**Spring 2018**

**BIOL24100 – Introduction to Genetics**

**and Molecular Biology**

**Midterm I – A (100 points)**

**2/6/2018**

**Name:\_\_\_\_\_\_\_\_\_\_\_\_\_KEY\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Purdue ID:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Enter **01** in “Test/Quiz Number” column on scantron sheet

Question A: (36) Question B: (10)

Question C: (10) Question D: (12)

Question E: (4) Question F: (10)

Question G: (10) Question H: (8)

**Total:**

**A. Multiple-choice questions (2 points each; please use scantron).**

**1) A human somatic cell (n=23) at the metaphase of mitosis will have:**

1. 23 chromosomes, consisting of 23 DNA molecules.
2. 23 chromosomes, consisting of 46 DNA molecules.
3. 46 chromosomes, consisting of 46 DNA molecules.
4. 46 chromosomes, consisting of 92 DNA molecules.
5. 92 chromosomes, consisting of 92 DNA molecules.

**2) In *Drosophila* males, homologous chromosomes will separate at:**

1. Metaphase of mitosis.
2. Anaphase of mitosis.
3. Metaphase I of meiosis.
4. Anaphase II of meiosis.
5. Anaphase I of meiosis.

**3) A mutation that completely inactivates the function of a gene is known as:**

1. A haplo-insufficient mutation.
2. A dominant negative mutation.
3. A hypomorphic mutation.
4. A null mutation.
5. A synthetic lethal mutation.

**4) Which of the following events is likely responsible for the phenomenon of certain genetic disorders exhibiting earlier onset and increased phenotypic severity in successive generations?**

1. The random inactivation of certain X-linked genes.
2. The formation of heteroduplex at certain genes.
3. The expansion of tri-nucleotide repeats in certain genes.
4. The expression of certain genes influenced by sex-specific hormones.
5. The methylation of cytosines in CG islands near certain genes.

**5) Which of the following events is responsible for the phenomenon of genomic imprinting?**

1. The formation of heteroduplex at certain genes.
2. The expansion of CAG repeats in certain genes.
3. The expression of certain genes influenced by sex-specific hormones.
4. The methylation of cytosines in CG islands near certain genes.
5. The random inactivation of certain X-linked genes.

**6) How many Barr bodies should be seen in the nuclei of somatic cells from a Turner syndrome individual?**

1. 0
2. 1
3. 2
4. 3
5. 4

**7) With recessive epistasis, a likely phenotyptic ratio resulting from a dihybrid cross would be:**

1. 9:3:4
2. 9:7
3. 12:3:1
4. 9:3:3:1
5. 1:1:2

**8) Which of the following tests should be performed to determine the order of gene functions along a biological pathway?**

1. Testcross.
2. Complementation test.
3. Epistasis test.
4. Meiotic Recombination mapping.
5. Reciprocal crosses.

(9 and 10 are a set) DNA from a bacteria strain that is *met+ cys+ gal+* is used to transform a strain that is *met- cys- gal-*. The following percentages of transformed cells are obtained:

Donor strain Recipient strain Genotype of transformed cells Percentage

*met+ cys+ gal+* *met- cys- gal-* *met+ cys+ gal+* 0.04

*met+ cys+ gal-* 0.01

*met+ cys- gal+* 3.00

*met+ cys- gal-*  4.50

*met- cys+ gal+* 0.25

*met- cys- gal+*  4.00

*met- cys+ gal-*  2.00

**9) Which gene is in the middle?**

1. *met*.
2. *cys*.
3. *gal*.

**10) Which two genes are closest?**

1. *met* and *cys*.
2. *cys* and *gal*.
3. *gal* and *met*.

(11 and 12 are a set) Red-green color blindness is a human X-linked recessive disorder. Betsy has normal color vision, but her father is color-blind. Betsy marries John, who also has normal color vision, but his father is also color-blind. Betsy and John have a daughter who has Turner syndrome and is color-blind.

