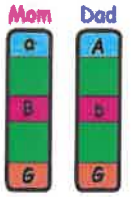
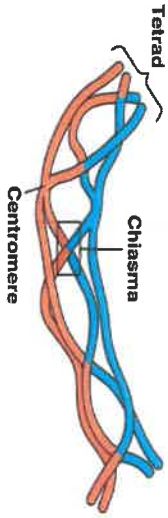
7. Gene Linkage and Cross-over



2 Chromosomes
3 Genes
6 Alleles

- Thomas Hunt Morgan
  1910 → Working with fruit flies he proved that genes on the same chromosome tended to be inherited together.
  = **Linked genes** ie. Eye color and hair color
- However, Morgan also noticed that he did not always get typical Mendelian ratios for his dihybrid crosses (9:3:3:1)
- He reasoned this was due to crossing over that occurs during meiosis
  - when paired, homologous chromosomes twist together (synapse), pieces of genetic material break off and reattach in new places
  - these new genes then are called **recombinants**
  - zygotes formed from these gametes will have new **phenotypes**
- The placement locus of the gene on a chromosome determines the chances of a cross over events for that gene
  - the longer the chromosomes, and the closer the gene is to the end of the chromosome, the greater the chance for a cross over



Sex Linkage

- Morgan also noticed that sometimes only males would express a recessive trait and females wouldn't in the normal ratio so he did test crosses of fruit flies for eye color
  - He crossed a red eyed female with a white eyed male

P_1 = RR x rr

	R	R
r	Rr	
r		

100% were red eyed = red is dominant

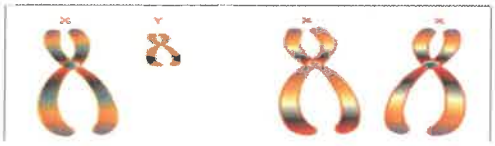
  - He then bred 2 offspring from the F_1 generation

F_1 = Rr x Rr

	R	r
R	RR	Rr
r	Rr	rr → male

Ratio of Red eyes to White eyes = 3:1 but ...
all the white eyed flies were MALE

- Morgan concluded:
  - of the 4 sets of fruit fly chromosomes, only 3 are identical (**autosomal**)
  - the fourth set were different in males and in females = sex chromosomes
    - Males: XY Females: XX



  - Y chromosomes are smaller and carry very few genes (except sex determination),
  - Males can contribute an **X or a Y** to offspring but females can only contribute an **X**
    = males determine the sex of the offspring
  - Traits that are found on the X chromosome are called **Sex Linked Traits**
    = **X-Linked Traits**
  - Humans = 46 chromosomes: 22 pairs of autosomes, 1 set of sex chromosomes
- In this class, we assume the Y chromosome carries no genes.
- For crosses, determining probability of sex linked traits is written as follows:
  XX = female ♀ XY = male ♂

  Ie. In humans, color blindness is a sex linked trait, males who carry the gene will be color blind because they only have one X chromosome

  B = normal sight b = color blind

  A female who is heterozygous for color blindness marries a color blind man. What are the phenotypic and genotypic ratios of their offspring.

$P_1 = X^BX^b \times X^bY$

	X^B	X^b
X^b	X^BX^b	X^bX^b
Y	X^BY	X^bY

Phenotypes: 50% normal
50% colorblind

Ratio: 1:1

Genotypes: 25% heterozygous ♀
25% homozygous cb ♀
25% homozygous normal ♂
25% homozygous cb ♂

Ratio: 1:1:1:1

What are the chances of having a colorblind child, either sex? 2/4 = 50%

What are the chances of having a colorblind boy? 1/4 = 25%

Chance ♂ = 1/2 × Chance CB = 1/2 ∴ 1/2 × 1/2 = 1/4

****Note: Genotypic Ratios are affected because of the different sexes.**