's Book of Genetics
FUN!

Live today like you're gonna die tomorrow Gus. But we're fruit flies so it's pretty much true.
Basic Genetics Problems
SHOW YOUR WORK FOR ALL PROBLEMS OR YOU WON’T RECEIVE CREDIT!!!

1. For any gene with a dominant allele \( C \) and recessive allele \( c \), what proportions of the offspring from a \( CC \times cc \) cross are expected to be homozygous dominant, homozygous recessive, and heterozygous.

2. An organism with the genotype \( BbDD \) is mated to one with the genotype \( BBdd \). Assuming independent assortment of these two genes, write the genotypes of all possible offspring from this cross and calculate the chance of each genotype occurring using the rules of probability.

3. What is the probability that an offspring form the cross in question 2 will exhibit either of the 2 recessive traits coded by the \( b \) and \( d \) alleles. Explain.

4. An organism that has the genotype \( AaBbCc \) is crossed with an organism that has the genotype \( AABbCc \). Assume all genes are on separate chromosomes.
   a) What is the probability that any of the offspring will have the genotype \( AABBCC \)?
   b) What is the probability that any of the offspring will have the genotype \( AaBbcc \)?

5. Consider the cross \( AaBbCcddEe \times AABBccDDEe \).
   a) What is the probability that any offspring will have the genotype \( AaBBCcDdEE \)?
   b) What is the probability that any offspring will have the genotype \( AABBCCDDee \)?

6. Maple sugar urine disease is a rare inborn error of human metabolism in which the urine of affected individuals smells like maple sugar. If 2 unaffected individuals have an affected child, what is the chance that the second child will be unaffected?
7. Mendel crossed tall pea plants with dwarf ones. The F₁ plants were all tall. When these F₁ plants were selfed to produce the F₂ generation, he got a 3:1 tall to dwarf ratio of offspring. Give the genotypes and phenotypes and relative proportions of the F₃ generation produced when the F₂ generation was selfed.

8. In a cross of \(AaBbCcDd\) to \(AabbCCDD\), the frequency with which we would expect to obtain progeny of the genotype \(AABbCcDd\) is....?

9. In a cross of \(AaBbCcDd\) to \(AabbCcDD\), the proportion of progeny that show all four dominant traits is....?

10. If the hypothetical autosomal dominant gene \(N\) is necessary for the production of the pigment required for normal vision and autosomal dominant gene \(S\) results in blindness because of the disorganization of neuronal synapses in the eye, what proportion of the progeny produced by the cross \(Nnss \times nnSs\) will be blind?

11. Assume that straight hair \((S)\), golden brown fur \((G)\), and hairy ears \((H)\) are dominant to curly hair, dark brown fur, and hairless ears. All three loci assort independently. In a cross of \(SsGgHH\) with \(SSGgHh\), how many different phenotypes would be found among the progeny?

12. Let us assume that two genes affect pod development in strains of beans you are studying. Long pods \((L)\) is dominant to short pods \((l)\), and round seeds \((R)\) is dominant to wrinkled seeds \((r)\). In the progeny produced from one cross, you find the following types and proportions of plants: 3/8 long and round, 3/8 long and wrinkled, 1/8 short and round, 1/8 short and wrinkled. What are the phenotypes and genotypes of the parent plants?

13. A woman asks the following question: “My husband and I plan to have a family of three children. We already have two girls. What is the probability that all of our children are girls?” What is your answer?

14. Polydactyly (extra fingers and toes) is due to a dominant gene. A father is polydactyl, the mother has the normal phenotype, and they have one normal child. What is the genotype of the father? Of the mother? What is probability that a second child will have the normal number of digits?
15. Two true-breeding varieties of garden peas are crossed. One parent had red, axial flowers, and the other had white, terminal flowers. All F₁ individuals had red, terminal flowers. If 100 F₂ offspring were counted, how many of them would you expect to have red, axial flowers?

