Reading Assignment for Genetics & Meiosis Lectures:

Chapter 20  pg. 659-679
Work questions 20-6, 7, 8, 10, 15,

In eukaryotic cells the genetic material in the nucleus is partitioned into chromosomes and the processes that parcel out the chromosomes are known as

- **mitosis** -- conservative, asexual propagation of genetic material

- **meiosis** -- non-conservative, sexual propagation of genetic material
Making connections:

KNOW THIS WELL AND FOREVER:
Diagram tracks one pair of homologous chromosomes in a diploid organism of 2n=2
**diploid**: a cell or organism with two sets of chromosomes (2n)

**haploid**: a cell or organism with one set of chromosomes (1n or n)

\( n = \) the number of chromosomes per set

Diploids have *two copies* or *two homologs* of each different type of chromosome
• Typical sexual lifecycle for a **diploid organism** – we spend most of our “existence” in the diploid form

• **Haploid organisms** spend most of their existence in the haploid form

**somatic cell:** any non-germline cell
**Meiosis I (reductional division)**
Homologous chromosomes are separated into different cells: each daughter cell contains one duplicated copy of each type of chromosome *(the number of chromosomes is cut in half)*

**Meiosis II (equational division)**
Sister chromatids are separated into different cells *(like a mitotic division)*
The stages of Meiosis I and Meiosis II and Mitosis have the same names

**Prophase**
- duplicated chromosomes condense
- *in meiosis I there are extra events*

**Late Prophase or Prometaphase**
1. nuclear envelope breaks down
2. spindle fibers attach to the kinetochore -- which is located at the centromere

**Metaphase**
- chromosomes align at the metaphase plate

**Anaphase**
- in mitosis and meiosis II, centromeres divide and sister chromatids are pulled to opposite poles of the cell
- in meiosis I, homologs separate but sister chromatids stay together

**Telophase**
- nuclear envelope reforms
- cytokinesis (division of the cytoplasm) occurs
- chromosomes become less condensed
Cells enter prophase of MI after replication of DNA and passage through G2

In prophase of MI
• the duplicated chromosomes condense as in mitosis

Two events occur in prophase of Meiosis that don’t happen in mitosis:
• synapsis of homologous chromosomes
• crossing-over
synapsis:
• close pairing (physical association) of homologs
• the pairing is based on DNA sequence homology (identity or close similarity) between the chromosomes

Homologous chromosomes
• chromosomes that possess the same genes at corresponding positions
• chromosomes that pair with each other during meiosis
crossing over:
• a precise breakage and reunion event that occurs between two non-sister chromatids
• pieces of the DNA strands in the two chromatids are exchanged

Crossover between homologous chromosomes
Diploid cell
\( n = 2, 2n = 4 \)

- **G1, S, G2**
- homologs
- centromere
  (= kinetochore + DNA)
- sister chromatids
- Meiosis I
- Meiosis II
- Mitosis

OR
Meiosis is a non-conservative propagation of genetic information: the products of meiosis have a different genetic composition than the mother cell

- Maternal and paternal chromosomes are randomly combined in the products of meiosis
- Crossing-over increases genetic variation by producing new combinations of maternal and paternal genetic information
Meiosis generates gametes with many genetic combinations. 

Diploid cell: $n = 2, \ 2n = 4$

Independent assortment

Crossing over

Meiosis I

Meiosis II
MEIOSIS I and II

**Meiosis**
- Paternal Chromosome with two chromatids
- Kinetochore of Paternal Chromosome
- Kinetochore of Maternal Chromosome
- Spindal Micotubules
- Pole of Spindle

**Mitosis**
- Chromatid II
- Chromatid I
- Kinetochore II
- Kinetochore I
- Pole of Spindle

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**Meiotic Metaphase I**
- Meiotic Metaphase I

**Meiotic Anaphase I**
- Meiotic Anaphase I

**Meiotic Metaphase II**
- Meiotic Metaphase II


**Kinetochore fibers of sister chromatids point in opposite directions**

**S U D D E N D E T A C H M E N T O F S I S T E R K I N E T O C H O R E S**

**ARM OF SISTER CHROMATIDS BECOME UNGLUED**

**MEIOSIS I and II**
What’s so great about sexual reproduction?

Genetically speaking?

What is the textbook explanation?
But there is another genetical issue here

The scientific world is up in arms about Asexual Amazon Molly

No sex for all-girl fish species

A fish species, which is all female, has survived for 70,000 years without reproducing sexually, experts believe.

Scientists from the University of Edinburgh think the Amazon Molly may be employing special genetic survival "tricks" to avoid becoming extinct.

The species, found in Texas and Mexico, interacts with males of other species to trigger its reproduction process.

The offspring are clones of their mother and do not inherit any of the male's DNA.

Typically, when creatures reproduce asexually, harmful changes creep into their genes over many generations.

The species will eventually have problems reproducing and can often fall victim to extinction.

uproar over Amazon Molly continues on the next page
The species will eventually have problems reproducing and can often fall victim to extinction.

Scientists at Edinburgh University have been studying complex mathematical models on a highly powerful computing system to look at the case of the Amazon Molly.

Researchers calculated the time to extinction for the fish based on modelling genetic changes over many thousands of generations.

