DO NOT OPEN UNTIL TOLD TO START

Genetics 466
December 16, 2008 –Final Exam

Name (print neatly) ANSWER KEY

10 Digit Student # _____

Signature _____

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Total

INSTRUCTIONS:

There are 12 pages (29 questions) on the exam. *Make sure you have all the pages. Some formulae and the genetic code are on the last two pages.*

1. Be sure to provide your student information above.
2. Make your answer clear. Show your work. Be succinct!
3. If you don't understand what is being asked. Raise your hand and ask for help.

Vocabulary (2 point each).

Find the word in the following list that **best** fits each of the definitions given below. Enter the number of the appropriate word on the line next to the definition. Write legibly.

1.	Anaphase I	9.	genotype fitness	17.	Polygenic inheritance
2.	Anaphase II	10.	incomplete penetrance	18.	prophase I
3.	centiMorgan	11.	Interphase	19.	prophase II
4.	chiasma(ta)	12.	Metaphase I	20.	Repulsion phase
5.	Codominance	13.	Metaphase II	21.	selection coefficient (s)
6.	Coupling phase	14.	Monogenic inheritance	22.	Telophase I
7.	epistasis	15.	natural selection	23.	Teophase II
8.	fitness	16.	pleiotropy	24.	variable expressivity

2 **1.** Centromeres split and sister chromatids are pulled to opposite poles during this time period.

18 **2.** Crossing over takes place during this time period.

3 **3.** Unit in which map distances are measured.

21 **4.** The relative fitness disadvantage of a genotype.

16 **5.** A gene that affects several traits exhibits this property.

True/False (1 point each)

T **6.** Domestication can make a crop dependent on humans for its survival.

T **7.** Single gene changes can establish new traits during crop domestication.

F **8.** Crop and their progenitors usually can not form fertile hybrids.

T **9.** Crop domestication took place at multiple locations around the world.

F **10.** Crops usually have greater genetic diversity (heterozygosity) than their progenitors.

T **11.** Crops often exhibit vegetative gigantism as compared to their progenitors.

T **12.** Polyploidy is very common among crop species.

F **13.** Allele mining is the extraction of gene variants from fossil crop plants.

T **14.** Mutation breeding can involve mutagenizing a crop using X-rays.

F **15.** Epistasis can not be used to explain hybrid vigor.

Question 16. The recessive alleles *pr b vg* cause purple eyes, black bodies, and vestigial wings, respectively, in Drosophila. A female of genotype *pr b vg/pr⁺ b⁺ vg⁺* was crossed with a male of genotype *pr b vg/ pr b vg*. The genotypes and number of offspring are shown in the table below.

16a. What is the correct gene order? **(4 pts)**

(A) b, pr, vg	(B) pr, b, vg	(C) pr, vg, b

A

Middle gene is swapped out of place in the double recombinants relative to the parental chromosomes.

16b. What is the recombination frequency between *vg* and *pr*? **(2 pts)**

b^+	pr^+	vg^+	4,224	Parental
b^+	pr^+	*vg*	500	
b^+	*pr*	vg^+	14	Double
b^+	*pr*	*vg*	296	
b	pr^+	vg^+	280	
b	pr^+	*vg*	10	Double
b	*pr*	vg^+	476	
b	*pr*	*vg*	4,200	Parental
			10,000	

0.10

500
14
476
10
1000

vg-pr recombinants

$\frac{1000}{10,000} = 0.10$

17. Among the progeny of a selfed triple heterozygote (*AaBbCc*), what proportion will be heterozygous for all three genes? (All three genes are independent.) (3 pts)

1/8

$$\left(\frac{1}{2}\right)^3 = \frac{1}{8}$$

18. In a human population, the A allele occurs at a frequency of 0.8 and the a allele at a frequency of 0.2. The gene in question is autosomal. You can assume Hardy-Weinberg. If you randomly select five people, what is the probability that you will pick exactly 3 AA and 2 Aa individuals? (4 points)

0.268

$$P(AA) = (0.8)^2 = 0.64$$

$$P(Aa) = 2(0.8)(0.2) = 0.32$$

$$\binom{5}{3} = \frac{5!}{3!2!}(0.64)^3(0.32)^2 = 0.268$$

19. If an X-linked recessive disease affects one in 5,000 human females, what percentage of human males will be affected? (3 points)

1.4%

$$q^2 = 1/5000$$

$$q = 0.0141$$

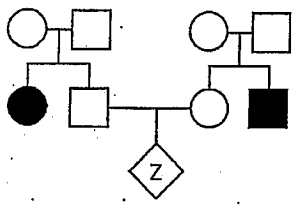
20. Members of a small religious sect of 5,000 people living in Europe have preferentially mated with other members of their own sect for many generations. As a result, this group has an average inbreeding coefficient (F) of 0.2. The frequency of a recessive autosomal disease allele (d) among this group is 0.1. What is the frequency of the disease among this group? (3 pts.)

