

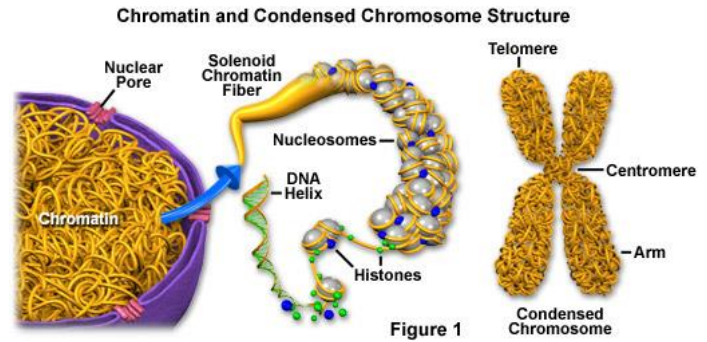
## Unit 5, Topic 1: DNA Organization

By the end of this topic, you should be able to...

1. Identify the parts of a chromosome
2. Explain why DNA has to copy and coil before cell division
3. Explain why cells cannot continue to grow forever
4. Explain how prokaryotes reproduce (binary fission)

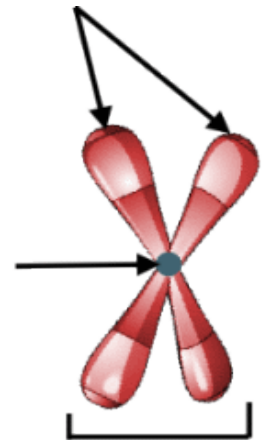
### Organization of Genetic Material

- All the DNA in a cell constitutes the cell's \_\_\_\_\_
- A genome can consist of a number of DNA molecules
- DNA molecules in a cell are packaged into \_\_\_\_\_
- Eukaryotic chromosomes consist of \_\_\_\_\_, a complex of DNA and protein that \_\_\_\_\_
- Every eukaryotic species has a characteristic number of chromosomes in each cell nucleus  
*How many chromosomes are in humans? \_\_\_\_\_*
- Non-reproductive cells have \_\_\_\_\_ of chromosomes



### DNA terms (LABEL THE IMAGE TO THE RIGHT!)

- In preparation for cell division, DNA is replicated and the chromosomes \_\_\_\_\_
- Each duplicated chromosome has two \_\_\_\_\_ which separate during cell division
- The \_\_\_\_\_ - is where the two chromatids are most closely attached



### Growth vs. Division

- When an animal or plant grows, what happens to its cells? Does an animal get larger because each cell increases in size (grows) or because it produces more of them?

\_\_\_\_\_  
\_\_\_\_\_

### Why can't cells grow forever?

- **REASON 1:** \_\_\_\_\_. As the cell increases in size, it keeps the same amount of DNA. Eventually the cell will grow too much for the DNA to control all its activities
  - What is "DNA Overload?" \_\_\_\_\_
  - Why do we age? \_\_\_\_\_
- **REASON #2:** \_\_\_\_\_ of membrane doesn't increase as quickly as cell \_\_\_\_\_
  - Too little membrane → not enough exchange of materials in and out of the cell

### The Solution

- Before a cell becomes too large, it divides to form 2 \_\_\_\_\_
- This process is called \_\_\_\_\_

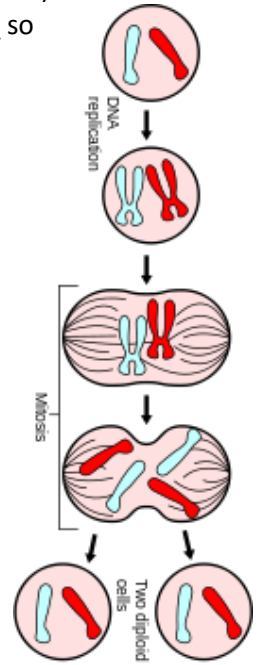
- Cell division can only happen once a cell has made a \_\_\_\_\_ so that each daughter cell can have a full genetic library

**Why Divide?**

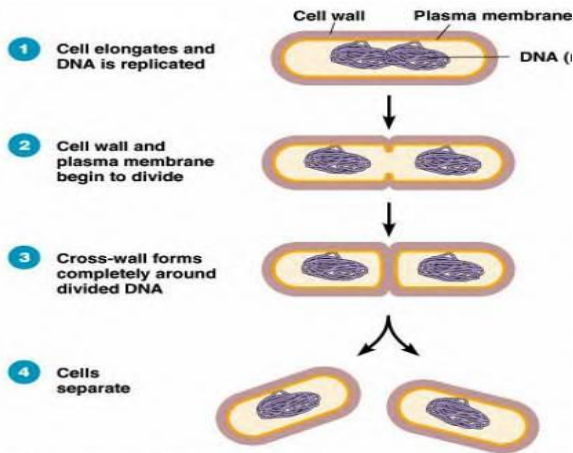
- Multicellular organisms depend on cell division for
  - \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_
- Cell division is an integral part of the \_\_\_\_\_, the life of a cell from formation to its own division