They are now able to say conclusively, for the first time, the fish ought to have become extinct within the past 70,000 years, based on the current simple models.

Scientists believe the fish, which are still thriving in rivers in south-east Texas and north-east Mexico, are using special genetic survival "tricks" to help them stay alive.

One theory is that the fish may occasionally be taking some of the DNA from the males that trigger reproduction, in order to refresh their gene pool.

**Species tricks**

Dr Laurence Loewe, of the university's School of Biological Sciences, said: "What we have shown now is that this fish really has something special going on and that some special tricks exist to help this fish survive.

"Maybe there is still occasional sex with strangers that keeps the species alive. Future research may give us some answers."
The Amazon molly ....... eggs contain an unreduced set of chromosomes, that need the sperm of one of the sister species .... mechanical trigger to start development

Background
The Amazon molly (Poecilia formosa) is a small unisexual fish that has been suspected of being threatened by extinction from the stochastic accumulation of slightly deleterious mutations that is caused by Muller's ratchet in non-recombining populations. However, no detailed quantification of the extent of this threat is available.

MULLERS RATCHET: name given to the process by which the genomes of an asexual population accumulate deleterious mutations in an irreversible manner.

MULLERS RATCHET = GENOMIC DECAY in the absence of a “cleansing effect of meiosis”
The Genetical FACTS of LIFE:
1. Mutations happen
2. Many mutations cause a decrease in fitness

How would meiotic processes reduce the rate of “genomic decay”?

Consider two individuals of genotype $CcDd$
$CdDD$

- The $C$ and $D$ alleles don't confer an advantageous fitness But $c$ and $d$ are bad:
- Need to purge $c$ and $d$ via sexual reproduction
Y can’t the Y chromosome get no respect?

The disrespected Y chromosome:

The mammalian Y chromosome had been considered by many to be a genetic shambles -- a virtual genetic wasteland:

- Recent estimates though suggest that the Y chromosome carries a whopping 300 genes in its 58 Megabases of DNA
  

  - Compare this to the smallest autosomes chromosomes: 21 (50 Mb) and 22 (48 Mb), which have ~352 and ~742 confirmed genes respectively

  - the X chromosome carries hundreds of confirmed genes -- current count is 1336 genes in 155 Mb of


- The Y chromosome is riddled with unusual amount of “junk” DNA: sequences of DNA that contain no protein coding instructions and have no apparent function
The X & Y chromosomes orginated a few hundred million years ago from the same pair of ancestral autosomes.

So 300 million years ago the primordial X and Y shared the same set of genes

Y then is the Y a shadow of its former self?

MapView of X chromosome

MapView of Y chromosome:
Y then is the Y a shadow of its former self?

MapView of X chromosome:
The X & Y chromosomes orginated a few hundred million years ago from the same ancestral autosome. **Y then is the Y a shadow of its former self?**  

The functionally specialized Y chromosome highlights two evolutionary processes that are thought to have produced the mammalian chromosome:  
- genetic decay  
- accumulation of genes that specifically benefit male fitness  

About 300 million years ago the mammalian X and Y chromosome probably looked a lot like a pair of homologous autosomes  

(300 million years = paleozoic/mesozoic/cenozoic?) before/during/after dinosaurs?)  

*Next page shows evidence supporting this statement?*
Presence of the genes in the pairing region on both chromosomes and the handful of housekeeping genes scattered throughout the differential region that are on both sex chromosomes.

MAP of the y chromosome
- vertical line represents chromosome (polymer of DNA)
- the position of specific gene on the chromosome is indicated by the mutant phenotype that defines the gene’s existence

Yellow bar: NRY = non-recombining region
RED BAR: pairs and recombines with X-chromosome
Genes to the right have X-chromosome homologs
Genes to the left do not
RED gene names: widely expressed housekeeping genes
BLACK gene Names: expressed in the testes only
The loss of genes in the Y chromosome probably resulted from a series of events which included:

1. **Evolution of the male-determining SRY gene from a gene (called SOX) found on both ancestral chromosomes (the X chromosome still carries a copy of this gene)**

2. **Chromosomal rearrangements between the ancestral X & Y chromosomes**: progressive loss of recombination between increasingly larger segments of the ancestral X and Y chromosomes [due to chromosomal inversions that inhibited crossing-over]

3. **Ancestral Y starts to accumulate mutations**: loss of recombination meant that on the evolving Y chromosome mutations accumulated in genes—these mutations couldn’t be purged by recombination with a homolog

4. **Over millions of years, the number of functional genes on the Y chromosome declines dramatically**

**BUT why didn’t the X chromosome decay?**
Mutations on the evolving X chromosome could be purged by recombination that occurred during meiosis in female animals
Bananas in the fertility clinic  Having shunned sex for thousands of years, bananas are in trouble. Those grown commercially are sterile mutants, propagated by replanting the suckers that sprout from existing trees. Lacking the genetic shuffling of sex, the single variety that dominates the export market is susceptible to any pest that evolves to evade its defences against disease.

In the late 1990s, the emergence in Southeast Asia of a new strain of Panama disease, a wilt caused by the fungus *Fusarium oxysporum*, devasted commercial plantations. It has since spread to Australia and Africa, and if it lands in Latin America, where most export bananas are grown, farmers will need a new resistant variety.