**Spring 2017**

**BIOL24100 – Introduction to Genetics**

**and Molecular Biology**

**Midterm I (100 points)**

**2/7/2017**

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

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

Question A: (20) Question B: (6)

Question C: (4) Question D: (10)

Question E: (12) Question F: (12)

Question G: (7) Question H: (10) Question I: (6) Question J: (5)

Question K: (8)

**Total:**

**A. Multiple-choice questions (2 points each; circle the correct answers).**

**1) In the G1 phase of cell cycle, a *Drosophila* somatic cell has 8 chromosomes (2n, n=4). A *Drosophila* germ cell at the metaphase of meiosis I will have:**

1. 4 chromosomes, consisting of 4 DNA molecules.
2. 4 chromosomes, consisting of 8 DNA molecules.
3. 8 chromosomes, consisting of 8 DNA molecules.
4. 8 chromosomes, consisting of 16 DNA molecules.
5. 16 chromosomes, consisting of 16 DNA molecules.

**2) In *Drosophila* males, pairing of homologous chromosomes can be seen at which of the following stages of cell divisions?**

1. Prophase of mitosis.
2. Metaphase of mitosis.
3. Metaphase I of meiosis.
4. Metaphase II of meiosis.
5. Homologous chromosomes do not pair during meiosis because there is no meiotic recombination in *Drosophila* males.

**3) A bacterium that is partially diploid for a number of genes is known as a:**

1. Auxotroph.
2. Hfr strain.
3. F+ strain.
4. Prototroph.
5. Merozygote.

**4) Neurodegenerative disorder, like Huntington’s disease, can exhibit earlier onset and increased phenotypic severity in successive generations. This is known as:**

1. Genetic anticipation.
2. Genomic Imprinting.
3. Lyon Hypothesis.
4. Sex-influenced trait.
5. Epistasis.

**5) The phenomenon described in 4) is caused by:**

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

**6) How many Barr bodies should be seen in the nuclei of somatic cells from a Klinefelter syndrome male (47, XXY)?**

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

**7) A *Drosophila* with XO and 2 sets of autosomes is expected to be:**

1. A female because of the absence of the Y chromosome.
2. A female because the ratio of X chromosome to autosomes is 1.
3. A male because of the random inactivation of X chromosome to compensate gene dosage.
4. A male because the ratio of X chromosome to autosomes is 1/2.
5. An intersex because of the aberrant ratio of X chromosome to autosomes.

**8) Which of the following tests should be performed to determine whether the inheritance of a particular trait is autosomal or sex chromosome-linked?**

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

**9) Methylation of cytosines in CG islands near certain genes is responsible for:**

1. The formation of heteroduplex DNA.
2. The resolution of Holiday structure.
3. The pairing between X and Y chromosomes during meiosis.
4. Genomic imprinting.
5. Positive interference during meiotic crossovers.

**10) In a biosynthetic pathway, the phenotype of gene A masks the phenotype of gene B. Based on this, you can conclude that:**

1. A and B are mutations in the same gene.
2. A is epistatic to B, and A acts upstream of B in the pathway.
3. A is epistatic to B, and A acts downstream of B in the pathway.
4. B is epistatic to A, and A acts upstream of B in the pathway.
5. B is epistatic to A, and A acts downstream of B in the pathway.

**B. Short answer questions** (**6 points, 2 points each**).

1. A complete loss-of-function mutation is known as:

Null

1. The glycine to valine substitution at the 12th position of the Ras small GTPase results in Ras locked in the GTP-bound (ON) state. This mutation is an example of:

Dominant active (I would accept hypermorph. Partial credit 1 point for gain-of-function).

1. A loss-of-function mutation produces a dominant mutant phenotype is known as:

Haplo-insufficient

**C.** DNA from a bacteria strain that is *pro+ met- lac+* is used to transform a strain that is *pro- met+ lac-*. The following percentages of cells were obtained:

Donor strain Recipient strain Transformed cells Percentage

*pro+ met- lac+* *pro- met+ lac-* *pro+ met- lac+* 0.02

*pro+ met- lac-* 0.0

*pro+ met+ lac+* 2.0

*pro+ met+ lac-* 4.0

*pro- met- lac+* 0.1

*pro- met+ lac+* 3.0

*pro- met- lac-* 1.5

Based on this, please deduce the arrangement of these genes (i.e. draw a map, **2 points**) and indicate which two genes are closest (**2 points**).

