**BIO1.LS3.1 Model chromosome progression through meiosis and fertilization in order to argue how the processes of sexual reproduction lead to both genetic similarities and variation in diploid organisms. Compare and contrast the processes of sexual and asexual reproduction, identifying the advantages and disadvantages of each.**

**(Numbers refer to page numbers in the student edition of Miler & Levine Biology)**

Pages: 340-349 (cell division, sex vs. non, chromosomes, cell cycle, mitosis)

393-399 (Diploid vs. haploid, meiosis, gene linkage and mapping*)*

**CCC: Students use cause and effect models at one scale to make predictions about the behavior of systems at different scales**

**SEP: Students test the predictive abilities of their models in a real-world setting and make comparisons of the two models of the same process or system**

**Introduction: (22-23)**

Points to emphasize:

All living things reproduce (some sexually, some asexually)

All living things as their genetic code and pass this down generations

Production of gametes cells that are used for sexual reproduction

In humans his occurs in the germ cellsof the:

-testes and ovaries creating sperm & egg

Like mitosis, meiosis passes chromosomes from one generation to the next

But meiosispromotes much more genetic variability than mitosis!

**Cute video that students may enjoy: https://www.youtube.com/watch?v=VzDMG7ke69g**

**Sexual vs. Asexual (341-342)**

Points to emphasize:

In asexual reproduction, a single individual is the only parent of an organism. They are essentially copies of the parent (exact genetic copies)

-An amoeba may split using binary fission, a hydra may have an identical offspring budding off of it

Also used in repairing, growing the body

Asexual populations grow very rapidly

Genetic variety only happens occasionally in asexual reproduction as a result of mutations

In sexual reproduction, two parents give rise to offspring that have *unique combinations* of genes

Produces genetic variety!

- family resemblance, but not exact copies

**SEP: AQDP-Some organisms cycle between sexual and asexual reproduction during their lifecycle or under environmental stress. How do they use this to their advantage?**

**Chromosomes return! (review the coiling of chromosomes)**

Points to emphasize:

DNA is bundled into packages called chromosomes

DNA is very thin

DNA wraps around proteins called histones, forming a nucleosome **(SEP:MOD-beads on a string)**

This collection of nucleosomes (beads on a string) is called **chromatin**

The chromatin may continue to coil during cell division and become visible under the microscope🡪visible **chromosomes**

**Describe cell cycle (345-346)**

Points to emphasize:

Like humans live their lives in stages

Most of a cell’s life is interphase

Interphase is composed of G1, S, G2

When first discovered, the cell didn’t seem to be doing much (G=GAP) but in G1 the cell is very busy growing and carrying out cell functions

S phase is where the DNA synthesizes and makes a copy of the DNA so it can divide

G2 is like a space shuttle countdown, many careful checks are made before the cell divides

**(CCC: CE** [**https://www.nasa.gov/mission\_pages/shuttle/launch/countdown101.html**](https://www.nasa.gov/mission_pages/shuttle/launch/countdown101.html) **why does the cell have safety checks before taking on the process of division?**

Mitosis phase: the cell splits into two identical daughter cells. If done properly, these cells will be not just the exact same, but the same as the parent as well

**Mitosis (346-349)**

Points to emphasize:

Four phases: Prophase, Metaphase, Anaphase, Telophase

Prophase: Prep phase

-Chromosomes condense, remember the cell has gone through S phase so the chromosome looks like an “X”. The original chromosome and the copy together are now called **sister chromatids** (“joined at the hip”). They attach at a point called a centromere

Even though it has an “X” form, it still counts as a ***single* chromosome**

The way to count how many chromosomes there are, is to count the **centromeres (attachment point)**

**-**The nucleus disappears; the chromosomes are free!

**-**Centrioles (located in a “home” called a centrosome) move to opposite ends of the cell (the “poles”)

Centrioles grow out tubes called spindle fibers which are like little fingers that grab onto the chromosomes and move and pull them

Metaphase: Line up in the middle

-The spindle fibers carefully move the chromosomes to the middle of the cell, the “X” shaped chromosomes are lined up single file

Anaphase: The spindle fibers pull the sister chromatids apart moving them to either side of the cell

Telophase: Two distinct cells start to form

-Two separate nuclei start to reform

-Two distinct cell membranes emerge

Cytokinesis: This is not a stage of mitosis! The word means “cell-movement”, this occurs usually in telophase where the cell starts to pinch inward, causing the cell to split

(**SEP: AQDP-These two cells still have the same number of chromosomes; how did we do that?)**

**Activity A: Mitosis exercise (playdough, tape, marker) (SEP:MOD)**

**Diploid vs Haploid (393-399)**

Points to emphasize:

We humans inherit *one chromosome set* from each parent.