**11) In which parent did the non-disjunction most likely take place?**

1. Betsy.
2. John.
3. Both.

**12) Which of the following statements most accurately describes the underlying inheritance of this trait?**

1. The daughter inherited her X chromosomes from both parents.
2. The daughter inherited her X chromosome from Betsy only.
3. The daughter inherited her X chromosome from John only.

(13 - 14 are a set) In one species of *Drosophila*, the wings are normally round in shape, but you have obtained a pure-breeding line, which has sickle-shaped wings. Crosses between these lines reveal the following results:

Parent F1

Female Male Female Male

sickle round *sickle sickle*

round sickle sickle round

**13) Based on these results, which of the following statements most accurately describes the inheritance of these traits?**

1. There are two autosomal genes involved, and the sickle-shaped mutation is recessive epistatic to the round allele.
2. This trait is controlled by one X-linked gene, and the round allele is recessive.
3. This trait is controlled by one X-linked gene, and the sickle-shaped allele is associated with recessive lethality.
4. This trait is controlled by one sex chromosome-linked gene, and this particular *Drosophila* species uses ZZ/ZW sex determination system.
5. This trait is controlled by two X-linked genes, and the sickle-shaped mutation is recessive epistatic to the round allele.

**14) If the F1 flies from cross 1 (sickle females and sickle males; *italicized* in the table) are crossed, what phenotypic proportions are expected in the progeny?**

1. All progeny will have sickle-shaped wings.
2. A 3:1 ratio of sickle-shaped wings to round wings.
3. All the daughters and ½ of the sons have sickle-shaped wings.
4. All the daughters and ½ of the sons have round wings.
5. All the daughters have sickle-shaped wings, and all the sons have round wings.

**15) The explanation for the pseudo-dominance of *white-* in a particular *N* background is that:**

1. The *white* mutation is X-linked, and males carry only one X chromosome.
2. The product of *white* gene interacts directly with the *N* gene product.
3. The *white* and *N* mutations are both haplo-insufficient.
4. The *white* mutation is epistatic to the *N* mutation.
5. This particular *N* mutation is a deletion, which removing the neighboring white gene.

(16 - 18 are a set) Two male mice (A and B) are both normal-sized. Male A was from a litter of eight mice that were all normal-sized. The parents of male A were a normal-sized male and a dwarf female. Male B was from a litter that contained half phenotypically normal mice and half dwarf mice. The mother of male B was known to be homozygous for the normal *Igf2* allele.

**16) Regarding the genotypes of male A’s and B’s parents, which of the following descriptions is correct?**

1. Both the fathers of male A and B are Igf2+/Igf2-.
2. Both the fathers of male A and B are Igf2+/Igf2+.
3. The father of male A is Igf2+/Igf2-, and the father of male B is Igf2+/Igf2+.
4. The father of male A is Igf2+/Igf2+, and the father of male B is Igf2+/Igf2-.
5. The mother of male A is Igf2-/Igf2-.

Male A and B were put into a cage with two female mice (C and D). Female C is a dwarf and female D is normal-sized. The mice were allowed to mate with each other, and the following data were obtained:

Female C gave birth to seven normal babies.   
  
Female D gave birth to four normal babies and two dwarf babies. 

**17) Which male mated with female C?**

1. Male A.
2. Male B.

**18) Which male mated with female D?**

1. Male A.
2. Male B.

**B.** Camelets are fictional haploid animals that are useful for genetic mapping. Type A camelet has two humps, two legs, and a tail, whereas type B camelet has one hump, but no legs and no tail. Camelets can mate with each other and produce recombinants. A type A camelet is crossed with type B camelet, and the resulting 1000 progeny are classified below.

1. Use appropriate symbols and determine the gene order **(2 points).**

L= legs; H= humps, and T = tail. The correct gene order is L T H (or T in the middle).

