

NAME: \_\_\_\_\_KEY\_\_\_\_\_

UFID: \_\_\_\_\_

DATE: \_\_\_\_\_

# PCB 3063 Genetics Spring 2015

## Exam 2A

- Please check to make sure your exam has 11 pages including this cover and 31 questions.
- Put your name at the top of each page where indicated
- Identify the easy questions and do them first. This way you will not be rushing through them at the end.
- Go with your first instinct!!!! Don't change your answer unless you absolutely misread the question the first time. Studies have shown that the first answer is almost always the right one.
- Read each question carefully and make sure you address all the parts of the question.
- Be clear and concise with your answers, and try to contain your answers to the space provided. Consider putting a box or circle around your final answer to avoid confusion.
- Do not overanalyze the questions. Don't try to second-guess the instructor or the grader.
- Keep track of the time.

**GOOD LUCK!**

PART 1: (1 point each) Multiple choice. For questions 1 – 25 choose the best answer

1. What significant genetic function occurs in the S phase of the cell cycle?
  - (A) Cytokinesis
  - (B) Karyokinesis
  - (C) DNA synthesis
  - (D) Chromosome condensation
  - (E) Centromere division
2. What is the outcome of synapsis, a significant event in meiosis?
  - (A) Dyad formation
  - (B) Monad movement to opposite poles
  - (C) Side-by-side alignment of non-homologous chromosomes
  - (D) Side-by-side alignment of homologous chromosomes
  - (E) Chiasma segregation
3. If a geneticist describes a trait as being 70% penetrant, what would they mean?
  - (A) Individuals with the trait show variation in expression
  - (B) It is lethal in 30% of the individuals who have the trait
  - (C) Only 70% of the individuals who carry the allele(s) for a trait express the trait
  - (D) The trait is present in 70% of the population
4. Multiple mutations that are found to be present in a single gene are said to belong to the same \_\_\_\_\_ group.
  - (A) allelic
  - (B) complementation
  - (C) expression
  - (D) phenotypic
  - (E) transfer
5. Assume that a cross is made between  $AaBb$  and  $aabb$  plants and that the offspring fall into approximately equal numbers of the following groups:  $AaBb$ ,  $Aabb$ ,  $aaBb$ ,  $aabb$ . These results are consistent with the following circumstance:
  - (A) Independent assortment
  - (B) Alternation of generations
  - (C) Complete linkage
  - (D) Incomplete dominance
  - (E) Hemizyosity

NAME: \_\_\_\_\_

6. The phenomenon in which one crossover decreases the likelihood of crossovers in nearby regions is called
  - (A) chiasma
  - (B) negative interference
  - (C) reciprocal genetic exchange
  - (D) positive interference
  - (E) mitotic recombination
  
7. Name the general category into which double-stranded circular extrachromosomal DNA elements such as F factors, ColE1, and *R* would fall.
  - (A) Capsid
  - (B) R-determinant
  - (C) Plaque
  - (D) Partial diploid
  - (E) Plasmid
  
8. During conjugation, one gene (A) is found to transfer to the recipient bacteria 26 minutes following the start of conjugation, while a second gene (M) is found to transfer 37 minutes following the start of conjugation. A third gene (T) transfers 45 minutes following the start of conjugation. Based on this information, which of the following is true?
  - (A) Genes A and M have a genetic distance of 11 minutes
  - (B) Genes A and T have a genetic distance of 19 minutes
  - (C) Genes M and T have a genetic distance of 8 minutes
  - (D) The order of the genes is A M T
  - (E) All of the answers are correct
  
9. The *Lygaeus* mode of sex determination is the \_\_\_\_\_.
  - (A) XY/XX scheme
  - (B) XX/XO scheme
  - (C) Hermaphroditic scheme
  - (D) Scheme based on single translocations in the X chromosome
  
10. For an individual with the XXY chromosomal composition, the expected number of Barr bodies in interphase cells is \_\_\_\_\_.
  - (A) Variable
  - (B) One
  - (C) Two
  - (D) Three
  - (E) Zero

