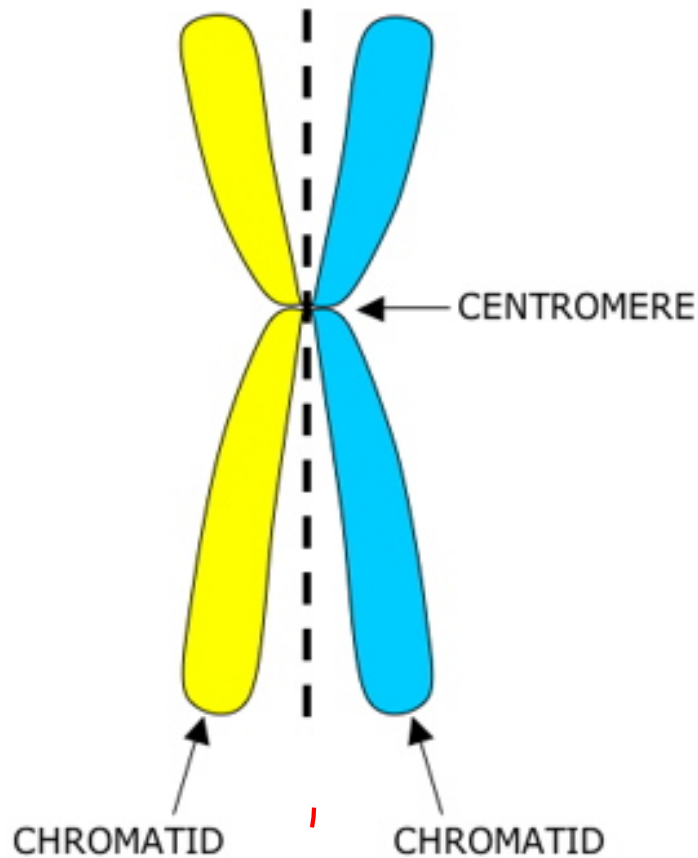


# Chromosomes

Replicated chromosome

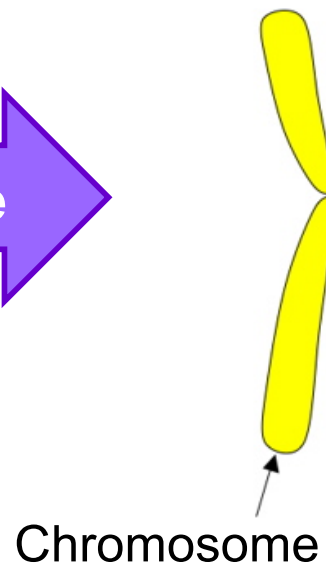
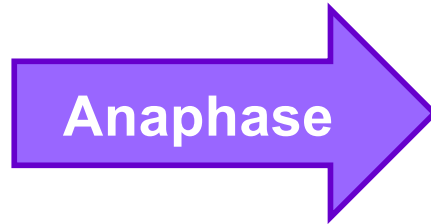
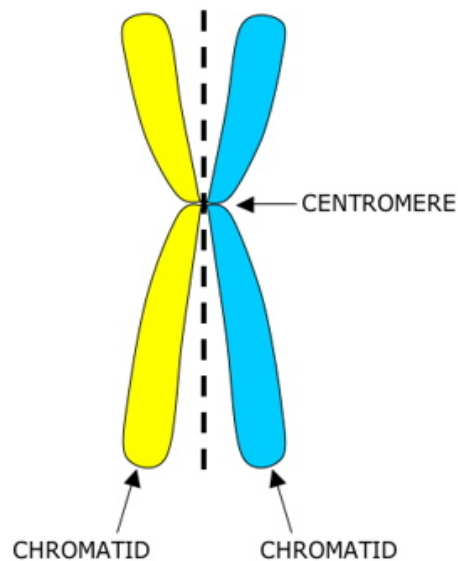


Chromosomes **MUST** replicate themselves prior to cell division. The two sister chromatids shown are identical to each other and were created during DNA synthesis!

