 3/8
- D) 1/2
- E) 1/4

30. In a mating between individuals with the genotypes $I^A i$ and $I^B i$, what percentage of the offspring are expected to have the O blood type?

- A) 100%
- B) 10%
- C) 75%
- D) 50%
- E) 25%

31. The BIOL*1090 professor can roll his tongue (allele designation F or f) and has unattached earlobes (allele designation A or a). He has the genotype F_A_, where the underscore (_) could be either the dominant or recessive allele. He has 12 children with the same women (isn't she lucky!). All of the children can roll their tongues but only 6 of the children have unattached earlobes. What is the most probable genotype of the mom?

- A) FFAA
- B) FFaa
- C) FfAa
- D) FfAA
- E) ffAa

32. A pedigree that demonstrates an autosomal recessive trait, such as Tay-Sachs disease, can show all of the following characteristics EXCEPT:

- A) mating between relatives.
- B) skipping of a generation by the trait.
- C) equal numbers of males and females affected.
- D) on average, half the offspring of carriers showing the trait.
- E) Actually, all of these are expected.

33. Assuming heterozygous parents and a recessive trait, which of the equations below best represents the situation where a couple have 3 children and 2 are affected?

A) $\left[\frac{3!}{2! \times 3!} \right] = 1/2$

B) $\left[\frac{3!}{1! \times 3!} \right] = 1$

C) $\left[\frac{3!}{1! \times 2!} \right] = 3$

D) $\left[\frac{2!}{3! \times 1!} \right] = 1/3$

34. Incomplete Penetrance can best be described as:
- A) an individual who lacks a genotype will lack the phenotype.
 - B) an individual who has a particular genotype will have the associated phenotype.
 - C) an individual who lacks a genotype might have the associated phenotype.
 - D) an individual who has a particular genotype might have the associated phenotype.
 - E) an individual will never have the phenotype if they have the genotype
35. Please select the best statement:
- A) Mitosis occurs in spermatogonium and oogonium
 - B) Meiosis occurs in spermatogonium and oogonium
 - C) Meiosis expands the number of primordial germ cells.
 - D) Mitosis only occurs in somatic stem cells
 - E) none of the above
36. What is the probability that a boy will have an X-linked recessive trait if both parents are phenotypically normal and only the mother is a carrier?
- A) 1/3
 - B) 1/2
 - C) 1
 - D) 1/4
 - E) 0
37. Which of the following has the MOST similarity in nucleotide sequence?
- A) homologous chromosomes
 - B) nonhomologous chromosomes
 - C) sister chromatids
 - D) complementary strands of DNA
 - E) maternal and paternal copies of the same chromosome
38. Which of the following statements is TRUE if a cell has a mutation in the *p53* gene such that the p53 protein is no longer able to be phosphorylated?
- A) The cell would proceed through the cell cycle even in the presence of DNA damage.
 - B) The cell cycle would arrest, giving time for the DNA damage to be repaired.
 - C) The amount of cytoplasmic p53 protein would increase in response to DNA damage.
 - D) The kinase activity in the nucleus would decrease in response to DNA damage.
 - E) The cell would undergo programmed cell death.

39. A missense mutation could be described by each of the following EXCEPT:
- loss of function.
 - silent.
 - neutral.
 - conditional.
 - Actually, all of these can describe missense mutations.
40. In a dihybrid cross, if the P generation consists of plants that are true breeding then the F2 generation will consist of organisms that exhibit what phenotypic ratio?
- 3 dominant for both traits : 9 dominant for trait #1 and recessive for trait #2 : 3 dominant for trait #2 and recessive for trait #1 : 1 recessive for both traits
 - 3 dominant for both traits : 3 dominant for trait #1 and recessive for trait #2 : 3 dominant for trait #2 and recessive for trait #1 : 1 recessive for both traits
 - 9 dominant for both traits : 3 dominant for trait #1 and recessive for trait #2 : 3 dominant for trait #2 and recessive for trait #1 : 1 recessive for both traits
 - 9 dominant for both traits : 1 dominant for trait #1 and recessive for trait #2 : 3 dominant for trait #2 and recessive for trait #1 : 1 recessive for both traits
 - None of the above
41. The chemical composition of nucleotides is known to include all of the following EXCEPT:
- a sugar—ribose in the case of RNA.
 - a sugar—ribose in the case of DNA.
 - a phosphate.
 - a nitrogenous base, adenine, cytosine, guanine, or thymine.
 - Actually, all of these are parts of nucleotides.
42. Lethal alleles: $\begin{matrix} A & a \\ A & a \\ a & a \end{matrix}$ AA Aa Aa a/a
- produce a 3:2 phenotypic ratio instead of a 3:1 ratio.
 - produce a 2:1 phenotypic ratio instead of a 3:1 ratio.
 - can persist in the population if recessive.
 - A and C.
 - B and C.
43. Nucleotides are composed of:
- A nitrogen-containing base
 - A pentose sugar
 - A phosphate group
 - All of these
 - None of these

44. Professor Dumbledore performed a genetic screen in zebrafish looking for novel eye phenotypes and found a recessive phenotype that produced small eyes. After several crosses to wild type fish to remove other background mutations and obtain a pure-bred line, he performed an incross with heterozygotes and observed that out of 800 zebrafish from a signal cross, 625 had wild-type eyes. Professor Dumbledore wants to test the hypothesis that his novel mutant is following Mendelian inheritance with respect to the eye phenotype. Use the Chi-Square formula and the Critical values list below to statistically test whether or not these numbers support Mendelian inheritance with 95% confidence.

$$\chi^2 = \sum \frac{(o-e)^2}{e}$$

do for both then
add together

df	0.05	0.01
1	3.84	6.64
2	5.99	9.21
3	7.82	11.34
4	9.49	13.28

- A) $\chi^2 = 1.04$, There is no significant difference, so the numbers support a Mendelian mode Inheritance
- B) $\chi^2 = 1.04$, There is a significant difference, so the numbers support a Mendelian mode Inheritance
- C) $\chi^2 = 4.17$, There is a significant difference, so the numbers do not support a Mendelian mode of Inheritance
- D) $\chi^2 = 4.17$, There is no significant difference, so the numbers do not support a Mendelian mode of Inheritance
- E) $\chi^2 = 3.13$, so the numbers support a Mendelian mode Inheritance
45. Which of the following is a principle that Mendel could have not discovered using only monohybrid crosses?
1. Principle of segregation
 2. Principle of dominance
 3. Principle of independent assortment
- A) 1
- B) 2
- C) 3
- D) 1, 2
- E) 2, 3

Blank Work Sheet