0.028

$q = 0.1 \quad p = 0.9$

$\text{Freq}(dd) = q^2 + Fpq = 0.028$

Question 21. The pedigree below shows the occurrence of a disease in a family. Shaded forms indicate affected individuals. "Z" is an unborn individual whose disease condition is unknown.



21a. Which of the following statements about this disorder is true? (2 pts)

3

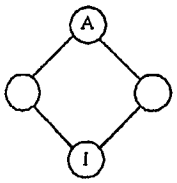
(1). dominant, autosomal
(2). dominant, X-linked
(3). recessive, autosomal
(4). recessive, X-linked
(5). none of the above

21b. What is the probability that individual "Z" will have this disease? (5 pts)

1/9

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

22. Suppose that the inbreeding coefficient of individual A in the pedigree below is 0.25. What is the inbreeding coefficient of I? (4 pts.)



$$F_I = \left(\frac{1}{2}\right)^3 (1 + 0.25)$$

$$= \frac{1}{8} \cdot \frac{5}{4}$$

$$= 5/32$$

$$= 0.156$$

5/32

0.156

23. A breeder is trying to shorten the time to flowering in a population of sunflower. In this population, the mean time to flowering is 100 days. Plants with a mean flowering time of 90 days were used to produce the next generation. The narrow-sense heritability for flowering time is 0.2. What will the average time to flowering be in the next generation? (4 pts.)

$$\hat{x}_{offs} = h^2 \bar{x}_{par}$$

$$= 0.2 \times (-10) = -2$$

$$\bar{X}_{offs} = \bar{X} + \hat{x}_{off}$$

$$= 100 + (-2)$$

$$= 98$$

98

24. (10 pts) Fill in the following table with the appropriate DNA, mRNA, or tRNA bases and the correct amino acids. Assume that transcription and translation are from left to right. Do not concern yourself with "wobble" rules.

T	A	C	C	A	T	G	C	A	G	T	C	DNA double helix
A	T	G	G	T	A	C	G	T	C	A	G	
A	U	G	G	U	A	G	C	U	C	A	G	mRNA transcribed
U	A	C	C	A	U	C	G	A	G	U	C	tRNA anticodon
M	e	t	V	a	l	A	l	a	G	l	n	amino acids of protein

25. (8 pts) The following questions test your general knowledge of the replication, transcription, and translation of genetic information.

The thymine content of one species DNA is 29%, therefore the guanine content of this species DNA is 21%.

T=A A=29
C+G=42 G=21

DNA is held together by hydrogen bonds, and there are two of these bonds between every A-T base pair.

Which amino acid is decoded by the tRNA anticodon 3' UGI 5'?
Threonine

5'AGX 3'

Many eukaryotic genes contain enhancers, which act in *cis* to regulate the place, time, and/or level of gene expression.

During translation, new tRNAs are brought to the A site of the ribosome where the amino terminus of the new amino acid is attached to the growing peptide chain.

During replication in eukaryotes, chromosome ends are maintained by an enzyme known as telomerase.

26. (8 pts) In cells of the following genotypes, indicate whether *lac* mRNA and β-galactosidase are made. lac operon genes are indicated by the symbols IPOZY. Enter a "+" or a "-" to indicate whether the mRNA or enzyme are produced in the presence of lactose as the sole carbon source in the medium.