**Binary Fission in Bacteria** = simplistic version of cell division

- Prokaryotes (bacteria and archaea) reproduce by a type of cell division called \_\_\_\_\_
- In binary fission, the DNA replicates, and the two daughter chromosomes actively move apart
- The \_\_\_\_\_ pinches inward, dividing the cell into two



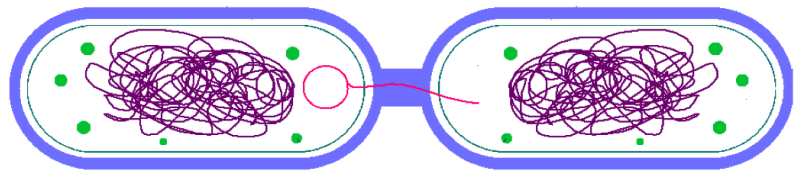
**Bacterial Reproduction**



(a) A diagram of the sequence of cell division.  
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- Binary Fission (\_\_\_\_\_): cell parts reproduce and cell divides in half
- The most common form of bacteria reproduction
- Produces \_\_\_\_\_ daughter cells.
- Conjugation (SEXUAL):** \_\_\_\_\_ of genetic material (plasmid) between two bacterium
- One bacterium transfers the \_\_\_\_\_ to the other bacterium through the conjugation bridge.
- This produces genetic diversity in bacteria that may \_\_\_\_\_

1. Can pick up resistance to antibiotics this way!



**[[Language Target for Topic 1: I can identify the parts of a chromosome given a diagram; I can use images to describe how DNA coils up before cell division and verbally explain the purpose.]]**

- Draw and label a chromosome with two sister chromatids; centromere; long arm (x2); short arm (x2); telomere
- Explain why DNA coils up prior to cell division:

## Unit 5, Topic 2: Mitosis

By the end of this topic, you should be able to...

- Explain why cells must divide
- Draw and label the stages of mitosis
- Compare and contrast animal cell division and plant cell division (cytokinesis)
- Compare and contrast prokaryotic and eukaryotic cell division

### Purpose of Mitosis

- To create two \_\_\_\_\_ from one parent cell
- Cells begin \_\_\_\_\_ (2 sets of chromosomes) and end \_\_\_\_\_

### Vocabulary to know

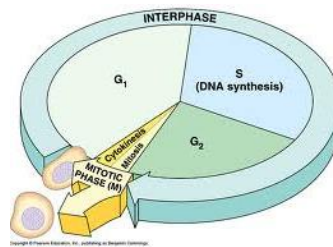
- Diploid (2n): \_\_\_\_\_ sets of \_\_\_\_\_ (one from each parent)
  - Example: \_\_\_\_\_
  - What kinds of cells are diploid? \_\_\_\_\_
- Haploid (n): \_\_\_\_\_ set of chromosomes (example: sex cells)
  - Example: \_\_\_\_\_
  - What kinds of cells are haploid? \_\_\_\_\_
- Sex Chromosomes: determine the \_\_\_\_\_ of an organism; either \_\_\_\_\_ or \_\_\_\_\_ (Male = \_\_\_\_\_; Female = \_\_\_\_\_)
- Autosomes: all the other \_\_\_\_\_ in an organism
- Cell cycle: the series of events that cells go through as they \_\_\_\_\_ and \_\_\_\_\_
  - A cell \_\_\_\_\_, preps for \_\_\_\_\_, and divides to form TWO \_\_\_\_\_; each of them then goes through the same process

### Stages of the Cell Cycle

- G<sub>1</sub>, S and G<sub>2</sub> = \_\_\_\_\_
- Mitosis
- Cytokinesis

### The Steps prior to Cell Division

- the cell doubles in size (\_\_\_\_\_)
- chromosomes replicate (\_\_\_\_\_)
- the number of organelles doubles (\_\_\_\_\_)
- most doubling is directed by the \_\_\_\_\_