1. Calculate the map distances between the genes (**4 points**) and draw a map **(1 point)**.

RFL-T=(70+69+8+6)/1000=0.153 or 15.3 m.u.

RFT-H=(45+34+8+6)/1000=0.093 or 9.3 m.u.

L 15.3 m.u. T 9.3 m.u. H

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1. Calculate the interference value **(2 points)**. Is this positive, negative, or no interference (**1 point**)?

I=1-(8+6)/(1000\*0.153\*0.093)=0.016

Positive interference.

**C.** The father of Mr. Spock (Star Trek) came from the planet Vulcan; his mother came from Earth. A Vulcan has pointed ears (P), adrenals absent (A), and a right-sided heart (R). All of these alleles are dominant over normal Earth alleles. These genes are autosomal, and they are linked as shown in this linkage map:

P/p 20 m.u. A/a 10 m.u. R/r

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If Mr. Spock marries an Earth woman and interference = 0, what proportion of their children:

1. Will show Vulcanian appearance for all three characters **(2 points)**?

½(1-0.2)(1-0.1)=0.36

1. Will show Vulcanian ears but Earth heart and adrenals **(2 points)**?

½(0.2)(1-0.1)=0.09

1. Will show Vulcanian ears and heart but Earth adrenals **(2 points)**?

½(0.2)(0.1)=0.01

Assuming 20 percent interference, what proportion of their children:

1. Will show Vulcanian ears and heart but Earth adrenals **(2 points)**?

½(0.2)(0.1)(1-0.2)=0.008

1. Will show Vulcanian ears but Earth heart and adrenals **(2 points)**?

0.09+0.002=0.092

**D.** In *Neurospora*, a cross *a b* x *+ +* is made and 100 linear asci from this cross are analyzed. The results are shown below.

1 2 3 4 5 6 7\_\_

a b a + a b a b a b a + a +

a b a + a + + b + + + b + b

+ + + b + + + + + + + b + +

+ + + b + b a + a b a + a b

16 14 2 60 1 2 5

1. What is the genetic distance between a and centromere (**2 points**)?

RFa-cent=1/2(60+1+2+5)/100=0.34 or 34 m.u.

1. What is the genetic distance between b and centromere (**2 points**)?

RFb-cent=1/2(2+1+2+5)/100=0.05 or 5 m.u.

1. Are a and b linked? If yes, what is the genetic distance between a and b (**2 points**)?

PD=17 and NPD=16, they are not linked.

1. Draw a map of a , b, and centromere(s) (**2 points**).

34 m.u. a 5 m.u. b

o----------------+-- o---------------+--

1. Diagram the events during meiosis responsible for ascus 2 (**2 points**). You get one point if you drew 4-strand double crossovers. The point here is that you can get NPD by independent assortment if the genes are unlinked.
2. Diagram the events during meiosis responsible for ascus 5 (**2 points**).



**E.** You have found a virgin *Drosophila* female with notched wings. You crossed this female with a male with normal wings, and obtained the following F1 progeny: 1/3 females with notched wings, 1/3 females with normal wings, and 1/3 males with normal wings. A cross of the notched-winged F1 females with their brothers gives 1/3 females with notched wings, 1/3 females with normal wings, and 1/3 males with normal wings.

Explain the genetic basis (using appropriate gene symbols and indicating the number of gene(s)) for the observed phenotypic ratio **(4 points)**.

The notched wing mutation is an X chromosome-linked mutation. It is dominant with respect to wing notching, but it is associated with recessive lethal.

XNX+ = female with notched wings

XNY males do not survive.