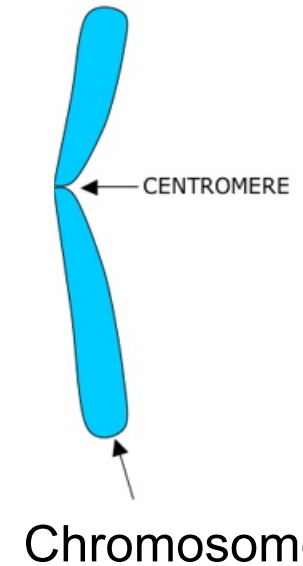
**A chromatid is  $\frac{1}{2}$  of a replicated chromosome. It's only called a chromatid while it is attached by the centromere to its sister chromatid.**

# Chromatids → Chromosomes

Replicated chromosome



Chromosome



Chromosome

**When replicated chromosomes or sister chromatids split apart in anaphase they are called chromosomes.**

# Cell Division

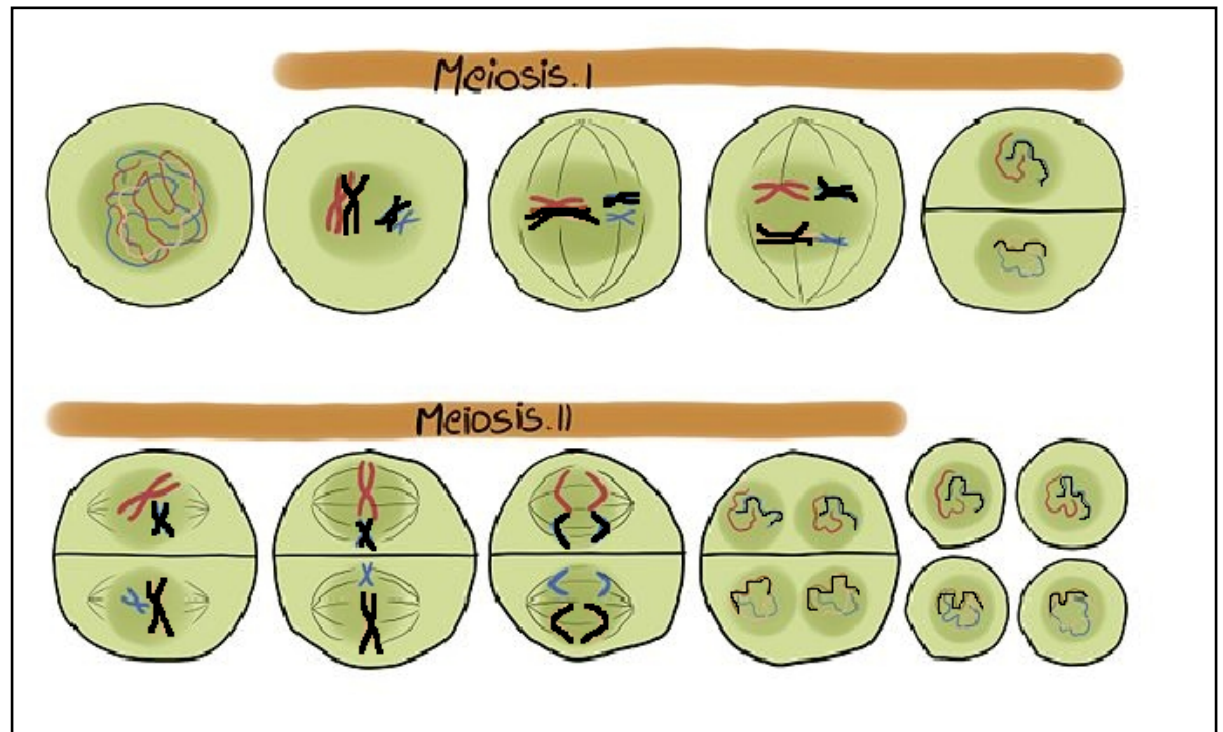
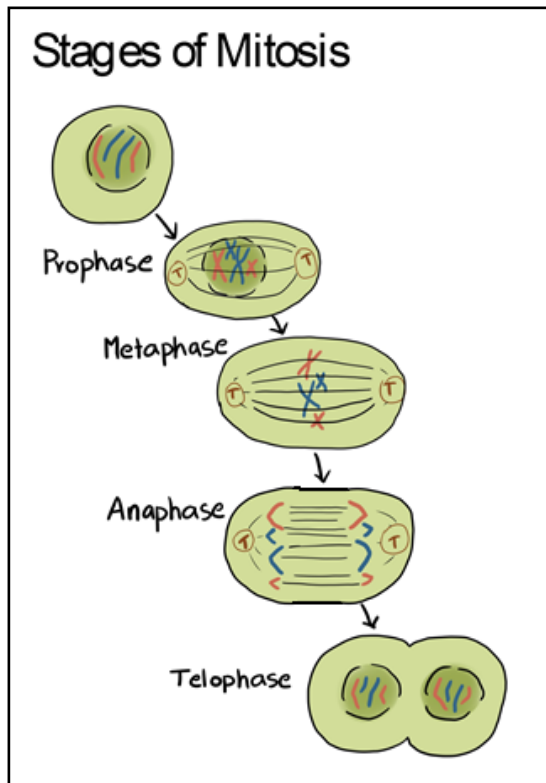
- Cells divide for two reasons:
  1. **Growth, maintenance & repair (MITOSIS)**
  2. **Gamete formation (MEIOSIS)**
- During mitosis, a diploid cell splits into two diploid cells
- During meiosis, a diploid cell splits into four haploid cells



