**1.** 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. What is the probability that a daughter of this mating will be a hemophiliac? A son? If the couple has four sons, what is the probability that all four will be born with hemophilia?

**Solution**

Genotypes:

A man with hemophilia is XhY where h = hemophilia gene and H = the normal gene.
Any daughter with normal phenotype whose father has hemophilia will be a carrier.

Her genotype must be:

**XhXH and NOT XHXH**

We can use a Punnett square to show the probability of a daughter or son having hemophilia.

**daughter** x **normal man**

**XhXH**  x  **XHY**



**A.** If the daughter marries a normal male the probability of a daughter having hemophilia is **zero**.

**B.** About **50%** **of male children** would have hemophilia (Boxes 2 and 4 above)

**C.** The probability that all 4 sons have inherited hemophilia would be: 1/2 x 1/2 x 1/2 x 1/2 or **1/16** **= 0.0625 = 6.25%.**

**2.** Pseudohypertropic muscular dystrophy is a disorder that causes gradual deterioration of the muscles. It is seen only in boys born to apparently normal parents and usually results in death in the early teens. (a) Is pseudohypertrophic muscular dystrophy caused by a dominant or recessive allele? (b) Is its inheritance sex-linked or autosomal? (c) How do you know? Explain why this disorder is always seen in boys and never girls.

**Solution**

**(a)** Pseudohypertropic muscular dystrophy is a **recessive allele** because if it were dominant then the heterozygous female would die before she was sexually mature, and thus could not pass on the trait

**(b)** Pseudohypertropic muscular dystrophy is a **sex-linked trait** because it only occurs in males.

**(c)** It is **never seen in girls** because for a girl to be homozygous recessive (and express the trait) XmXm, her father would have to be hemizygous recessive XmY) and her mother would have to be heterozygous or homozygous recessive (XmXM or XmXm). It is impossible for a homozygous recessive male or a homozygous recessive female to have children because they will die before

 being old enough to have children.

****

The Punnett square above shows that in a cross between two apparently normal parents, but the mother is a carrier, three children will be normal but one, always a boy will inherit the disease**.**

**3.** Red-green color blindness is caused by a sex-linked recessive allele. A color-blind man marries a woman with normal vision whose father was color-blind. (a) What is the probability that they will have a color-blind daughter? (b) What is the probability that their first son will be color-blind? (Note: the two questions are worded a bit differently.)

 **Solution**

The first step in solving this problem requires an examination of the possible genotypes of the parents. As stated color-blindness is a recessive sex linked trait. So the genotypes of the parents should be:

mother's genotype (normal vision but whose father was color blind) **XNXn**

She is a **carrier** because of her heterozygous condition. For the recessive gene to be expressed one must be homozygous for it.

father's genotype (color blind) **XnY**

****

**From the Punnett square it is obvious that half of the children will be color blind and the other half will be normal. More specifically there will be 1 normal boy to 1 color-blind boy to 1 normal girl to 1 color- blind girl.**

**XNXn one normal (carrier) girl**

**XNY one normal boy**

**XnXn one color blind girl**

**XnY one color blind boy**

1. Probability of having a color blind daughter is**(1/2 x 1/2) or 1/4 or 25% (0.25)**This is because both sex and colorblindness are involved in the solution.
2. The probability that their first son is color blind is **1/2 (0.50) = 50%.**

 *(In this question only males are part of the solution.)*

**4.** A wild-type fruit fly (heterozygous for gray body color and normal wings was mated with a black fly with vestigial wings. The offspring had the following phenotypic distribution: wild type, 778; black- vestigial, 785; black-normal, 158; gray-vestigial, 162. What is the recombination frequency between these genes for body color and wing type.

**Solution**

First count the total number of offspring **778+785+158+162 = 1883**

In all dihybrid test crosses (*a cross between a known heterozygote for two wild type traits and a homozygous recessive individual for both traits*) the expected ratio of phenotypes if the genes are on separate chromosomes must be:

wild type, 25%; black-vestigial, 25% black-normal, 25%; gray-vestigial, 25%. These results do not fit the experimental data above (778+785+158+162).

In fact the **black-normal (158)** and **gray-vestigial (162)** offspring represent **recombinant** individuals because they have a phenotype **different from the parents (P1).**

Calculation of recombination frequency:

778 - wild type

785 - black-vestigial

*158 - black-normal*

*162 - gray-vestigial*

**Recombination frequency = # of Recombinants = 320 = 0.169 = 17%**

 **Total # of Offspring 1883**

The generally accepted method of symbolizing the genotypes for a dihybrid cross of linked genes is as follows (pg. 264 - Campbell):

 b+ = wild-type (gray body)

 b = black body

 vg+ = normal wing shape

 vg = vestigial wings

The testcross is symbolized as follows: 

If no cross over occurs then only two phenotypes should be seen. That is 50% of the offspring should be dominant for both traits ---- and the other 50% should be homozygous recessive ---- just as in the parents above.

**5.** In another cross, a wild-type fruit fly (heterozygous for gray body color and red eyes) was mated with a black fruit fly with purple eyes. The offspring were as follows: wild-type, 721; black-purple, 751; gray- purple, 49; black-red, 45. (a) What is the recombination frequency between these genes for body color and eye color? (b) Following up on this problem and problem 4, what fruit flies (genotypes and phenotypes) would you mate to determine the sequence of the body color, wing shape, and eye color genes on the chromosomes?