*pro lac met*

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The *lac* gene is in the middle.

The *pro* and *lac* genes are closer.

**D.** In a hypothetical species, the following allelic pairs have been identified: +/x, +/y and +/z. A testcross involving triple recessives and F1 heterozygous for the three gene pairs yields the following progeny phenotypes:

+ y z 390

x + + 399

x + z 54

+ y + 57

+ + z 45

x y + 46

+ + + 4

x y z 5

1000

1. Which gene is in the middle **(2 points)**?

X is in the middle.

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

Distance between y and x: (45+46+5+4)/1000=10 m.u.

Distance between x and z: (54+57+5+4)/1000=12 m.u.

y 10 m.u. x 12 m.u. z

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

I = 1-(5+4)/(1000\*0.1\*0.12) =0.25

Positive Interference.

**E.** In a certain diploid plant, three loci A/a, B/b, and C/c are linked as follows:

A/a 10 m.u. B/b 30 m.u. C/c

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One plant is available to you and it has the constitution ***A B C /a b c***

1. Assuming no interference between the regions, if the parental parent plant is crossed with the *a b c/a b c* plant, what proportion of the progeny will have the phenotype of *a b c* **(2 points)**?

This is half of the NCO class. Thus ½\*(1-0.1)\*(1-0.3)=0.315

1. Assuming no interference between the regions, if the parental parent plant is selfed, what proportion of the progeny will have the phenotype of *a b c* **(2 points)**?

Both parents need to produce the NCO class. Thus [½\*(1-0.1)\*(1-0.3)]2=0.099

1. Assuming no interference between the regions, if the parental parent plant is crossed with the *a b c/a b c* plant, what proportion of the progeny will have the phenotype of *A b C* **(2 points)**?

This is half of the DCO class. Thus ½\*(0.1)\*(0.3)=0.015

1. Assuming 10% interference, if the parental parent plant is crossed with the *a b c/a b c* plant, what proportion of the progeny will have the phenotype of *A b C* **(2 points)**?

With interference, the observed DCO is: 0.015\*(1-0.1)=0.0135

1. Assuming 10% interference, if the parental parent plant is crossed with the *a b c/a b c* plant, what proportion of the progeny will have the phenotype of *A b c* **(2 points)**?

A b c represents half of the SCO between A-B. With interference, this is:

½\*(0.1)\*(1-0.3)+(0.015-0.0135)=0.0365

1. Assuming 10% interference, if the parental parent plant is crossed with the *a b c/a b c* plant, what proportion of the progeny will have the phenotype of *a b c* **(2 points)**?

a b c represents half of the NCO. With interference, this is:

0.315-(0.015-0.0135)=0.3135

**F.** 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

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

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

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

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

71 1 18 1 8 1

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

½\*(1+8+1)/100=5 m.u.

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

½\*(18+8+1)/100=13.5 m.u.

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

As PD>>>NPD, they are linked. The distance is (1+1/2\*(18+1+1))/100=11 m.u.

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

5 m.u. a 11 m.u. b

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1. Diagram the crossover events responsible for ascus 4 (**2 points**).
2. Diagram the crossover events responsible for ascus 6 (**2 points**).



**G.** In a genetics lab course, students have isolated seven homozygous wingless *Drosophila* mutants (mutant 1-7). To determine the number of genes defined by these mutants, they perform pair-wise crosses and the results are shown below.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | wingless |  |  |  |  |  |  |
| 2 | normal | wingless |  |  |  |  |  |
| 3 | normal | wingless | wingless |  |  |  |  |
| 4 | wingless | normal | normal | wingless |  |  |  |
| 5 | normal | wingless | wingless | normal | wingless |  |  |
| 6 | wingless | normal | normal | wingless | normal | wingless |  |
| 7 | normal | normal | normal | normal | normal | normal | wingless |

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, 4, and 6 are in one gene.

2, 3, and 5 are in one gene.

7 is in another gene.