16. A brown-eyed, long-winged fly is mated with a red-eyed, long-winged fly. The progeny are

51 long, red       18 short, red
53 long, brown    16 short, brown

What are the genotypes and phenotypes of the parents?

17. In peas, tall (T) is dominant to short (t), yellow (Y) is dominant to green (y), and round (R) is dominant to wrinkled (r). From a cross of two triple heterozygotes, what is the chance of getting a plant that is

a. Tall, yellow, round?

b. Short, green, wrinkled?

c. Short, green, round?

18. In corn, the genotype A_C_R_ is colored. Individuals homozygous for at least one recessive allele are colorless. Consider the following crosses involving colored plants all with the same genotype. Based on the results, deduce the genotype of the colored offspring.

Colored x aaccRR → ½ colored, ½ colorless

Colored x aaCCrr → ¼ colored, ¾ colorless

Colored x AAccrr → ½ colored, ½ colorless
Non-Mendelian Genetics Problems
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19. In fruit flies, the most common eye color is red. One allele of the gene for eye color produces white eyes. The gene is located on the X chromosome.

   a) What is the probability that a heterozygous red-eyed female fruit fly mated with a white-eyed male will produce any white-eyed offspring?

   b) What is the probability that the mating in part (a) will produce any white-eyed females?

   c) What is the probability that this mating will produce any white-eyed males?

20. A heterozygous brown-eyed human female who is a carrier of color blindness marries a blue-eyed male who is not color blind. Color blindness is a sex-linked trait. Assume that eye color is an autosomal trait and that brown is dominant over blue. What is the probability that any of the offspring produced will have the traits listed?

   a) Brown eyes

   b) Blue eyes

   c) Color blindness

   d) Color blind males

   e) Brown-eyed, color blind males

   f) Blue-eyed, color blind females

   g) What is the probability that any of the males will be color blind?

21. In a variety of onions, three bulb colors segregate: red, yellow, and white. A plant with a red bulb is crossed to a plant with a white bulb and all the offspring have red bulbs. When these are selfed, the following plants are obtained:

   Red-bulbed     119
   Yellow-bulbed  32
   White-bulbed   9

   What is the mode of inheritance of bulb color and how do you account for the ratio?
22. Four o’clock plants have a gene for color and a gene for height with the following phenotypes:

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Color</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR</td>
<td>red</td>
<td>tall</td>
</tr>
<tr>
<td>Rr</td>
<td>pink</td>
<td>medium</td>
</tr>
<tr>
<td>rr</td>
<td>white</td>
<td>dwarf</td>
</tr>
<tr>
<td>TT</td>
<td></td>
<td>tall</td>
</tr>
<tr>
<td>Tt</td>
<td></td>
<td>medium</td>
</tr>
<tr>
<td>tt</td>
<td></td>
<td>dwarf</td>
</tr>
</tbody>
</table>

If a dihybrid plant is self-fertilized, give the proportions of genotypes and phenotypes produced.

\[ RrTt \times RrTt \quad RRTT \quad RRTt \quad RRtt \quad RRTt \]

23. A particular variety of corn has a gene for kernel color and a gene for height with the following phenotypes:

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Kernel Color</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC, Cc</td>
<td>purple</td>
<td>tall</td>
</tr>
<tr>
<td>cc</td>
<td>white</td>
<td>dwarf</td>
</tr>
<tr>
<td>TT</td>
<td></td>
<td>medium</td>
</tr>
<tr>
<td>Tt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tt</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If a dihybrid plant is selfed, give the resulting proportions of genotypes and phenotypes produced.