- WORKBOOK
- Pages 2 and 3

# Mitosis and Meiosis

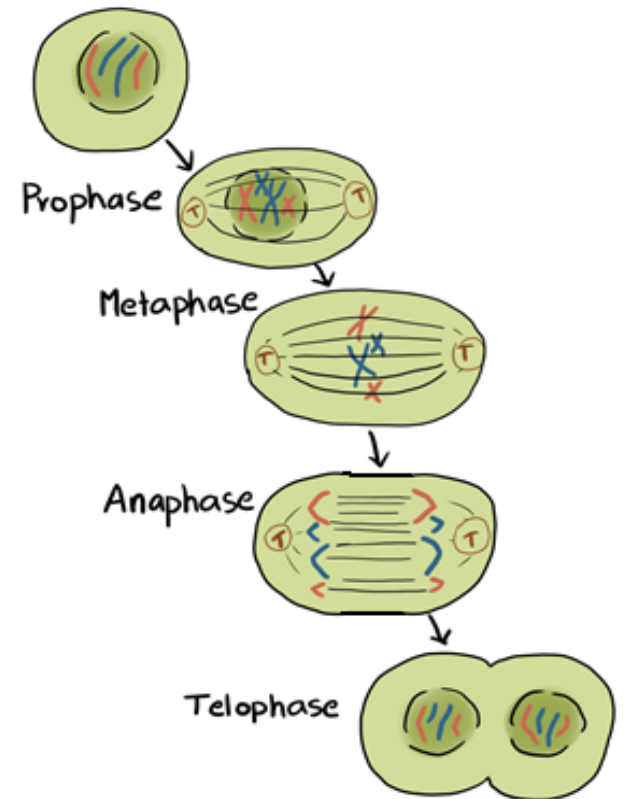
- There are two types of cell division: **mitosis** and **meiosis**. Most of the time when people refer to “cell division,” they mean mitosis, the process of making new body cells. Meiosis is the type of cell division that creates egg and sperm cells.