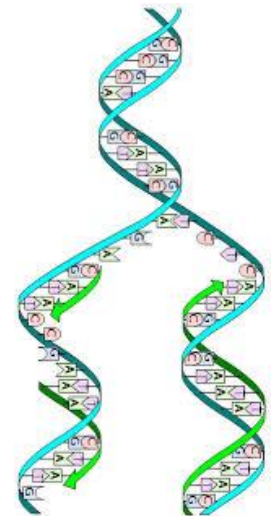
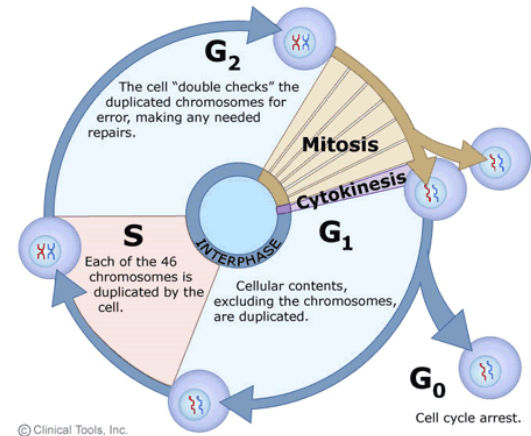


### What is DNA Replication?

- A chromosome is unzipped and thus starts as one strand of DNA
- Each daughter cell \_\_\_\_\_ of the DNA strand.
- The DNA strand is duplicated and the two parts are "tied" together

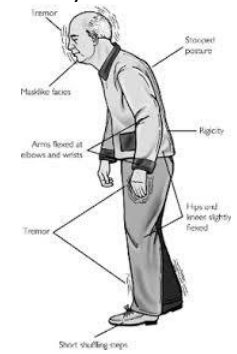
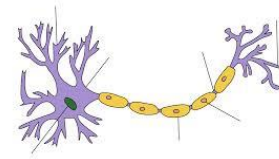
### Important Details

- DNA replication occurs during the \_\_\_\_\_.
- Mitosis and \_\_\_\_\_ overlap.
- Cells may also enter a \_\_\_\_\_ phase where they no longer divide.
- Cells move onto the next stage of the cycle when enough \_\_\_\_\_ builds up.



The Cell Cycle (Division)

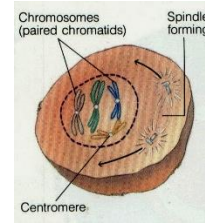
- Cells of the \_\_\_\_\_ and spinal cord do not divide.
- \_\_\_\_\_ is a disease where brain cells dies, and because nervous system cells \_\_\_\_\_ replicate so the body is unable to replace the dead cells.
- Mitosis is the process of dividing just the \_\_\_\_\_, not the \_\_\_\_\_ cell.



**STEPS OF MITOSIS (PMAT):**

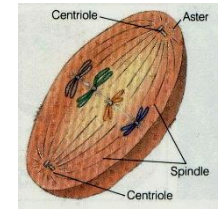
• **PROPHASE:**

- \_\_\_\_\_ is broken down.
- \_\_\_\_\_ appear for the first time.
- Centrioles migrate - ( \_\_\_\_\_ don't have centrioles).



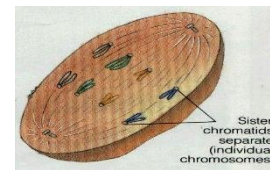
• **METAPHASE:**

- Chromosomes align on the \_\_\_\_\_.
- Spindle fibers attach to the \_\_\_\_\_.



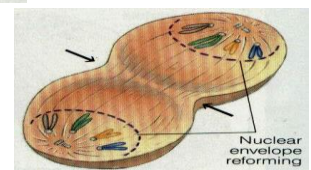
• **ANAPHASE:**

- Chromatids move to \_\_\_\_\_ ends of the cell (with the help of \_\_\_\_\_).



• **TELOPHASE:**

- Chromosomes \_\_\_\_\_ moving.
- \_\_\_\_\_ reforms.



**Cytokinesis is the \_\_\_\_\_ of the entire cell after the nucleus divides.**

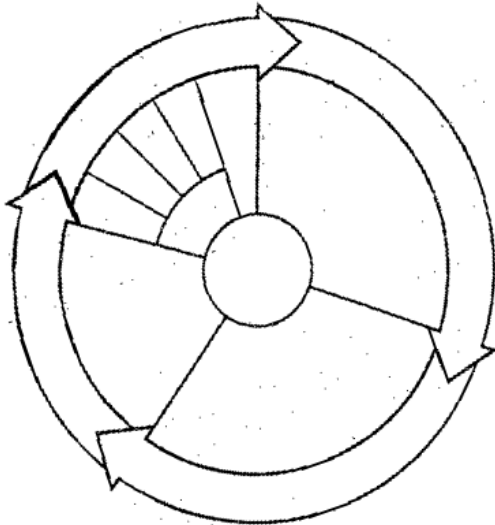
- Differs for plants and animals because plants cells have \_\_\_\_\_

Animal Cells	Plant Cells
The _____ constricts to make a groove and divide.	Vesicle produced by _____ form a _____ in the cell.
The groove is referred to as the _____	Vesicles fuse to make a _____ which attached to the cell wall

How does the beginning cell differ from the ending cells?