24. In the ABO blood system in human beings, alleles A and B are codominant and both are dominant to the O allele. In a paternity dispute, a type AB woman claimed that one of four men was the father of her type A child. Which of the following men could be the father of the child on the basis of the evidence given? Explain.

a. Type A  
b. Type B  
c. Type O  
d. Type AB

25. True-breeding tall red-flowered plants are crossed with dwarf white-flowered plants. The resulting F₁ generation consists of all tall pink-flowered plants. Assuming that height and flower color are each determined by a single gene locus on different chromosomes, predict the results of an F₁ cross of dihybrid plants. Choose appropriate symbols for the alleles of the height and flower color genes. List the phenotypes and predicted ratios for the F₂ generation.
26. In a family, the father and mother have normal red-green color vision. Red-green color blindness is a sex-linked recessive trait in humans. If their son is color-blind and their daughter has normal vision, give the genotypes of all members of the family.

27. A woman with blood type O has a child with blood type O. She claims that a friend of hers is the child’s father. Explain your answers to the questions below.

   a) His blood type is A. Can he be excluded as the father on this evidence alone?

   b) Does the fact that the accused man’s mother is type A and his father is type AB permit him to be excluded?

   c) Does the additional information that his mother’s parents are both AB permit him to be excluded?

28. Assume that a gene for baldness (B) is dominant to its allele for hair production (b) and that a gene for curly hair (Cy) is dominant to its allele for straight hair (cy). The two loci are not linked, and baldness shows the dominant epistasis over hair form. In a cross of BbCycy x bbcycy, the expected progeny will show what proportion of phenotypes?

29. Some years ago, the well-known movie star Charlie Chaplin was named in a paternity suit by an actress. Her blood type was A, the child’s was B, and Chaplin’s was O. The first jury was hung; the second found him guilty. What do you think of the verdict, and why?

30. In rabbits, the homozygous CC is normal, Cc results in rabbits with deformed legs, and cc is lethal. For a gene for coat color, the genotype BB produces black, Bb brown, and bb a white coat. Give the phenotypic ratio of offspring for a cross of a deformed-leg, brown rabbit with a deformed-leg, white rabbit.
31. In dogs, black (B) is dominant to chestnut (b), and solid color (S) is dominant to spotted (s). What are the genotypes of the parents in a mating that produced 3/8 black solid, 3/8 black spotted, 1/8 chestnut solid, and 1/8 chestnut spotted puppies? (Hint: First determine what genotypes the offspring must have before you deal with the fractions.)

A: $I^A I^a m$ $I^a I^A$

32. Two pigs whose tails are exactly 25 cm in length are bred over 10 years and they produce 96 piglets with the following tail lengths:

- 6 piglets at 15 cm
- 25 at 20 cm
- 37 at 25 cm
- 23 at 30 cm
- 5 at 35 cm

a) How many pairs of genes are regulating the tail length character. (Hint: count the # of phenotypic classes, or determine the sum of the ratios of the classes)

b) What offspring phenotypes would you expect from mating between a 15-cm and 30-cm pig?

33. Fur color in rabbits is determined by a single gene locus for which there are four alleles. Four phenotypes are possible: black, Chinchilla (gray color caused by white hairs with black tips), Himalayan (white with black patches on extremities), and white. The black allele (C) is dominant over all other alleles, the Chinchilla allele ($C^{ch}$) is dominant over Himalayan ($C^h$), and the white allele (c) is recessive to all others.

a. A black rabbit is crossed with a Himalayan, and the $F_1$ consists of a ratio of 2 black to 2 Chinchilla. Can you determine the genotypes of the parents? Explain.

b. A second cross was done between a black rabbit and a Chinchilla. The $F_1$ contained a ratio of 2 black to 1 Chinchilla to 1 Himalayan. Can you determine the genotypes of the parents of this cross? Explain.

34. In Labrador retriever dogs, the dominant gene B determines black coat color and bb produces brown. A separate gene E, however, shows dominant epistasis over the B and b alleles, resulting in a golden coat color. The recessive e allows expression of B and b. A breeder wanted to know the genotypes of her three dogs, so she breeds them and makes note the offspring of several litters. Determine the genotypes of the three dogs.

a. golden female (Dog 1) x golden male (Dog 2)
   offspring: 7 golden, 1 black, 1 brown

b. black female (Dog 3) x golden male (Dog 2)
   offspring: 8 golden, 5 black, 2 brown
35. In the human ABO blood system, the alleles \( A \) and \( B \) are dominant to \( O \). What possible phenotypic ratios do you expect from a mating between a type A individual and a type B individual?

