

In the following numbered questions (on the left), chose from the possible answers given by the letters (on the right). Not all answers are necessarily used, and some answers might be used more than once.

1. a \_\_\_\_\_ uncovers a recessive allele, it is said to cause pseudodominance.
  2. \_\_\_\_\_ is an accident of cell division in which the homologous chromosomes fail to separate and migrate to opposite poles, responsible for monosomy and trisomy.
  3. A map unit is equivalent to the physical distance along a chromosome which will experience 1 crossover event in every \_\_\_\_\_ meiotic divisions.
  4. \_\_\_\_\_ is an accident of cell division in which the homologous chromosomes fail to separate and migrate to opposite poles, responsible for monosomy and trisom.
  5. A polyploid individual in which sets of chromosomes are derived from different species is an \_\_\_\_\_.
  6. A chromosomal inversion that does not include the centromere is a \_\_\_\_\_ inversion.
  7. \_\_\_\_\_ results because the occurrence of crossing over in a chromosomal region is *not* independent of the occurrence of crossing over in nearby regions.
  8. \_\_\_\_\_ causes the proportion of homozygotes to increase above that expected under Hardy-Weinberg equilibrium.
  9. \_\_\_\_\_ causes random allele frequency change from generation to generation but does not usually lead to significant deviations from Hardy-Weinberg proportion within generations.
  10. \_\_\_\_\_ does not change allele frequencies, but leads to an excess of homozygotes within populations.
- a) 1
  - b) 10
  - c) 50
  - d) 100
  - e) allopolyploid
  - f) autopolyploid
  - g) coefficient of coincidence
  - h) deletion
  - i) duplication
  - j) genetic drift
  - k) inbreeding
  - l) inversion
  - m) interference
  - n) migration
  - o) mutation
  - p) nondisjunction
  - q) nonrandom mating
  - r) paracentric
  - s) pericentric
  - t) selection
  - u) sex limited
  - v) sex-linked
  - w) translocation

1. Pick the most accurate term from the following list to fill in the blank in this statement: a locus with two alleles in which the phenotypic effects of both alleles are expressed in the heterozygote is an example of \_\_\_\_\_

- a) overdominance
- b) epistasis
- c) pleiotropy
- d) codominance
- e) incomplete dominance

2. You find phenotypic variation in body color in a species of earthworm. You cross a pure-breeding red worm with a pure-breeding yellow worm. The F1 offspring from this cross are all red. You self-fertilize one of these F1 offspring, and you see the following phenotypic ratios in the offspring: 207 red: 68 brown: 93 yellow. Which of the following mechanisms do you think controls skin color in this species?

- a) two genes, complete dominance
- b) one gene, normal dominance
- c) one gene, epistasis
- d) two genes, incomplete dominance
- e) two genes, epistasis

3. Two Manx cats are mated. In a large litter, two-thirds of the kittens are Manx and one-third have normal tails. Which symbols below most accurately describe the genotypes of the parental cats?

- a) M/+ and +/+
- b) M/M and +/+
- c) M/+ and M/+
- d) M/- and +/+
- e) M/M and M/+

4. In some plants, a red pigment (cyanidine) is synthesized from a colorless precursor. The addition of a hydroxyl group to the cyanidine molecule causes it to become purple. In a cross between two purple plants, the following results are obtained: 94 purple; 31 red; 43 colorless. Of the following list, what were the most likely genotypes of the parental purple plants?

- a) Aa and Aa
- b) AA and aa
- c) Aa and aa
- d) Aa Bb and Aa Bb
- e) AABB and aabb

5. Black and orange pigments in the coats of cats are determined by an X-linked pair of alleles,  $c^b$  (black) and  $c^o$  (orange). Females are either black ( $c^b c^b$ ), orange ( $c^o c^o$ ) or tortoiseshell with patches of black and patches of orange ( $c^b c^o$ ). Males are either black ( $c^b Y$ ) or orange ( $c^o Y$ ). What genotypes and phenotypes would be expected among the offspring of a cross between a black female and an orange male?

- a) all orange males; all black females
- b) all black males; all orange females
- c) all orange males; all tortoiseshell females

- d) all black males; all tortoiseshell females
- e) all tortoiseshell males; all black females

6. Fragile X syndrome is caused by expansion of the number of CGG repeats in a region immediately adjacent to the FMR-1 gene. Expansion occurs from the normal range (~6 to ~50 repeats) to the permutation range (~55 to ~230 repeats) to the full mutation range (>230 repeats). Expansion to the full mutation tends to occur in the offspring of individuals with permutations, but not in the offspring of individuals within the normal range. This condition is an example of a kind of inheritance called:

- a) incomplete penetrance
- b) genotype-environment interaction
- c) genetic anticipation
- d) recessive X-linked inheritance
- e) dominant X-linked inheritance

7. An individual that is heterozygous for a pericentric inversion will produce:

- a) all abnormal gametes.
- b) 50% normal gametes and 50% gametes containing deletions and duplications.
- c) as above, but only if crossing over occurs within the inversion.
- d) 50% normal gametes; 25% gametes containing dicentric chromosomes; 25% gametes containing acentric chromosomes.
- e) as above, but only if crossing over occurs within the inversion.

8. Assume that a chiasma forms between genes A and B in 12% of the meioses of an individual of genotype AB//ab. The // represent two homologous chromosomes that contain the A and B genes: one homolog contains the A and B alleles and the other contains the a and b alleles. You cross this individual to an ab//ab individual, and examine resulting progeny. What proportion of the testcross progeny will be Ab//ab ?