**[[Language Target for Topic 2: I can discuss the impact of surface area to volume ratios; I can diagram the cell cycle, identifying key structural components while describing the events within; I can diagram the four stages of mitosis; I can create a Venn Diagram to explain the difference between plant and animal cell division; I can differentiate between prokaryotic and eukaryotic cell division.]]**

1. Surface area to volume ratios: Most of this has been completed using our in-class POGIL, but take a moment to write what size cells are *most* efficient: \_\_\_\_\_
  - a. What do we mean when we say these cells are most efficient?  
 \_\_\_\_\_  
 \_\_\_\_\_
  - b. How does DNA overload relate to this?  
 \_\_\_\_\_  
 \_\_\_\_\_
  - c. Why can eukaryotic cells be larger than prokaryotic cells?  
 \_\_\_\_\_  
 \_\_\_\_\_
  
2. Place the appropriate component of the cell cycle in each sliver of the following image. Draw or describe what happens at each point (use the space to the right of the image, if needed).



3. Complete the following table comparing plant and animal cell division:

	PLANT CELLS	ANIMAL CELLS
Centrioles used?		
Cleavage furrow forms?		
Cell plate forms?		

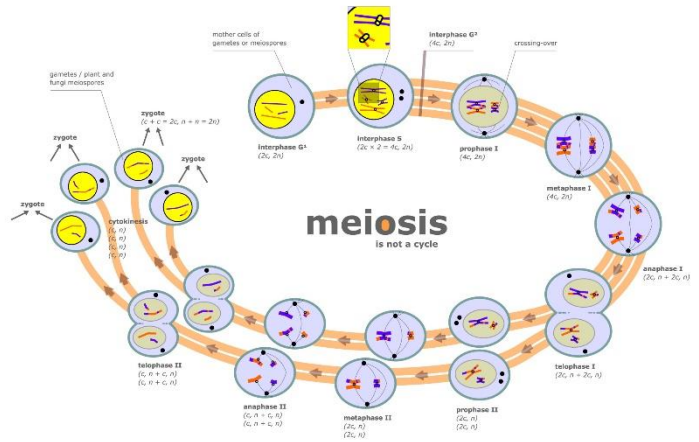
4. Complete the following table comparing prokaryotic and eukaryotic cell division:

	PROKARYOTIC CELLS	EUKARYOTIC CELLS
Involves dividing the nucleus?		
Produces identical daughter cells?		
Uses binary fission?		
Uses mitosis?		
Produces two organisms?		
Involves PMAT (pro, meta, ana...)?		
Requires duplicating DNA?		

### Unit 5, Topic 3: Meiosis

By the end of this topic, you should be able to...

- Compare and contrast sexual and asexual reproduction
- Illustrate meiosis I and meiosis II
- Explain fertilization of eukaryotic cells
- Explain production of egg and sperm cells
- Explain nondisjunction and read a karyotype



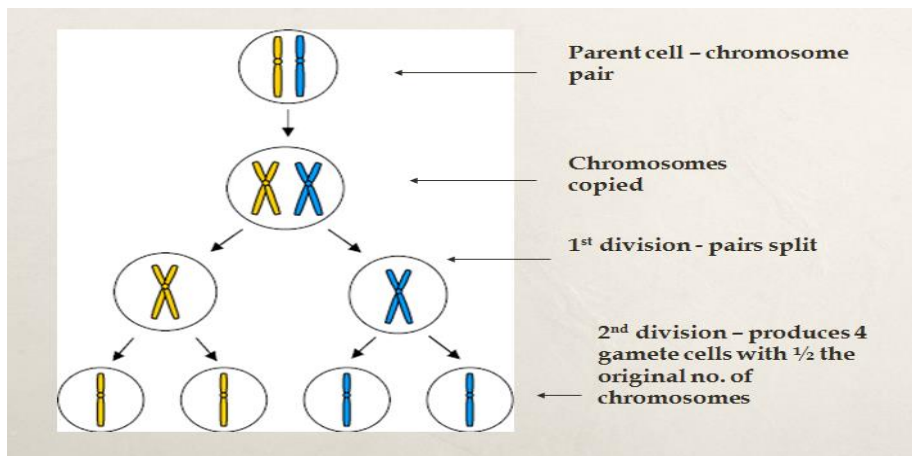
#### Meiosis does two things

- 1) Meiosis takes a cell with two copies of every chromosome (\_\_\_\_\_ ) and makes cells with a single copy of every chromosome (\_\_\_\_\_ ).
  - In meiosis, one diploid cells produces \_\_\_\_\_.
- 2) Meiosis scrambles the specific forms of each gene that each sex cell (egg or sperm) receives.
  - This makes for a lot of genetic diversity. This trick is accomplished through \_\_\_\_\_ and \_\_\_\_\_.