**F.** Normal T4 bacteriophages can lyse both *E. coli B* and *K12*, while some mutant strains can lyse only *E. coli B*. 7 mutant T4 strains have been isolated because of their inability to lyse *E. coli K12*. In an experiment, *E. coli K12* were simultaneously infected with two mutant strains, and the results are shown below (+ indicates lysis, - indicates no lysis).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | - |  |  |  |  |  |  |
| 2 | + | - |  |  |  |  |  |
| 3 | + | + | - |  |  |  |  |
| 4 | + | - | + | - |  |  |  |
| 5 | + | + | - | + | - |  |  |
| 6 | - | + | + | + | + | - |  |
| 7 | - | + | + | + | + | - | - |

1. Based on these results, how many genes (complementation groups) do these 7 mutants define **(2 points)**?

3 genes

1. Please indicate which mutants are in the same genes **(3 points)**.

1, 6, and 7 are in one gene.

2 and 4 are in another one.

3 and 5 are in the other one.

**F cont.** To determine the genetic distance between the mutations in strains 6 and 7, *E. coli B* were simultaneously infected with both mutants 6 and 7. The phages produced by this lysis were collected. Serial dilutions of these phages were then used to infect *E. coli B* and *E. coli K12*, and the results are shown below.

Bacterial strain Dilution Number of plaques

E. coli B 10-8 4

E. coli K12 10-1 6

1. Calculate the recombination frequency (RF) between the mutations in strains 6 and 7 **(3 points)**.

RF=2(60)/(4\*108)=3\*10-7

The same simultaneous infection experiment was performed with strains 1 and 6, but no plaque (lysis) was seen on the *E. coli K12* plate. Likewise, when the experiment was performed with strains 1 and 7, no plaque was seen on the *E. coli K12* plate.

d. Based on these observations, what is likely the nature of the mutation in strain 1 **(2 points)**?

Strain 1 is likely a deletion.

**G.** Consider the following F1 individuals in different species (A and B) and the F2 ratios produced by selfing:

|  |  |  |
| --- | --- | --- |
| ***Species*** | ***F1 phenotype*** | ***F2 phenotypic ratio*** |
| A | red | 9/16 red, 7/16 white |

1. Please use appropriate terminology (i.e., number of genes, gene symbols, phenotypes, and types of gene interactions) to describe the mode of inheritance for species A (**3 points**).

Two unlinked autosomal genes involved in a complementary interaction. A= red, a=white; B=red, b=white.

1. If the F1 were testcrossed, what phenotypic ratio (indicating both the phenotypes and the ratio) would result in the progeny of this testcross (**2 points**)?

If AaBb is testcrossed, the progeny ratio will be 1(red) : 3 (white).

|  |  |  |
| --- | --- | --- |
| ***Species*** | ***F1 phenotype*** | ***F2 phenotypic ratio*** |
| B | golden | 3/16 black, 1/16 brown, 12/16 golden |

1. Please use appropriate terminology (i.e., number of genes, gene symbols, phenotypes, and types of gene interactions) to describe the mode of inheritance for species B (**3 points**).

Two unlinked autosomal genes involved in dominant epistasis. A=golden (epistatic gene), a=allows B/b to be expressed; B=black, b=brown.

1. If the F1 were testcrossed, what phenotypic ratio (indicating both the phenotypes and the ratio) would result in the progeny of this testcross (**2 points**)?

If AaBb is testcrossed, the progeny ratio will be 2(golden) : 1 (black): 1(brown).

**H.** The allele *B* on an autosome gives mice a black coat, and *b* gives a brown one. The genotype *ee* of another gene on a different autosome prevents the expression of B and b, making the coat color beige, whereas *E* permits the expression of B and b. In the following pedigree, black symbols indicate a black coat, dotted symbols indicate brown, and white symbols indicate beige.

1. What is the genetic basis for this inheritance **(2 points)**?

Recessive epistasis

1. What is the genotype of mouse 1 **(**if there are alternative possibilities, please state them; **2 points)**?

EeBb

1. What is the genotype of mouse 3 **(**if there are alternative possibilities, please state them; **2 points)**?

Eebb

1. What is the genotype of mouse 15 **(**if there are alternative possibilities, please state them; **2 points)**?

eeBb or eebb

*End of the exam*