

Biology 210 – Genetics & Evolution – Exam I – Spring 2009

Name (see below): _____

Instructions:

- 1) Print your name (first name first, middle initial and last name) on the line above. Please use the form of your name that matches university records (e.g., no nicknames, or recently changed names).
- 2) Read each question carefully before you begin work on it.
- 3) Be sure to put your final answers in the spaces provided. You may use other areas to show your work, but you will receive full credit only for answers that are clearly indicated.
- 4) Numerical problems. You should be able to do any of these problems without a calculator, but feel free to use one if you want.

Permutations

$$P_r^n = n(n-1)(n-2)\cdots(n-r+1)$$

Combinations

$$\binom{n}{r} = \frac{P_r^n}{r!}$$

Bionomial Probability

$$b(x; n, p) = \binom{n}{x} p^x (1-p)^{n-x}$$

Chi-Square Formula and Table

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

d.f.	Probability				
	0.9	0.5	0.1	0.05	0.01
1	.02	0.46	2.71	3.84	6.64
2	.21	1.39	4.6	5.99	9.21
3	.58	2.37	6.25	7.82	11.34
4	1.06	3.86	7.78	9.49	13.28

Part 1. Mendelian Probabilities. One of the traits that Mendel studied in peas was flower color. A cross between a variety with purple flowers and a variety with white flowers produced F1 progeny with purple flowers. When two of these F1 plants with purple flowers were crossed, the F2 progeny included both purple and white flower plants. (3 points each)

1. What ratio of purple to white flowers is expected in the F2 generation?

3:1 or ¾ purple ¼ white

2. What proportion of the F2 generation is expected to be heterozygous?

1/2

3. If a white flower F2 plant is crossed with an F1 plant, what proportion of the progeny is expected to have white flowers?

1/2

4. What is the probability that two random plants from the F2 generation will both have white flowers?

1/16

5. What is the probability that two random plants from the F2 generation will have the same flower color?

5/8

6. What is the probability that two random plants from the F2 generation will have the same genotype?

3/8

7. What is the probability that two random plants from the F2 generation will have different genotypes?

5/8

8. What is the probability that an F2 plant with purple flowers is a heterozygote?

2/3

Part 2. Combinations, Permutations and Binomial Probabilities. Full credit will be given for setting up the problem with the correct numbers put in the appropriate formula, expanded to show all terms (3 points each).

Example: How many permutations of 3 objects are possible?

Answer: $P_3^3 = 3(3-1)(3-2)$

9. In a clinical trial each subject is given **four** different drugs but only one drug can be taken at a time. The order in which the drugs are taken is important. How many different orderings of the four drugs are possible?

$$P_4^4 = 4(4-1)(4-2)(4-3)$$

10. Interactions between drugs taken at the same time are studied in another clinical trial. Each subject is given **three** different drugs from a list of **ten** drugs. How many different combinations of **three** drugs are possible?

$$\binom{10}{4} = \frac{P_4^{10}}{4!} = \frac{10(10-1)(10-2)(10-3)}{4 \times 3 \times 2}$$

11. Cystic fibrosis is a genetic disease caused by a recessive allele. If two parents who are both heterozygous for this allele have six children, what is the probability that **three of the six children** will have cystic fibrosis?

$$b(x;n,p) = b(3;6,1/4) = \binom{6}{3} (1/4)^3 (3/4)^3 = \frac{6(6-1)(6-2)}{3 \times 2 \times 1} \left(\frac{1}{4}\right)^3 \left(\frac{3}{4}\right)^3$$

Part 3. Mitosis and Meiosis. The diploid number of chromosomes in the mosquito is 6. (3 points each)

12. How many chromosomes are there in a mosquito sperm cell?

3

14. How many **chromatids** are there in a mosquito spermatocyte just after **meiosis I**?

6

13. How many **chromosomes** are there in a mosquito spermatocyte just after **meiosis I**?

3

15. How many **chromatids** are there in a mosquito muscle cell just after **mitosis**?

6

Part 4. Crosses and Chi-squares.

16. An Austrian monk crossed a pure breeding pea plant that was tall and had green pods with a pure breeding plant that was short and had yellow pods. All of the progeny were tall and had green pods. These F1 progeny were then self-fertilized, and produced the progeny listed in the table below.

Phenotype	Number of Plants	Expected Number of Plants
Tall, Green Pods	30	36
Tall, Yellow Pods	12	12
Short, Green Pods	12	12
Short, Yellow Pods	10	4

a. Based on the hypothesis that height and pod are each determined by a gene with two alleles and complete dominance, calculate the expected numbers of each phenotype and fill in the column for expected numbers in the table above (4 points)

b. Write out the complete formula (a term for every phenotype) used to calculate χ^2 for this experiment. (2 points)

$$\chi^2 = \sum \frac{(O-E)^2}{E} = \frac{(30-36)^2}{36} + \frac{(12-12)^2}{12} + \frac{(12-12)^2}{12} + \frac{(10-4)^2}{4} = 10$$

c. In the spaces below, write the value of the chi-square statistic and number of degrees of freedom (2 points)

$\chi^2 =$ 10 with 3 degrees of freedom

d. Use the table on the first page of this exam and a Type I error set at 0.05 to fill in the blanks in the following statement (2 points):

The probability of a deviation as large or larger than the one observed is between 0.01 and 0.05, therefore I would reject (reject/not reject) the hypothesis.