# Mitosis Versus Meiosis

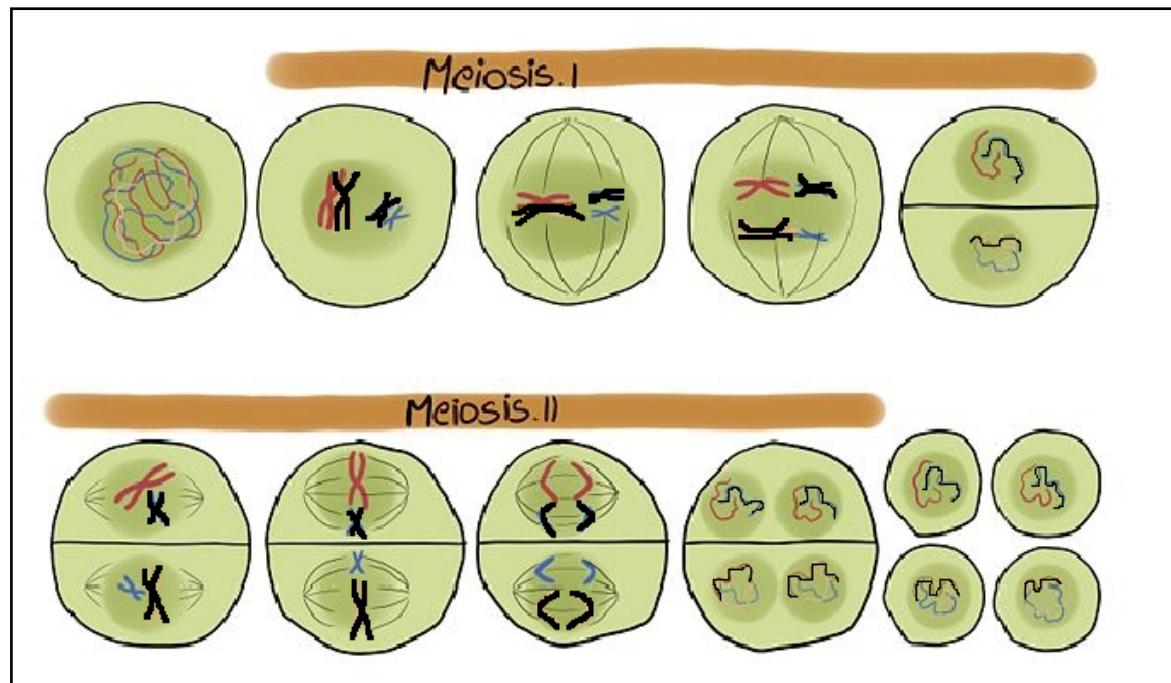
- Mitosis is a fundamental process for life. During Interphase, a cell duplicates all of its contents, including its chromosomes, then through mitosis splits to form two identical daughter cells. Because this process is so critical, the steps of mitosis are carefully controlled by a number of genes. When mitosis is not regulated correctly, health problems such as cancer can result.