36. Two short-eared pigs are mated. In the progeny, three have no ears, seven have short ears, and four have long ears. Explain these results by diagramming the cross.

37. A plant with red flowers is crossed with a plant with white flowers. All the progeny are pink. When the pink flowers are crossed, the progeny are 11 red, 23 pink, and 12 white. What is the mode of inheritance of flower color? Explain.

38. In screech owls, crosses between silver and red individuals sometimes yield all red; sometimes \( \frac{3}{4} \) red : \( \frac{1}{4} \) silver; and sometimes \( \frac{1}{2} \) red : \( \frac{1}{4} \) white : \( \frac{1}{4} \) silver offspring. Crosses between two red owls yield either all red, \( \frac{3}{4} \) red : \( \frac{1}{4} \) silver, or \( \frac{3}{4} \) red : \( \frac{1}{4} \) white offspring. What is the mode of inheritance? Explain.

39. A man with hemophilia (a recessive, sex-linked condition) has a daughter of normal phenotype. She marries a man who is normal for the trait.

   a) What is the probability that a daughter of this mating will be a hemophiliac?

   b) That a son will be a hemophiliac?

   c) If the couple has four sons, what is the probability that all four will be born with hemophilia?
40. The ability to taste phenylthiocarbamide (PTC) is controlled in humans by a single dominant allele (T). A woman nontaster married a main taster, and they had three children, two boy tasters and a girl nontaster. All the grandparents were tasters. Create a pedigree for this family for this trait. (Solid symbols should signify nontasters tt.) Where possible, indicate whether the tasters are TT or Tt.

41. Albinism is inherited as an autosomal recessive. In the figure below, assuming that persons from the general population are not heterozygous for albinism (Aa), what are the genotypes of all persons whose genotypes are known? (i.e., indicate the genotypes on the figure for all known AA, Aa, and aa individuals)
42. A man has a double row of eyelashes, which he inherited from his mother as a dominant trait. His maternal
grandfather is the only other relative to have the trait. He marries a woman with normal eyelashes, and their
first daughter has normal eyelashes. The couple is now expecting a second baby, which they hope has double
eyelashes.

a) What is the chance that the second baby will have double eyelashes?

b) Draw a pedigree for this family, accounting for all known individuals and genotypes.
43. In guinea pigs, black (B) is dominant to brown (b), and solid color (S) is dominant to spotted (s). A heterozygous, black, solid-colored pig is mated with a brown, spotted pig. The total offspring for several litters are:

- Black, solid = 16
- black, spotted = 5
- brown, solid = 5
- brown, spotted = 14

Are these genes linked or unlinked? If they are linked, how many map units apart are they?

44. The following recombination frequencies were found. Determine the order of these genes on the chromosome.

- \(a,c\): 10%
- \(b,c\): 24%
- \(a,d\): 30%
- \(b,d\): 16%

45. Recombination frequency is given below for several gene pairs. Create a linkage map for these genes, showing the map unit distance between loci.

- \(j,k\): 12%
- \(k,l\): 6%
- \(j,m\): 9%
- \(l,m\): 15%

46. Genes \(A\), \(B\), and \(C\) are located on the same chromosome. Testcrosses show that the recombination frequency between \(A\) and \(B\) is 28% and between \(A\) and \(C\) is 12%. Can you determine the linear order of these genes? Explain.
47. You design *Drosophila* crosses to provide recombination data for gene $a$, which is located on the same chromosome shown below. Gene $a$ has recombination frequencies of 14% with the vestigial-wing locus and 26% with the brown-eye locus. Where is $a$ located on the chromosome?