*Genetic diversity is important for the evolution of populations and species.*

#### Why do we need Meiosis?

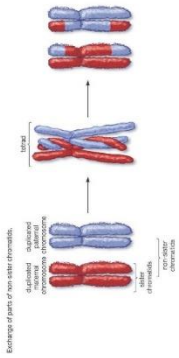
- Meiosis is necessary \_\_\_\_\_ the number of chromosomes going into the sex cells
- Why halve the chromosomes in gametes?
  - At fertilization the male and female sex cells will provide 1/2 of the chromosomes each –



#### Meiosis I : \_\_\_\_\_

- \_\_\_\_\_ (THIS ONLY HAPPENS BEFORE MEIOSIS I, NOT IN BETWEEN I AND II)
  - DNA is replicated
  - The result is two genetically identical sister chromatids which remain attached at their centromeres





- During this phase each pair of chromatids don't move to the equator alone, they match up with their homologous pair and fasten together (synapsis) in a group of four called a \_\_\_\_\_

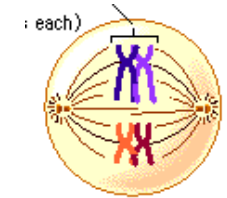


- Extremely IMPORTANT!!!

- Crossing Over is the exchange of segments during synapsis.

- The chromosomes line up at the equator attached by their centromeres to spindle fibers from centrioles.

- Still in homologous pairs



- The spindle guides the movement of the chromosomes toward the poles

1. \_\_\_\_\_ remain attached
2. Move as a unit towards the same pole

- The homologous chromosome moves toward the opposite pole



- This is the end of the first meiotic cell division.

- The cytoplasm divides, forming \_\_\_\_\_.

- Each of the newly formed cells has \_\_\_\_\_

\_\_\_\_\_ of the parent cell's chromosomes, but each chromosome is already replicated ready for the second meiotic cell division



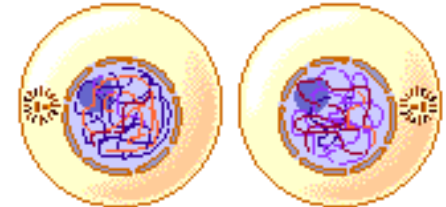
- Occurs simultaneously with \_\_\_\_\_

1. Forms 2 daughter cells

- Plant cells – \_\_\_\_\_

- Animal cells – \_\_\_\_\_

- NO FURTHER REPLICATION OF GENETIC MATERIAL PRIOR TO THE SECOND DIVISION OF MEIOSIS

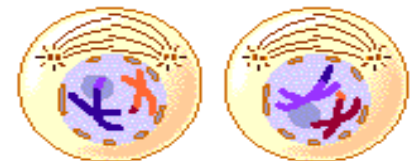


**Meiosis II :** \_\_\_\_\_

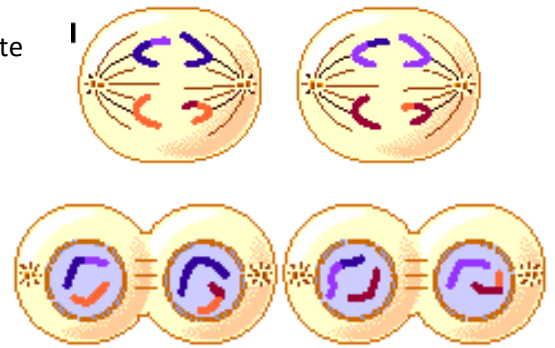
*There is no Interphase II!!!*

- Each of the daughter cells forms a spindle, and the double stranded chromosomes move toward the equator

- The chromosomes are positioned on the metaphase plate in a mitosis-like fashion