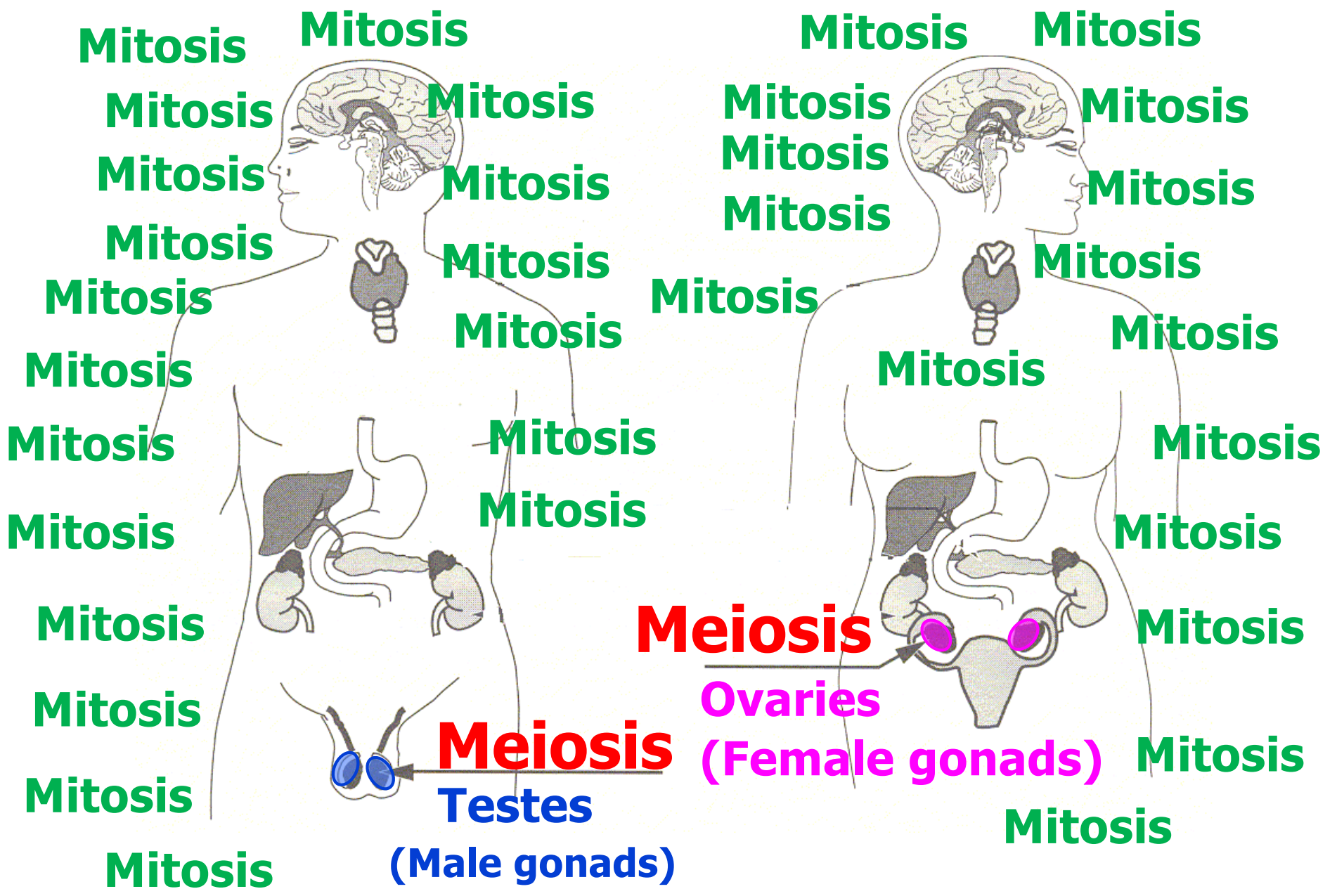
Stages of Mitosis



# Mitosis Versus Meiosis

The other type of cell division, meiosis, ensures that humans have the same number of chromosomes in each generation. It is a two-step process that reduces the chromosome number by half – from 46 to 23 – to form sperm and egg cells. When the sperm and egg cells unite at conception, each contributes 23 chromosomes so the resulting embryo will have the usual 46. Meiosis also allows genetic variation through a process of DNA shuffling while the cells are dividing.





Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Mitosis

Meiosis

Mitosis

Mitosis

Ovaries

(Female gonads)

Mitosis

Mitosis

Meiosis

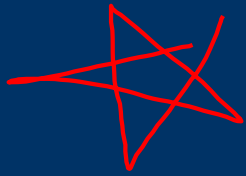
Testes

Mitosis

Mitosis

(Male gonads)

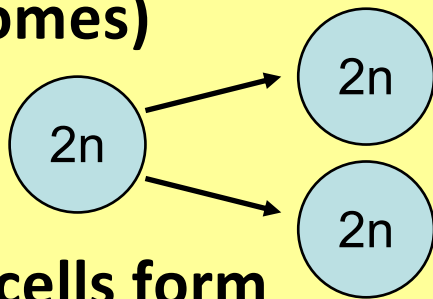




# Two Types of Cell Division

## MITOSIS (IPMAT)

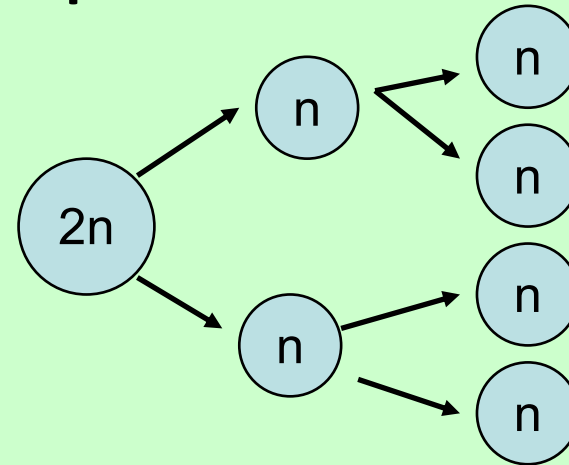
- mitosis is used in the process of organism growth, maintenance & repair of old cells **BUT KEEP IN MIND** mitosis specifically is the **SEPARATING OF GENETIC MATERIAL**
- $2n$  cell  $\rightarrow$   $2n$  cells *Diploid*  
(46 chromosomes  $\rightarrow$  46 chromosomes)



- 2 diploid cells form
- Occurs in somatic cells in the human body!