A paternal set (from our father)

A maternal set (from our mother)

-a set = 23 chromosomes

Giving us humans 46 chromosomes in our somatic “body” cells and germ cells.

*A single set of chromosomes is represented by the letter n.*

Any cell with two chromosome sets is called a diploid cell

-(abbreviated as 2*n*)

For humans (2*n* = 46)

Gametes have only a single set of chromosomes

These cells are called haploid cells (*n*).

SO IN A HUMAN, IF 2n=46, HOW MANY CHROMOSOMES WILL BE IN THE HAPLOID CELL?

n=23

HOW ABOUT A HEDGEHOG? (2n=90)

*n=45*

A new human life cycle begins when a haploid sperm from the father fuses with a haploid egg from the mother

This fusion of cells is called fertilization. The resulting fertilized egg, or zygote, is now diploid (2n)

This zygote will undergo many series of mitosis and create a new body

**Mitosis vs Meiosis differences (396)**

Points to emphasize:

In the human body, mitosis is essentially cloning cells making many exact copies of themselves.

This occurs in most of the body’s cells (somatic cells)

Special germ cells found in the testes and ovaries will undergo a special division called meiosis

Instead of cloning exact copies, meiosis will take the germ cell and eventually divide, ending with 4 unique cells called gametes.

These will become sperm and egg

**Homologous Pairs**

Points to emphasize:

If you were to look at a human cell under the microscope when the chromosomes are very dense...

You would notice the 23 matching pairs

- (one paternal, one maternal)

The matching chromosomes (same length, centromere position, staining pattern) are called homologous pairs

Both chromosomes are essentially the same, coding for the same inherited traits

[**http://cosbiology.pbworks.com/f/1267565925/module10-02.png**](http://cosbiology.pbworks.com/f/1267565925/module10-02.png)

The X and Y chromosomes are the exception in human cells.

Human females have a homologous pair of X chromosomes (XX), but males have one X and one Y chromosome (XY).

The X and Y chromosomes are called sex chromosomes. The other chromosomes are called autosomes.

**Meiosis I (394)**

Points to emphasize:

Meiosis will use the same mechanisms as mitosis

BUT will undergo PMAT twice!

(Review Mitosis stages above if needed)

During prophase I:

The two homologues pairs find each other and sit so close together, they may crossover each other, forming a tetrad

This crossing over is a DNA “swap” between the homologs

- (little bit of mom rubs off on dad and vice versa)

During metaphase I:

Unlike mitosis where the chromosomes line up single file along the middle…

**Homologous pairs lining up on each side of the division line is unique to meiosis!**

During Anaphase I Homologous pairs separate and spindle fibers move them toward opposite ends of the cell

Telophase I ends the same way as mitosis, but:

-The two resulting cells only have one entire set of chromosomes (n) unlike the original cell which had (2n) or two copies

- Meiosis I is a reductional division (reduces the number of chromosomes)(Diploid🡪Haploid) **(CCC:SPQ)**

**Meiosis II (395)**

Points to emphasize:

**The goal is to separate the sister chromatids**

**No duplicates, no special exceptions happen in meiosis II, basically it’s just mitosis**

Prep the cell, line up in the middle (single file!), two distinct cells form in telophase thanks to cytokinesis (just something that happens, NOT a phase of mitosis)

This results in 4 BRAND NEW haploid cells that are genetically unique from each other AND the parent cell

Meiosis II is an **equational division**

(It’s equal! Haploid🡪Haploid)

**Activity B: Meiosis exercise (playdough, tape, marker) (SEP:MOD)**

**Sexual reproduction produces variety in the genetics of a population (SEP: CE)**

Points to emphasize:

**Independent assortment**

Remember in our class demonstration you weren’t instructed anyone on how to line up along the division, you were **independent** in your choice on which side you stood on

It may not seem like much of a difference, but the combinations are astronomical!

The possible combinations are 2n where n=haploid number

**WHAT THE NUMBER OF POSSIBLE CHROMOSOMAL ARRANGEMENT IN YOUR GAMETES? (SEP: MATH)**

223=8,400,000

Just by pairs being about to independently assort to either side

**Crossing over**

Due to the crossing over that took place in prophase I, the chromosomes in the sperm or egg are not exclusively maternal or paternal.

The gametes now contain **recombinant chromosomes,** brand-new arrangements of the genetic material in a sequence never before seen!

Combine this with the effects of random mating (no one should tell you who you should be mating with!) and mutation…

This makes you one of a kind, nothing before or after the universe will probably be quite like you. **All thanks to meiosis, and your parents**

NOTE: It may be helpful to define very similar words on the board of the class:

**(Ex. Chromatin, Chromosome, Sister chromatids, centromere, centriole, centrosome)**