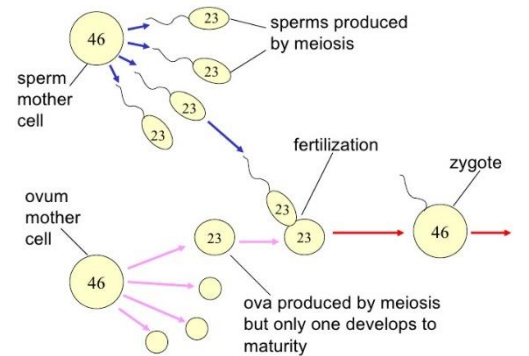


- \_\_\_\_\_
  - The centromeres of sister chromatids finally separate
  - The sister chromatids of each pair move toward opposite poles
    1. Now individual chromosomes
- \_\_\_\_\_
  - Nuclei form at opposite poles of the cell and cytokinesis occurs
  - After completion of cytokinesis there are four daughter cells
    1. All are haploid (n)
- One Way Meiosis Makes Lots of Different Sex Cells (Gametes) – \_\_\_\_\_
  - Independent assortment produces  $2^n$  distinct gametes, where n = the number of unique chromosomes.
  - In humans, n = 23 and  $2^{23} = 6,000,0000$ .
- Another Way Meiosis Makes Lots of Different Sex Cells – \_\_\_\_\_
  - Crossing-over multiplies the already huge number of different gamete types produced by independent assortment.
  - Swapping genes is known as a \_\_\_\_\_
  - Crossovers occur while the homologous chromosomes are paired in \_\_\_\_\_



**Meiosis Summary**

- Sex cells divide to produce \_\_\_\_\_ (sperm or egg).
- Gametes have \_\_\_\_\_ the # of chromosomes.
- Occurs only in gonads (testes or ovaries).
  - Male: \_\_\_\_\_
  - Female: \_\_\_\_\_
- Meiosis is similar to mitosis with some chromosomal differences

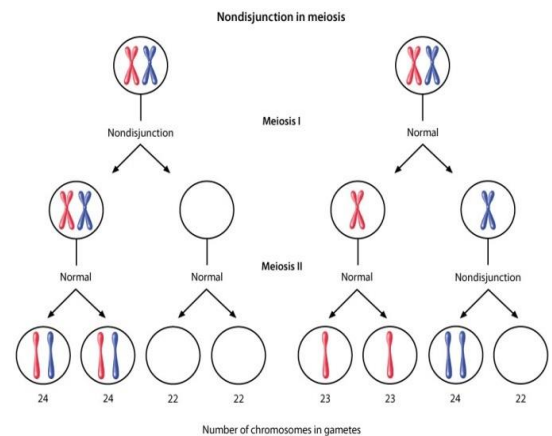


**Fertilization**

- The fusion of a sperm and egg to form a \_\_\_\_\_.
- A zygote is a fertilized egg

**Nondisjunction**

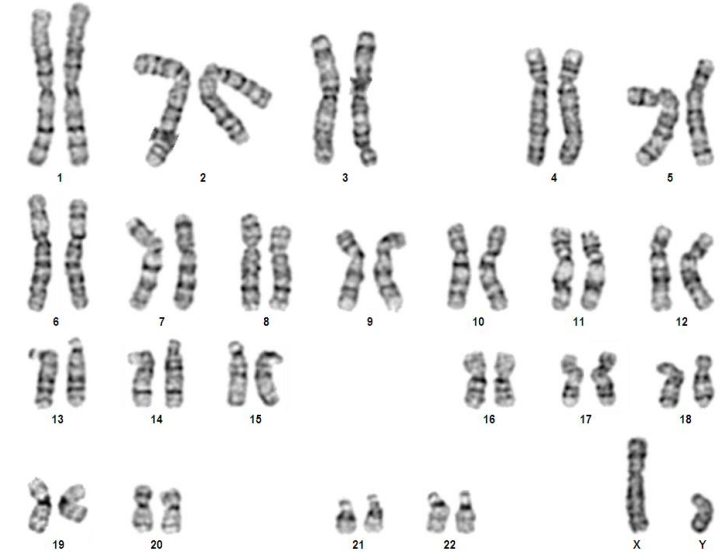
- Occurs when chromosomes \_\_\_\_\_.
- Can occur during \_\_\_\_\_ or \_\_\_\_\_ of Meiosis
- Result: eggs or sperm with \_\_\_\_\_ number of chromosomes
- If the mutated egg or sperm is fertilized, the child will have abnormalities.





- Note: It may also occur in anaphase of \_\_\_\_\_, but usually the abnormal cells die and the whole organism is not affected.

- \_\_\_\_\_: Each cell has an **extra** chromosome
- \_\_\_\_\_: Each cell has **one less** chromosome
- \_\_\_\_\_: can detect chromosomal abnormalities



- Chromosomes are photographed, cut, and matched based on size

### Examples of Nondisjunction

- Trisomy \_\_\_\_\_ → Down Syndrome
- Trisomy \_\_\_\_\_ → Patau Syndrome
- Turner Syndrome → only has an X in pair 23 (missing another sex chromosome)
- Klinefelter Syndrome → has XXY (an extra sex chromosome)