11. The African clawed frog (*Xenopus laevis*) is allotetraploid, likely as a result of an interspecies mating long ago, followed by a duplication of the entire genome. *X. laevis* is fertile and has a normal life cycle. In contrast, mules, the allodiploid offspring of a male donkey and a female horse, are generally sterile. Why can *Xenopus* reproduce and mules cannot?
- (A) Frogs are less sensitive to multiple copies of the genome than mammals
  - (B) In allotetraploid organisms each chromosome has a chromosome to pair up with in meiosis, whereas in allodiploid organisms they do not.
  - (C) The two frogs that interbred to form *X. laevis* must have been more closely genetically related than the donkey and horse are
  - (D) The mule must have a genetic mutation that prevents it from reproducing
12. To which of the following does the term *heteroplasmy* refer?
- (A) Cells with a variable mixture of normal and abnormal organelles
  - (B) Heterozygous individuals with more than one gene pair involved
  - (C) Conditions in which the germ plasm is a mixture of dominant and recessive genes
  - (D) A circumstance that is homologous to incomplete dominance
  - (E) Various stages of development of mitochondria and chloroplasts
13. The failure of chromosomes to separate during anaphase is called \_\_\_\_\_.
- (A) synapsis
  - (B) maternal effect
  - (C) epistasis
  - (D) nondisjunction
14. Direction of shell coiling in *Lymnaea peregra* is strongly and most directly influenced by \_\_\_\_.
- (A) the genotype of the mother
  - (B) the genotype of the father
  - (C) the genotype of the embryo itself
  - (D) the phenotype of the mother
  - (E) the phenotype of the father
15. A wholphin is a rare animal born from mating a female bottlenose dolphin with a male false killer whale. What can you conclude from the fact that wholphins are fertile?
- (A) Wholphins are allotetraploid
  - (B) Dolphins and false killer whales likely have the same number of chromosomes
  - (C) Dolphins and false killer whales are actually the same species
  - (D) One of the parents must have been aneuploidy

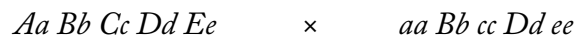
NAME: \_\_\_\_\_

16. Trisomy 21, or Down syndrome, occurs when there is a normal diploid chromosomal complement but one (extra) chromosome 21. Although fertility is reduced in both sexes, females have higher fertility rates than males. Van Dyke et al. (1995; *Down Syndrome Research and Practice* 3(2): 65-69) summarize data involving children born of Down syndrome and a normal 46-chromosome male. What proportion of the offspring would be expected to have Down syndrome?
- (A) 1/3 of the offspring would be expected to have Down syndrome
  - (B) 2/3 of the offspring would be expected to have Down syndrome
  - (C) 1/2 of the offspring would be expected to have Down syndrome
  - (D) All the children would be expected to have Down syndrome
  - (E) None of the offspring would be expected to have Down syndrome
17. The sex of birds, some insects, and other organisms is determined by a *ZW* chromosomal arrangement. Assume that a recessive allele on the *Z* chromosome causes death of an embryo in birds. What sex ratio would result in the offspring if a cross were made between a male heterozygous for the lethal allele and a normal female?
- (A) 4:1 male to female
  - (B) 2:1 male to female
  - (C) 3:1 male to female
  - (D) 1:2 male to female
  - (E) 1:1 male to female
18. The *Protenor* mode of sex determination is the \_\_\_\_\_.
- (A) scheme based on F plasmids inserted into the *FMR-1* gene
  - (B) XX/XO scheme
  - (C) XO/YY scheme
  - (D) Hermaphroditic scheme
  - (E) Scheme based on single translocations in the X chromosome
19. A histidine, methionine auxotroph \_\_\_\_\_.
- (A) can synthesize only histidine and methionine
  - (B) can only use histidine and methionine as nutrition sources
  - (C) cannot synthesize histidine and methionine
  - (D) is killed by histidine and methionine
  - (E) lacks proteins with histidine or methionine
20. Which of the following are highly desirable characteristics of an organism that make it relatively easy to construct a genetic linkage map?
- (A) Short generation times
  - (B) Produces large numbers of offspring
  - (C) Easily crossed
  - (D) All of the answers are correct
  - (E) None of the answers are correct

