Chapter 15
Chromosomes, Mapping, and the Meiosis - Inheritance Connection

EXTENSIONS (not really EXCEPTIONS)
Sex Linkage

*Drosophila melanogaster*
fruit fly species
eats fungi on fruit
generation time 2 weeks

Fruit flies - three pairs of autosomes and a pair of sex chromosomes (XX in females, XY in males).

Thomas Hunt Morgan discovered a mutant male fly with white eyes instead of the usual red eyes (wild type).

Could this new trait be inherited in a Mendelian fashion?

Results:
F1 progeny = red dominant

F2 progeny = actually >3:1 overall
all white eyed F2 flies were males!

all females and ¼ males are wild type
Possible explanation for F2 results = white eyed female flies don’t exist? Not viable?

Test cross shows white eyed females can exist
Need alternative explanation – eye color LINKED TO SEX

X-linked

- Gene with the white-eyed mutation is on the X chromosome alone
  - Males with mutation have white eyes because they have only 1 X chromosome
  - For females to have white eyes, must have a mutation on both chromosomes.

- Why not on Y chromosome?
  - Y chromosome in flies carries almost no functional genes

Sex Chromosomes and Sex Determination

Structure and # sex chromosomes vary in different species

In humans, Y chromosome determines “maleness”
- very condensed

autosomes = all other chromosomes besides sex chromosomes
Default = female?
• SRY gene on Y Chromosome responsible for "maleness"

EXCEPTIONS
- movement of a part of the Y chromosome to the X chromosome = male

- Androgen insensitivity syndrome – XY individuals develop as female because body fails to respond to androgens (female hormones)

Human Genetic Disorders & Sex Linkage

Affects males more than females
• Red-green color blindness—ability to absorb the different-colored wavelengths in light.
• Hemophilia—blood-clotting protein (Factor VIII)
  - Allele for hemophilia introduced into European royal families by Queen Victoria of England
  - In 5 generations after Victoria, 10 males decedents had hemophilia
Human Chromosomes
- Human somatic cells normally have 23 pairs of chromosomes.
  - divided into seven groups characterized by size and shape
  - 22 pairs of autosomes
  - 1 pair of sex chromosomes
    - XX = Female
    - XY = Male

Value of Having Two X Chromosomes
- X chromosome that male gets from his mother determines phenotype
- Diseases caused by X-linked recessive alleles more common in males than females
- Women have two X chromosomes, so can be heterozygous but still have normal color vision

Dosage compensation - one of X chromosomes in females inactivated early in development
Ensures equal level of expression from sex chromosomes

X inactivation Random
Inactivated chromosome is highly condensed and is visible as darkly staining Barr body attached to nuclear membrane
Random X inactivation

- Female mammals inherit two X chromosomes, BUT only ONE is active
  - One X chromosome in each cell condenses into a Barr body
  - Its genes are inactivated

- The condensed Barr body chromosome is reactivated in ovarian cells that produce ova

Mary Lyon—Barr body occurs randomly and independently in embryonic cells at the time of X inactivation

- Females are mosaics—some active paternal X, others active maternal X
  - After Barr body formation, all descendent cells have the same inactive X
  - If female is heterozygous for sex-linked trait, approximately half her cells will express one allele and other half will express other allele

X inactivation = genetic mosaics

Cells express different alleles, depending on which chromosome inactivated also epistasis!

Expressed gene is epistatic—suppressed is hypostatic.

X chromosomes

Allele for orange fur
Allele for black fur

Cell division and X chromosome inactivation

Active X
Inactive X
Black fur
Orange fur

Two cell populations in adult cat:
Genetic Maps from Human Genome

Anonymous markers - molecular techniques
no detectable phenotype

Single Nucleotide Polymorphisms (SNPs)
- polymorphisms – any differences b/w individuals in a population
(2 million!!)

SNPs - affect single base of a gene loci
Gene Disorders Due to Protein Alteration

- Sickle-cell anemia recessive
  - defective hemoglobin, unable to properly transport oxygen
  - Heterozygotes have sickle-cell.
    - Heterozygotes usually appear normal, but are resistant to malaria.

Sickle cell disease

- 1 in 400 African Americans
- Single amino acid substitution!
- Hemoglobin deforms
- Carriers healthy – except under stress
- Carriers – alleles are codominant
- Benefit? Malaria resistance
- Homozygous normal – die of malaria
- Homozygous recessive die of sickle cell anemia
- Carriers - OK
Nondisjunction of Chromosomes

Failure of homologues (sister chromatids) to separate during meiosis = nondisjunction

Leads to gain or loss chromosome - aneuploidy
humans who’ve lost a copy of an autosome - monosomics

gained - trisomics
Exceptions to Chromosomal Theory of Inheritance

- MITOCHONDRIA from mom
  - Organelles usually come from mom; ALL mitochondria come from egg
  - Maternal Inheritance
- Chloroplast genes
  - Usually maternal, depends on species