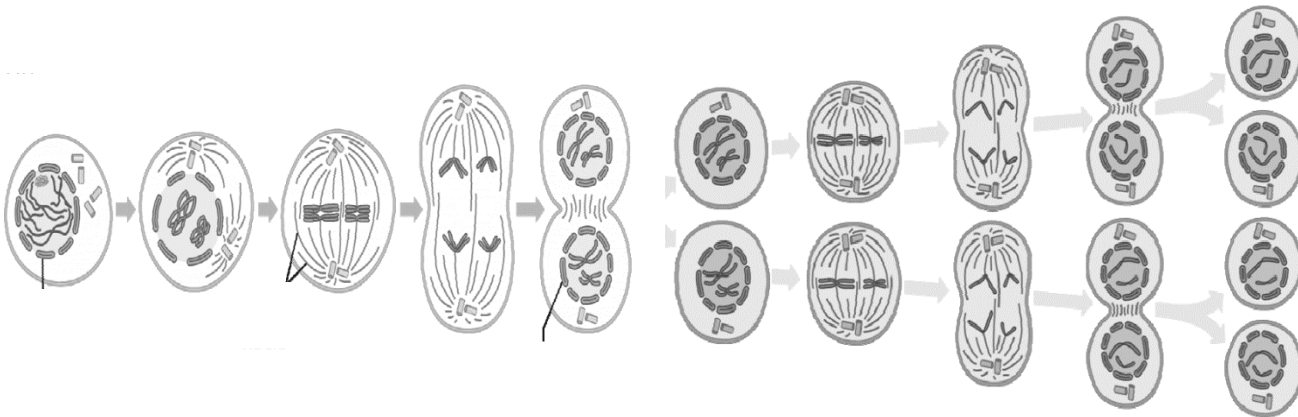
**[[Language Target for Topic 3: I can create a Venn Diagram to compare and contrast sexual and asexual reproduction; I can diagram the stages of Meiosis I and provide written descriptions for each stage; I can diagram the stages of Meiosis II and provide written descriptions for each stage; I can explain how meiosis creates egg and sperm cells; I can locate an abnormality on a karyotype and explain how nondisjunction caused it.]]**

1. Complete the following table comparing sexual and asexual reproduction:

	Asexual Reproduction		Sexual Reproduction	
Number of parents				
Genetic info compared to the parents	Same	Different	Same	Different
Complexity of organism that uses this method	Simple	Complex	Simple	Complex
Example of an organism that uses this method				

Provide an advantage for asexual reproduction: \_\_\_\_\_  
 Provide an advantage for sexual reproduction: \_\_\_\_\_  
 Provide a disadvantage for asexual reproduction: \_\_\_\_\_  
 Provide a disadvantage for sexual reproduction: \_\_\_\_\_

2. Label each stage of meiosis in the following diagrams:



3. Why must egg and sperm cells be haploid?

4. Analyze the following karyotype:



Sex of individual: \_\_\_\_\_  
 Normal/Trisomy/Monosomy: \_\_\_\_\_  
 If tri- or monosomy, on which chromosome? \_\_\_\_\_

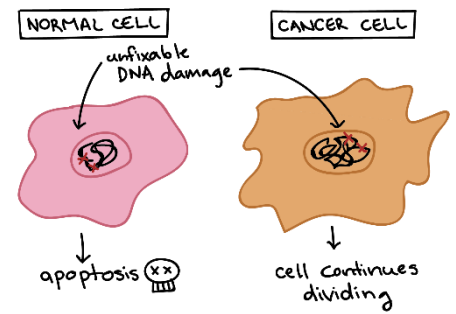
## Unit 5, Topic 4: Cell Cycle Regulation

By the end of this topic, you should be able to...

- Explain the role of cell regulation checkpoint
- Explain what happens when the cell cycle controls fail

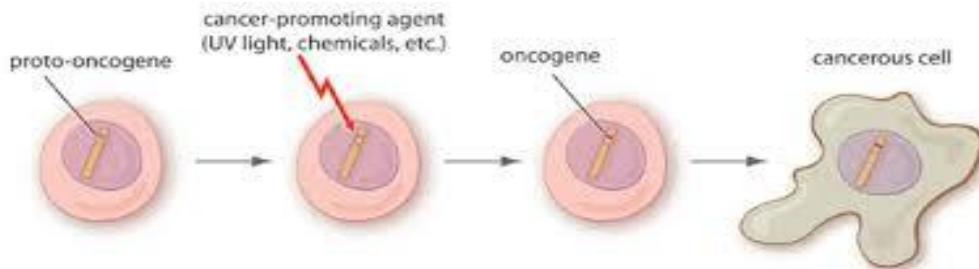
### Cell Regulation Checkpoints

- \_\_\_\_\_
- \_\_\_\_\_
- Tumor suppressor genes can control these checkpoints
  - Tumor suppressor genes turn \_\_\_\_\_ rate of cell division
- For many cells, the \_\_\_\_\_ checkpoint seems to be the most important
  - If a cell receives a go-ahead signal at the G<sub>1</sub> checkpoint, it will usually divide
  - If the cell does not receive the go-ahead signal, it will exit the cycle, switching into a nondividing state called the \_\_\_\_\_
- Neighboring cells \_\_\_\_\_ with dividing cells to regulate their growth also.