	***lac* mRNA**		**β-galactosidase enzyme**	
Genotype	**no lactose**	**lactose**	**no lactose**	**lactose**
Haploid strains				
$I^{S}P^{+}O^{c}Z^{-}Y^{+}$	+	+	−	−
$I^{-}P^{+}O^{+}Z^{+}Y^{+}$	+	+	+	+
Diploid Strains				
$\frac{I^{-}P^{-}O^{c}Z^{-}Y^{+}}{I^{+}P^{+}O^{+}Z^{-}Y^{+}}$	−	+	−	−
$\frac{I^{s}P^{+}O^{+}Z^{+}Y^{+}}{I^{S}P^{+}O^{c}Z^{-}Y^{+}}$	+	+	−	−

27. (6 pts) Short answer questions about genetic switches.

a) (2 pts) A yeast is unable to make *Gal1* mRNA in the presence of galactose as the sole carbon source. Name <u>two</u> genes in which mutations could yield this phenotype.

GAL 4
GAL 3

b) (2 pts) In embryos homozygous for a mutation that inactivates the gap gene *hunchback*, name <u>two classes</u> of gene expression that will be abnormal.

pair-rule genes
segment polarity genes
homeotic genes

c) (2 pts) A bacteriophage λ lambda is isolated that is unable to form lysogens at 42°C but can form lysogens at 30°C. Name <u>two genes</u> that could contain temperature-sensitive mutations in this phage.

cI
cII
cIII

unable to form lysogens means "clear" mutants

28. (10 pts) The following paragraph contains the roles of regulatory genes in animal development and evolution. Fill in the blank with the most correct term, phrase, or description.

All *Hox* genes are found in clusters, which indicate that they evolved through a process known as gene duplication. While birds, reptiles, and mammals generally have the same number of *Hox* genes, their morphology along the main body axis differs because Hox genes expression is shifted (why?). Individual *Hox* proteins, like most other members of the toolkit, regulate many genes and are therefore said to be pleotropic, meaning having many roles. Mutations in their coding region (what part of the gene?) are likely to be catastrophic, but mutations in cis-regulatory enhancers or sequences can allow the expression of the gene to change in one body part without altering expression elsewhere. Mutations in genes such as MC1R or Oca2, which cause melanism or albinism (which phenotypes?), respectively, are better tolerated because they do not have many functions. Sometimes, however, even mutations that can cause major diseases, such as the HbS (which gene?) mutation that protects against malaria, can be favored because they provide a greater benefit than cost, at least in AS (heterozygotes) (which genotype?). Other mutations may include the complete inactivation a gene, such as occurred in the globin (which gene?) gene of icefish (which species?).

29. (4 pts) The following statements concern the discovery and process of evolution. Circle whether they are true or false (1 pt each).

(True) / False	The Galapagos mockingbirds were pivotal to Darwin's realization that species change..
True / (False)	No fossils were known at the time of the publication of The Origin of Species.
(True) / False	The antifreeze genes in Antarctic fish evolved from a digestive enzyme gene.
True / (False)	Children with the sickle cell mutation never get malaria.

Happy Holidays. Travel Safely.