1. Another homozygous wingless mutant (8) was isolated, and it has been shown to produce wingless progeny when crossed with mutant 7. Based on this, please predict the results (by completing the table below) when this mutant is crossed with other wingless mutants (**2 points**)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | normal | normal | normal | normal | normal | normal | wingless |

**H.** 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 | pink | ¼ red, ½ pink, ¼ 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**).

One autosomal gene involved. A = red, and a = white. This is an example of incomplete dominance. Aa = pink. (Note, some of you used a two-genes/recessive epistasis/recessive-lethal explanation. If you explained the scenario properly and thoroughly, I gave you full credit).

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**)?

Pink (1) : white (1)

|  |  |  |
| --- | --- | --- |
| ***Species*** | ***F1 phenotype*** | ***F2 phenotypic ratio*** |
| B | black | 9/16 black, 3/16 brown, 4/16 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**).

This is an example recessive epistasis with two autosomal genes involved. In one locus, A = black, and a = brown. In a separate locus, B = allows pigment, and bb = no pigment deposition. b is recessive epistatic to A/a.

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**)?

Black (1): brown (1): golden (2)

**I.** Mice with wild-type Igf2 function are normal-sized, whereas mice without Igf2 function are dwarf.

1. If an Igf2+/Igf2- dwarf male were crossed with an Igf2-/Igf2- dwarf female, what would be the phenotypic ratio (indicating both the phenotypes and the ratio) in the progeny **(2 points)**?

Normal (1) : dwarf (1)

1. If the same Igf2+/Igf2- dwarf male were crossed with an Igf2+/Igf2+ normal female, what would be the phenotypic ratio (indicating both the phenotypes and the ratio) in the progeny **(2 points)**?

Normal (1) : dwarf (1)

1. If the father of this Igf2+/Igf2- dwarf male is normal-sized and the mother of this Igf2+/Igf2- dwarf male is dwarf, what are the genotypes of the parents of this male **(2 points)**?

Father: Igf2+/Igf2- Mother: Igf2+/Igf2-

**J.** In mice, a locus (A) controls whether pigments are deposited; the dominant allele (A) allows pigment deposition, whereas homozygous aa mice are albino because no pigments are deposited. On a different autosome, another locus (B) controls the pigment color; the dominant allele (B) produces a yellow pigment, while the recessive allele (b) produces an agouti pigment. If a yellow male mouse is crossed with a yellow female mouse, ½ of the progeny are yellow, ¼ are agouti, and ¼ are white.

1. Explain the genetic basis for this phenotypic ratio **(3 points)**.

aa is recessive epistatic to B/b. in addition, B is associated with recessive lethal.

1. If the yellow male mouse is testcrossed, predict the progeny phenotypic ratio **(2 points)**.

Yellow (1): agouti (1): albino (2)

**K.** In Dexter and Kerry cattle, animals may be polled (hornless) or horned. The Dexter animals have short legs, whereas Kerry animals have long legs. Crosses between polled Kerrys and horned Dexters produce ½ polled Dexters and ½ polled Kerrys. When these two types of F1 cattle (polled Dexters x polled Kerrys) were crossed, the following F2 data were obtained:

3/8 polled Dexters

3/8 polled Kerrys

1/8 horned Dexters

1/8 horned Kerrys

It is known that Kerrys were true breeding, whereas Dexters were not true breeding and never produced as many progeny as Kerrys. Based on this, please use gene symbols (indicating the number of genes involved) and appropriate terminology to explain the inheritance of these traits (**3 points**).

There two unlinked autosomal genes involved. One locus (A) controls the leg length, with the short-legged (Dexter, A) allele being dominant and the long-legged (Kerry, a) allele being recessive. However, A is associated with recessive lethality. On a separate autosome, another locus (B) controls the horn presence, with the polled allele (B) being dominant, and the horned allele (b) being recessive.

What will be the result from a mating between two F1 polled Kerrys (**2.5 points**)?

The genotypes of two polled Kerrys are aaBb and aaBb.

Thus the progeny phenotypic ratio will be:

3/4 polled Kerrys

1/4 horned Kerrys

What will be the result from a mating between two F1 polled Dexters (**2.5 points**)?

The genotypes of two polled Dexters are AaBb and AaBb.

Thus the progeny phenotypic ratio will be:

1/2 polled Dexters

1/6 horned Dexters

1/4 polled Kerrys

1/12 horned Kerrys