17. A four-o'clock plant with red flowers was crossed with a four-o'clock plant with white flowers and all of the progeny had pink flowers. Two of these plants with pink flowers were crossed, and ten of the progeny had red flowers, twenty had pink flowers, and ten had white flowers. Your null hypothesis is that this is a case of incomplete dominance. (3 points each)

a. What is the chi-square value for this cross? Hint: this is really very easy to do in your head!

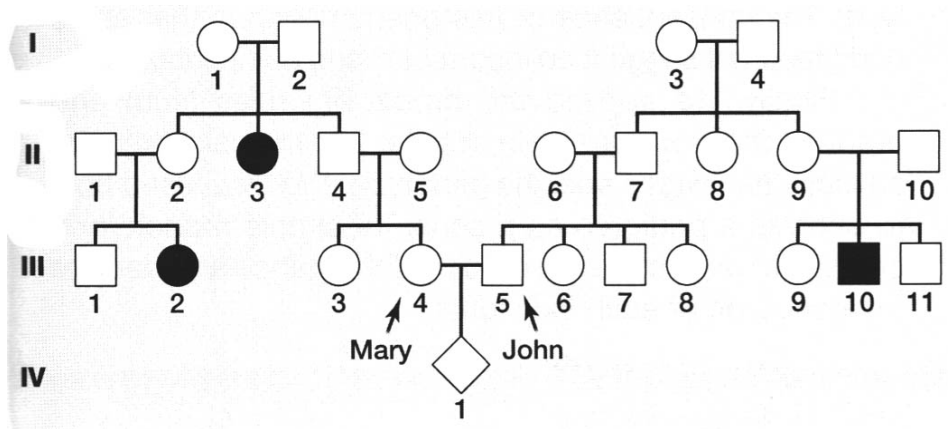
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b. What is the *p* value for this cross? Hint: you should be able to figure out the **exact value**, without even looking at a table!

1

Part 5. Pedigree Chart (10 points)

18. The pedigree chart below shows the inheritance of a rare form of anemia. (This pedigree is from an example in your textbook).



a. What is the mode of inheritance of this disease? (i.e. is it dominant or recessive?, sex-linked or autosomal?)

Autosomal recessive

b. What is the genotype of II-1?

Aa

c. What is the genotype of III-2?

aa

d. What is the probability that II-2 is a carrier of the disease?

1

e. What is the probability that II-4 is a carrier?

2/3

Part 6. Beyond Mendel (3 points each)

19. Color-blindness is a sex-linked trait. Mrs. Smith is color blind, and Mr. Smith is not color-blind. All of their sons are color blind, but none of their daughters are. What are the genotypes of both Mr. and Mrs. Smith?

Mr: XY Mrs: XcXc

20. Mrs. Jones' blood type is A and Mr. Jones doesn't know his blood type. One of their children is type B, and the other is type O. What is the probability that their next child will be type A?

1/4

21. Roan horses have white hairs mixed with other colors. A horse breeder tries to make a pure-breeding line of roan horses, but in every cross between two roan horses about 1/3 of them are non-roan. If you can rule out incomplete penetrance, what genetic model with two alleles at one locus can explain this?

Recessive lethal

22. In the F₂ generation of a trihybrid cross, what proportion of the progeny are expected to be heterozygous at all three loci?

1/8

23. In the F₂ generation of a trihybrid cross with complete dominance, what proportion of the progeny are expected to have the dominant phenotype for all three traits?

27/64

24. In a cross between two different strains of pure-breeding white corn, all of the progeny had purple kernels. What does this suggest about the genes that determined kernel color in the two strains of white corn?

Different genes

25. In mice, the albino locus *C* is epistatic to the Agouti locus, *A*. In mice with the albino locus genotypes *CC* or *Cc* the Agouti locus determines coat color, but mice that are *cc* (homozygous recessive) are albino, and the Agouti locus has no effect on coat color. In a cross between two mice with the genotypes *AaCc*, what proportion of the mice are expected to be albino?

1/4

Part 7. Recombination and Mapping (2 points each)

26. Thread arista (*th*) and raisin eye (*rai*) are recessive traits controlled by autosomal genes on chromosome III of the fruit fly. Wild-type flies that were homozygous for the dominant alleles at both loci (*th+ th+ rai+ rai+*) were crossed with flies that were homozygous for the recessive mutant alleles at both loci (*th th rai rai*). The F1 progeny of this cross were then test-crossed with homozygous recessive flies (*th th rai rai*). The numbers of each phenotype in the progeny of the test-cross were counted, with the following results:

Phenotype	Number
Wild-type	36
Thread arista and raisin eyes	38
Thread arista	12
Raisin eyes	14

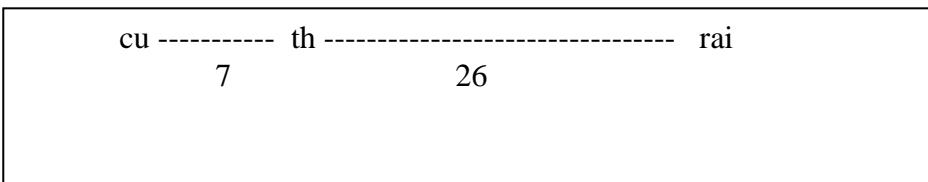
a. Which phenotypes are recombinants?

Thread, raisin eyes

b. What is the estimated rate of recombination between *th* and *rai*?

0.26

c. Another gene, curled wings (*cu*) has a rate of recombination with *th* of 0.07 and a rate of recombination with *rai* of 0.33. Draw a map of the three genes with map distances indicated.



Part 8. Easy Question (2 points)

27. What famous evolutionary biologist who sailed around the world on the ship *Beagle* had his 200th birthday on February 12th last week?

Charles Darwin