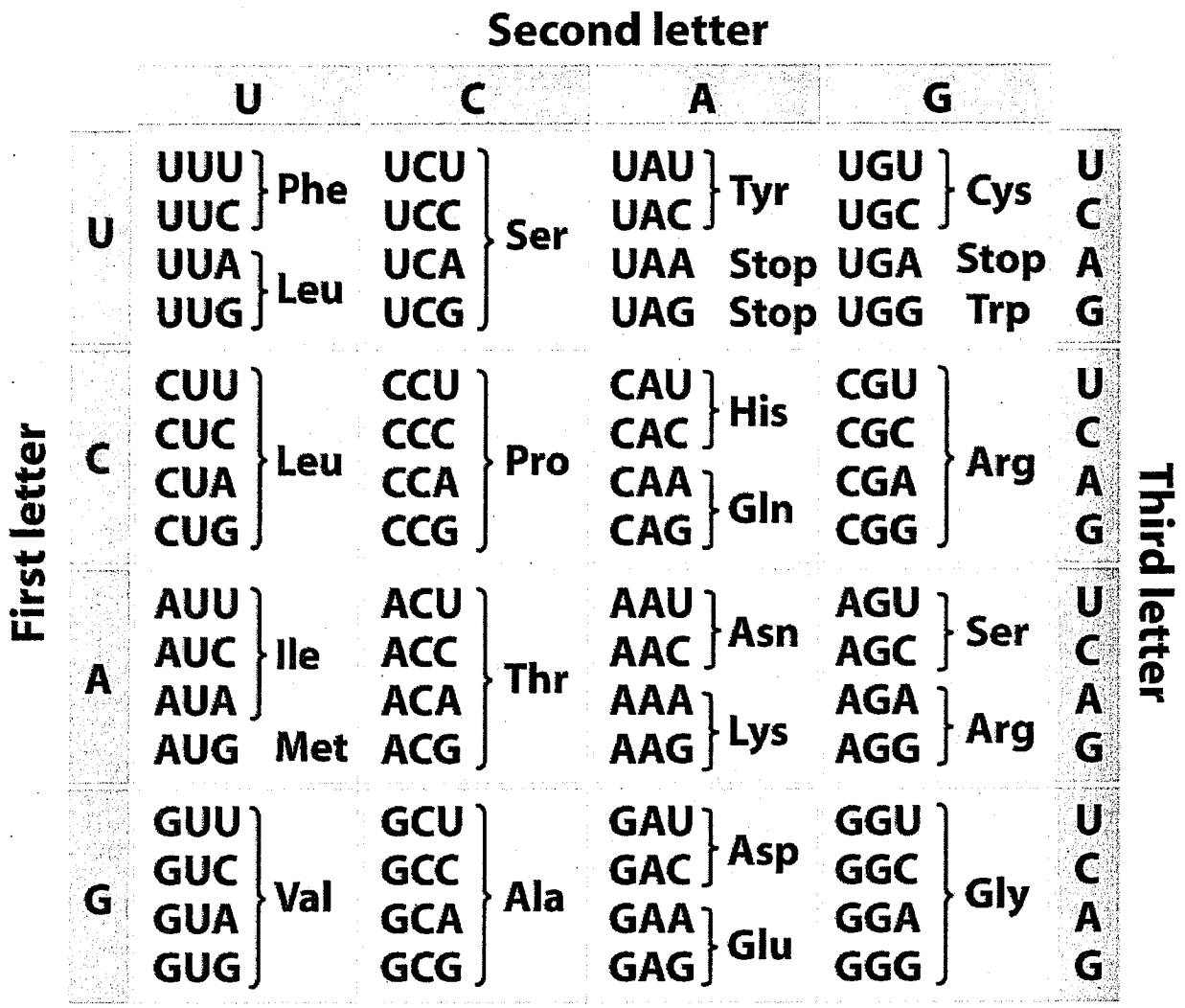


Figure 9-6
Introduction to Genetic Analysis, Ninth Edition

Some Useful Formulae:

$$X = \bar{X} + g + e \qquad V_x = V_g + V_e \qquad V_x = V_a + V_d + V_e$$

$$h^2 = \frac{V_a}{V_x} \qquad \hat{x}_{off} = \bar{x}_{par} h^2 \qquad h^2 = \frac{T_o - \mu}{T_s - \mu} \qquad x = X - \bar{X}$$

$$h^2 = \frac{R}{S} \qquad H^2 = \frac{V_g}{V_x} \qquad r_{XY} = H^2 \qquad x = g + e$$

$$P(A \mid B) = \frac{P(A)P(B \mid A)}{P(\bar{A})P(B \mid \bar{A}) + P(A)P(B \mid A)} \qquad P(k) = \left(\frac{n!}{k!(n-k)!}\right) p^k (1-p)^{n-k}$$

$$P(A) = P(A \mid \bar{B})P(\bar{B}) + P(A \mid B)P(B) \qquad P(A \cup B) = P(A) + P(B) - P(AB)$$

$RF = 1/2 \bullet [T + 2NPD]/N$ $\qquad$ $RF = 1/2 \bullet [1 - e^{-2x}]$

$$F_I = \sum_{loops} \left(\frac{1}{2}\right)^n (1 + F_A)$$

Freq(AA) = $p^2 + Fpq$
Freq(Aa) = $2pq - 2Fpq$
Freq(aa) = $q^2 + Fpq$

$$F = 1 - H$$

Freq(AA) = p^2
Freq(Aa) = $2pq$
Freq(aa) = q^2

$$p = d + \tfrac{1}{2}h \qquad q = r + \tfrac{1}{2}h \qquad p + q = 1 \qquad p^2 + 2pq + q^2 = 1$$

$$D = P_{AB} - p_A p_B$$

$$\hat{p} = \frac{t}{s+t} \qquad \hat{q} \approx \frac{\mu}{s} \qquad \hat{q} = \sqrt{\frac{\mu}{s}}$$