**Solution**

To help see the process write out the genotypes. The genes can be symbolized as follows:

 b+ = gray body

 b = black body

 pr+= red eyes

 pr = purple eyes

Genotype of the heterozygous wild type (gray body and red eyes) using Morgan's method:



The genotype of the homozygous recessive individual (used in a testcross) would be:



Determine the recombination frequency:

721 wild-type (gray-red)

751 black-purple

49 gray-purple

45 black-red

 (Total flies = 1566)

**(a) Recombination frequency = # of Recombinants = 94 = 0.060 = 6%**

 **Total # of Offspring 1566**

The percent recombination is**6%**

 Therefore the **recombination frequency between genes T and A is 6%**

**6.** A space probe discovers a planet inhabited by creatures who reproduce with the same hereditary patterns as those in humans. Three phenotypic characters are height (T = tall, t = dwarf), hearing appendages (A = antennae, a = no antennae), and nose morphology (S = upturned snout, s = downturned snout). Since the creatures were not "intelligent" Earth scientists were able to do some controlled breeding experiments, using various heterozygotes in testcrosses. For a tall heterozygote with antennae, the offspring were tall-antennae, 46; dwarf-antennae 7; dwarf-no antennae 42; tall-no antennae 5. For a heterozygote with antennae and an upturned snout, the offspring were antennae-upturned snout 47; antennae-downturned snout, 2; no antennae-downturned snout, 48: no antennae-upturned snout 3. Calculate the recombination frequencies for both experiments.

**Solution**

Experiment 1. (Frequency/Distance between T and A)

Determine the recombination frequency for the genes controlling Tallness and Antennae:

 46 tall-antennae

 42 dwarf-no antennae

 **7 dwarf-antennae**

 **5 tall-no antennae**

 (Total = 100)

**Recombination frequency = # of Recombinants = 12 = 0.12 = 12%**

 **Total # of Offspring 100**

The percent recombination is **12%**

Therefore the **recombination frequency between genes T and A is 12%**

Experiment 2. (Frequency/Distance between A and S)

Determine the recombination frequency for the genes controlling Antennae and Snout: 47 antennae-upturned snout

 48 no antennae-downturned snout

 ***2 antennae-downturned snout***

 ***3 no antennae-upturned snout***

 **(Total = 100)**

**Recombination frequency = # of Recombinants = 5 = 0.05 = 5%**

 **Total # of Offspring 100**

 **The percent recombination is therefore 5%**

 **Therefore this recombination frequency between genes A and S is 5%**

**7.** Using the information from problem 6, a further testcross was done using a heterozygote for height and nose morphology. The offspring were tall-upturned nose, 40; dwarf-upturned nose, 9; dwarf-downturned nose, 42; tall-downturned nose, 9. Calculate the recombination frequency from these data; then use your answer from problem 6 to determine the correct sequence of the three linked genes.

**Solution**

(Frequency/Distance between T and S)

Determine the recombination frequency for the genes controlling Tallness and Snout: 40 tall-upturned snout

 42 dwarf-downturned snout

 *9 dwarf-upturned snout*

 *9 tall-downturned snout*

 **(Total = 100)**

**Recombination frequency = # of Recombinants = 18 = 0.18 = 18%**

 **Total # of Offspring 100**

The percent recombination is therefore**18%**

**Therefore this recombination frequency between genes T and S is 18%**

One can determine the relative frequency between genes using the percent frequencies as distances (map units or centimorgans:cM).

The Recombinant relationships from experiments 1-3 are:

 **Exp. 1 T-A = 12 map units / centimorgans (cM)**

 **Exp. 2 A-S = 5 map units / centimorgans (cM)**

 **Exp. 3 T-S = 18 map units / centimorgans (cM)**

An arrangement that fits the data would be:

****

**8.** What pattern of inheritance would lead a geneticist to suspect that an inherited disorder of cell metabolism is due to a defective mitochondrial gene?

**Solution**

The disorder would always **be inherited from the mother because the mother's mitochondrial gene is the only one that survives when the zygote is formed**. The gamete from the mother contains all the information. The head of the father's sperm is the only part that survives during fertilization. The tail of the sperm containing the male's mitochondria (an their genes) is lost when the zygote begins development. Thus it is only from the mother that the disorder can be inherited.

**9.** Determine the sequence of genes along a chromosome based on the following recombination frequencies:

 A-B = 8 map units; A-C = 28 map units; A-D = 25 map units; B-C = 20 map units; B-D = 33 map units.

**Solution**

To solve this type of genetics problem choose the greatest map distance (in this case 33) and place the genes involved at opposite ends of a line representing a portion of the chromosome in question.

B-D = 33 map units so:



Now choose a gene combination with either B or D in it. For example:

A-D = 25 map units:



Two combinations remain: A-C = 28 and B-C = 20. Where to put the C-gene? Since:

a) the distance from A to B is about 8 (see above) and

b) the distance from C to B is less than the distance from A to B

the C-gene must be to the left of the B-gene. So:



**10.** In Drosophila, the gene for white eyes and the gene that produces "hairy" wings have both been mapped to the same chromosome and have a crossover frequency of 1.5%. A geneticist doing some crosses involving these two mutant characteristics noticed that in a particular stock of flies, these two genes assorted independently; that is they behaved as though they were on different chromosomes. What explanation can you offer for this observation?

**Solution**

One possibility is that a translocation has occurred where a segment of chromosome containing only one of the 2 genes has moved to a different chromosome.

****

***\* \* \* Don’t worry if you don’t fully understand this question. \* \* \****

**11. Solution**

 **X2 = *5.15***

***Since your chi square value of 5.15 > 3.85 (critical value at p 0.05 with 1 degree of freedom) you must REJECT the null hypothesis.***

**12. Solution**

 **X2 = *0.16*** *(your answer may be SLIGHTLY different due to rounding)*

***Since your chi square value of 0.16 < 7.82 (critical value at p 0.05 with 3 degrees of freedom) you must ACCEPT the null hypothesis.***