21. Assume that a cross is made between  $AaBb$  and  $aabb$  plants and that the offspring occur in the following numbers: 106  $AaBb$ , 48  $Aabb$ , 52  $aaBb$ , 94  $aabb$ . These results are consistent with the following circumstance:
- (A) Sex-linked inheritance with 30% crossing over
  - (B) Linkage with 50% crossing over
  - (C) Linkage with approximately 33 map units between the two gene loci
  - (D) Independent assortment
  - (E) 100% recombination
22. What is the molecular mechanism for imprinting a gene?
- (A) Acetylation
  - (B) Methylation
  - (C) Nitration
  - (D) Phosphorylation
23. If an allele is dominant in one sex and recessive in another, it is an example of
- (A) sex-limited inheritance
  - (B) sex-influenced inheritance
  - (C) incomplete dominance
  - (D) simple Mendelian inheritance
24. What is the probability that an offspring will have an  $ssRR$  genotype from a cross of two  $SsRr$  individuals?
- (A) 25%
  - (B) 12.5%
  - (C) 6.25%
  - (D) 3.12%
25. Vincristine is a cancer chemotherapy drug. It binds to tubulin dimers, inhibiting assembly of microtubules. Where do you predict that vincristine stops the cell cycle?
- (A) S phase
  - (B) Prophase
  - (C) Metaphase
  - (D) Telophase

## PART 2: Questions 26 – 31

26. Consider the following cross:

(A) What proportion of progeny will *phenotypically* resemble:

i) (2.5 points) the first parent

$$\frac{1}{2} \times \frac{3}{4} \times \frac{1}{2} \times \frac{3}{4} \times \frac{1}{2} = \frac{9}{128}$$

or 0.07

ii) (2.5 points) the second parent

$$\frac{1}{2} \times \frac{3}{4} \times \frac{1}{2} \times \frac{3}{4} \times \frac{1}{2} = \frac{9}{128}$$

or 0.07

iii) (2.5 points) either parent

$$\frac{9}{128} + \frac{9}{128} = \frac{18}{128} \text{ or } \frac{9}{64}$$

or 0.14

iv) (2.5 points) neither parent

$$1 - \frac{18}{128} = \frac{110}{128} \text{ or } \frac{55}{64}$$

or 0.86

(B) What proportion of progeny will be genotypically the same as:

i) (2.5 points) the first parent

$$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{32}$$

or 0.03

ii) (2.5 points) the second parent

$$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{32}$$

or 0.03

iii) (2.5 points) either parent

$$\frac{1}{32} + \frac{1}{32} = \frac{2}{32} \text{ or } \frac{1}{16}$$

or 0.06

iv) (2.5 points) neither parent

$$1 - \frac{2}{32} = \frac{30}{32} \text{ or } \frac{15}{16}$$

or 0.94

27. Dosage compensation leads to a variety of interesting coat color patterns in certain mammals. For instance, a female cat that is heterozygous for two coat color alleles say black and orange, will usually have the “calico” or mosaic phenotype.

(A) (4 points) Explain dosage compensation

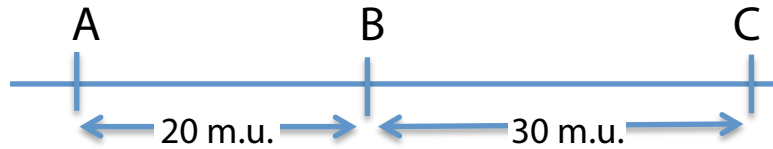
Dosage compensation is the mechanism to balance X chromosome expression between males and females due to the difference in number of X chromosomes present between males and females. Basically, in females, one of the X chromosomes is inactivated so that expression levels are similar to males.

(B) (4 points) Describe the chromosomal basis for the mosaicism (calico) in the female  
X chromosome inactivation is random and occurs in somatic cells during early embryo development. All descendants of a cell line will have the same inactivated X chromosome but different cells lines will have different inactivated X chromosomes resulting in patches or mosaicism

(C) (4 points) Explain why male cats do not usually show the mosaic phenotype  
Males only have one X chromosome so all cells will express the X chromosome

(D) (4 points) Is there a mutation that could produce a male calico? Explain  
Yes. Non-disjunction of X chromosome during gametogenesis/meiosis could result in a male that is XXY. In this case dosage compensation would result in mosaicism in a male cat.

28. In a certain diploid plant, the three loci  $A$ ,  $B$ , and  $C$  are linked as follows:



One plant is available to you (call it the parental plant). It has the constitution  $A b c / a B C$ .