### Proto-Oncogenes

- Proto-oncogenes encode proteins that function to \_\_\_\_\_ cell division
- Important for normal human development and for the \_\_\_\_\_ of tissues and organs.
- Sometimes a proto-oncogene undergoes a \_\_\_\_\_ and becomes an \_\_\_\_\_
  - When mutated into an oncogene it may produce a large amount of these growth proteins, resulting in \_\_\_\_\_
  - When a cell can no longer regulate its rate of cell division it becomes a \_\_\_\_\_.



- Because there are several genes that act as proto-oncogenes it may take \_\_\_\_\_ to cause harm.
  - Anything that can damage genes can cause these harmful mutations.
  - These are called \_\_\_\_\_

### Cancer

- Cancer is a disease of the \_\_\_\_\_. Some of the body cells divide uncontrollably and tumors form.
- Mutations may be caused by: \_\_\_\_\_
- Due to DNA mutations, cancer cells ignore the chemical signals that start and stop the cell cycle.
- Due to DNA mutations, cancer cells cannot communicate with neighboring cells. Cells continue to grow and form tumors.

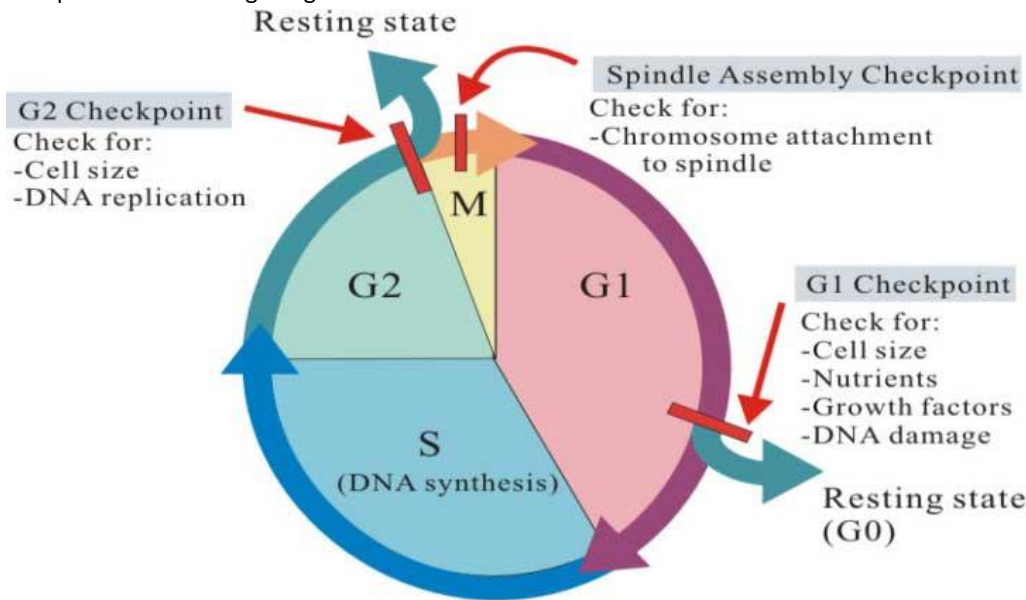
Normal Cell	Cancer Cell
DNA is replicated _____	Mutations occur in the _____ when it is _____
_____ start & stop the cell cycle	Chemical signals that start & stop the cycle are _____
Cells _____ with each other to avoid becoming _____	Cells DO NOT _____ with each other and _____ form

**Cancer Vocabulary**

- \_\_\_\_\_ = loss of cell cycle control = abnormal growth of cells
- \_\_\_\_\_ = non-spreading
- \_\_\_\_\_ = spreading
- \_\_\_\_\_ = spread rate of a malignant cancer to locations other than their origin
  - tumor cells enter blood vessels and travel to other parts of the body

**[[Language Target for Topic 4: I can identify the cell cycle checkpoints on a diagram; I can explain in writing how cancer relates to the cell cycle.]]**

1. Explain the following image:



2. What stage of the cell cycle do normal cells spend the majority of their time in? \_\_\_\_\_
3. Comparing cancer cells to normal cells, how does your answer for number 2 change for cancerous cells? \_\_\_\_\_  
\_\_\_\_\_
4. What can cause cancer? \_\_\_\_\_
5. Why don't all cells with mutated DNA cause cancer? \_\_\_\_\_  
(think of what happens at certain points in the cell cycle for normal cells- see #1).