- a) 0%
- b) 3%
- c) 6%
- d) 12%
- e) 24%

9. In *Drosophila*, a heterozygous female for the X-linked recessive traits a, b, and c was crossed to a male that phenotypically expressed a, b, and c. The offspring occurred in the phenotypic ratios given below. The next two questions refer to this data.

+ b c	460
a + +	450
a b c	32
+ + +	38
a + c	11
+ b +	9
+ + c	0
a b +	0

What is the order and correct linkage pattern of the alleles in the heterozygous female parent?

- a) + b c / a + +
- b) a c b / + + +
- c) a + c / + b +
- d) + + c / b a +
- e) a c + / + + b

10. What pair of map distances below represents the correct map distances between linked genes for this problem?

- a) 11; 9
- b) 14; 4
- c) 38; 11
- d) 70; 20
- e) 7; 2

11. What is the interference in the above cross?

- a) 0
- b) 0.2
- c) 0.4
- d) 0.8
- e) 1.0

12. In a large randomly mating population of peas, the pod-color alleles, G=green and g=yellow are at frequencies of 0.75 and 0.25, respectively, and green is dominant to yellow. You sample peas from 400 plants in this population. By doing a series of test-crosses, you discover that 220 plants have genotype GG, 155 have genotype Gg, and 25 have genotype gg. Can you reject the hypothesis that this population is in Hardy-Weinberg equilibrium (and what is the value of the test statistic and the P value, assuming that the d.f.=1.)

- a) No;  $\chi^2=0.001$ ;  $P>0.90$ ;
- b) No;  $\chi^2=0.28$ ;  $P>0.50$ ;
- c) Yes;  $\chi^2=0.28$ ;  $P>0.90$ ;
- d) No;  $\chi^2=0.10$ ;  $P>0.90$ ;
- e) No;  $\chi^2=1.00$ ;  $P>0.20$ ;

13. Consider a gene with two alleles (A and a). The a allele causes a debilitating disease when homozygous, and causes reduced fertility when heterozygous. Relative fitnesses of the three genotypes are:  $W_{AA} = 1.0$ ;  $W_{Aa} = 0.5$ ;  $W_{aa} = 0.0$ . In a population, 1/10,000 infants are born with the disease, and 198/10,000 individuals are heterozygotes. Assume the population starts at H-W genotype proportions, and that selection operates on survival, but no other forces are acting. What will the allele frequencies be after one generation of selection? (Let p' be the frequency of the A allele and q' be the frequency of the a allele.)

- a)  $p'=0.99$ ;  $q'=0.01$
- b)  $p'=0.98$ ;  $q'=0.02$
- c)  $p'=0.995$ ;  $q'=0.005$
- d)  $p'=0.998$ ;  $q'=0.002$
- e)  $p'=0.999$ ;  $q'=0.001$

14. List 5 processes that cause deviations from Hardy-Weinberg predictions.

15. Which of these processes cause adaptive evolution and which cause non-adaptive evolution?

16. List two kinds of natural selection that can actively maintain genetic variation within populations.

17. On average, how many new mutations is each individual human born with?

18. a) Selfing reduces the heterozygosity of a population by \_\_\_\_\_ per generation. b) Brother-sister and parent-offspring mating reduce the heterozygosity of a population by \_\_\_\_\_ per generation.

19. Two biologists are enjoying an evening stroll along the shore of Lake Michigan. They find a group of bugs (all the same species) on the beach. Some are living and some are dead. Having nothing better to do they collect the insects and bring them to the lab. They measure the wingspan of all the bugs. The mean value for the entire sample is 5.6 mm. The living bugs have a mean wingspan of 6.4 mm. They keep the surviving bugs and breed them and rear up the offspring. The offspring have a mean wingspan of 5.8 mm. What is the heritability of wingspan?

- a) 0.2
- b) 0.25
- c) 0.5
- d) 1.0
- e) 1.2

20. Genetic and non-genetic variances for traits related to running speed was determined for a herd of thoroughbred race horses.

	Hind leg length	Muscle mass
Environmental variance	25	20
Dominance variance	5	5
Additive variance	10	5

Which trait would respond fastest to directional selection, given the same selection differential?

## Formulae, etc.

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

### $\chi^2$ Table

Probabilities						
df	0.90	0.50	0.20	0.05	0.01	0.001
1	0.02	0.46	1.64	3.84	6.64	10.83
2	0.21	1.39	3.22	5.99	9.21	13.82
3	0.58	2.37	4.64	7.82	11.35	16.27
4	1.06	3.36	5.99	9.49	13.28	18.47

$cc = \text{Obs}/\text{Exp}$

$I = 1 - cc$

$R = h^2S$

$V_P = V_A + V_D + V_E$

$h^2 = V_A/V_P$

$H^2 = V_G/V_P$

$H^2 = 2(r_i - r_f)$

$p + q = 1$

$p^2 + 2pq + q^2 = 1$

$\bar{W} = p^2W_{AA} + 2pqW_{Aa} + q^2W_{aa}$

$p' = p^2 W_{AA}/\bar{W} + pq W_{Aa}/\bar{W}$

$q' = q^2 W_{aa}/\bar{W} + pq W_{Aa}/\bar{W}$

$q_e = \sqrt{\frac{U}{S}}$