- (A) (5 points) With the assumption of no interference, if the plant is selfed, what proportion of the progeny will be of the genotype  $a b c / a b c$ ?

$$P_{(\text{SCO } AB)} = 1/2 (0.2) (0.7) = 0.07$$

$$=(0.07)^2 = 0.0049$$

- (B) (5 points) With the assumption of no interference, if the parental plant is crossed with the  $a b c / a b c$  plant, what genotypic classes will be found in the progeny? What will be their frequencies if there are 1000 progeny?

$$\begin{array}{ll}
 \text{Abc} = \frac{1}{2} (0.8) (0.7) = 0.28 * 1000 = 280 & \text{AbC} = \frac{1}{2} (0.3) (0.8) = 0.12 * 1000 = 120 \\
 \text{aBC} = 280 & \text{aBc} = 120 \\
 \text{ABC} = 0.07 * 1000 = 70 & \text{ABc} = \frac{1}{2} (0.2) (0.3) = 0.03 * 1000 = 30 \\
 \text{abc} = 70 & \text{abc} = 30
 \end{array}$$

- (C) (5 points) Repeat part b, this time assuming 20% interference between the regions.

$$\begin{array}{ll}
 I = 1 - (\text{obs}/\text{exp}) & 0.2 - 0.048 = 0.152 \\
 0.2 = 1 - \{\text{obs}/[(0.2) (0.3)]\} & 0.3 - 0.048 = 0.252 \\
 0.2 = 1 - (\text{obs}/0.06) & 1 - 0.152 - 0.252 - 0.048 = 0.548 \\
 0.8 = \text{obs}/0.06 & \\
 \text{obs} = 0.048 &
 \end{array}$$

$$\begin{array}{ll}
 \text{Abc} = \frac{1}{2} (0.548) = 0.274 * 1000 = 274 & \text{AbC} = \frac{1}{2} (0.252) = 0.126 * 1000 = 126 \\
 \text{aBC} = 274 & \text{aBc} = 126 \\
 \text{ABC} = \frac{1}{2} (0.152) * 1000 = 76 & \text{ABc} = \frac{1}{2} (0.048) = 0.024 * 1000 = 24 \\
 \text{abc} = 76 & \text{abc} = 24
 \end{array}$$

29. During the analysis of seven *rII* mutations in phage T4, mutants 1, 2, and 6 were in cistron A while mutants 3, 4, and 5 were in cistron B. Of these, mutant 4 was a deletion overlapping mutant 5. The remainder were point mutations. Nothing was known about mutant 7.

(A) Predict the results of complementation (+ or -) between

- i) (1.5 points) 1 and 2 -
- ii) (1.5 points) 1 and 3 +
- iii) (1.5 points) 2 and 4 +
- iv) (1.5 points) 4 and 5 -

(B) (2.5 points) Recombination studies between mutants 1 and 2 (i) give the following results

Strain	Dilution	Plaques	Phenotypes
<i>E. coli</i> B	$10^{-7}$	4	R
<i>E. coli</i> K12	$10^{-2}$	8	1

Calculate the recombination frequency.

$$= 2 (8 \times 10^2) / (4 \times 10^7) = 2 (2 \times 10^{-5}) = 4 \times 10^{-5}$$

(C) (2.5 points) Mutant 7 failed to complement with any of the other mutants (1 - 6). Define the nature of mutant 7.

Mutant 7 has a deletion covering cistrons A and B

NAME: \_\_\_\_\_

30. Answer the following questions about chromosomal inversions

(A) (2 points) Explain the difference between paracentric and pericentric inversions

Pericentric inversions include the centromere in the inverted region.  
Paracentric do not.

(B) (6 points) The outcome of a single crossover between nonsister chromatids in the inversion loop of an inversion heterozygote varies depending on whether the inversion is of the paracentric or pericentric type. What differences are expected?

In paracentric inversions, crossovers will produce an acentric chromosome and a dicentric chromosome. The acentric chromosome will be lost. The dicentric one will be ripped apart.

All chromosomes in crossovers with a pericentric inversion will have one centromere and make it, but two chromosomes will have deletions and duplicated regions

See lecture 16 slides 36-38

31. (5 points) In a family of eight children, where both parents are heterozygous for albinism, what is the probability that six are normal and two are albinos?

$$= \frac{8!}{6!2!} \left(\frac{3}{4}\right)^6 \left(\frac{1}{4}\right)^2 = \frac{40320}{720 \cdot 2} \left(\frac{3}{4}\right)^6 \left(\frac{1}{4}\right)^2 = \frac{40320}{1440} \left(\frac{3}{4}\right)^6 \left(\frac{1}{4}\right)^2 = 28 (0.178)(0.0625) = 0.3115$$