## MEIOSIS (IPMATPMAT)

- For gamete formation
  - sperm & egg
- $2n$  cell  $\rightarrow$   $n$  cells *haploid.*  
(46 chromosomes  $\rightarrow$  23 chromosomes)
- 4 haploid cells form



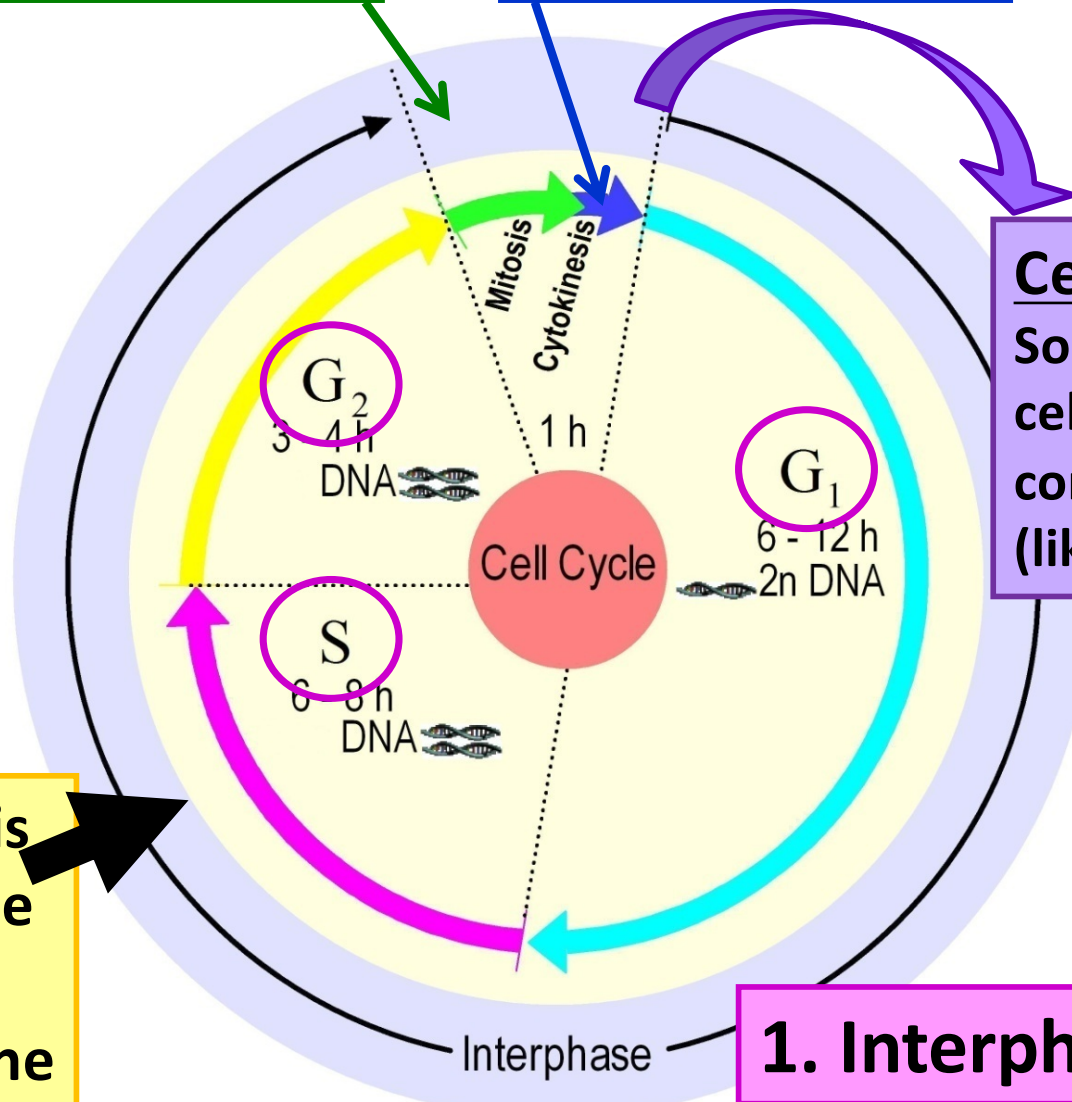
- Occurs only in gonads (ovaries and testes)
- Cause of most existing genetic variation

# The Cell Cycle – 3 Phases

## INTERPHASE – MITOSIS - CYTOKINESIS

2. Mitosis

3. Cytokinesis



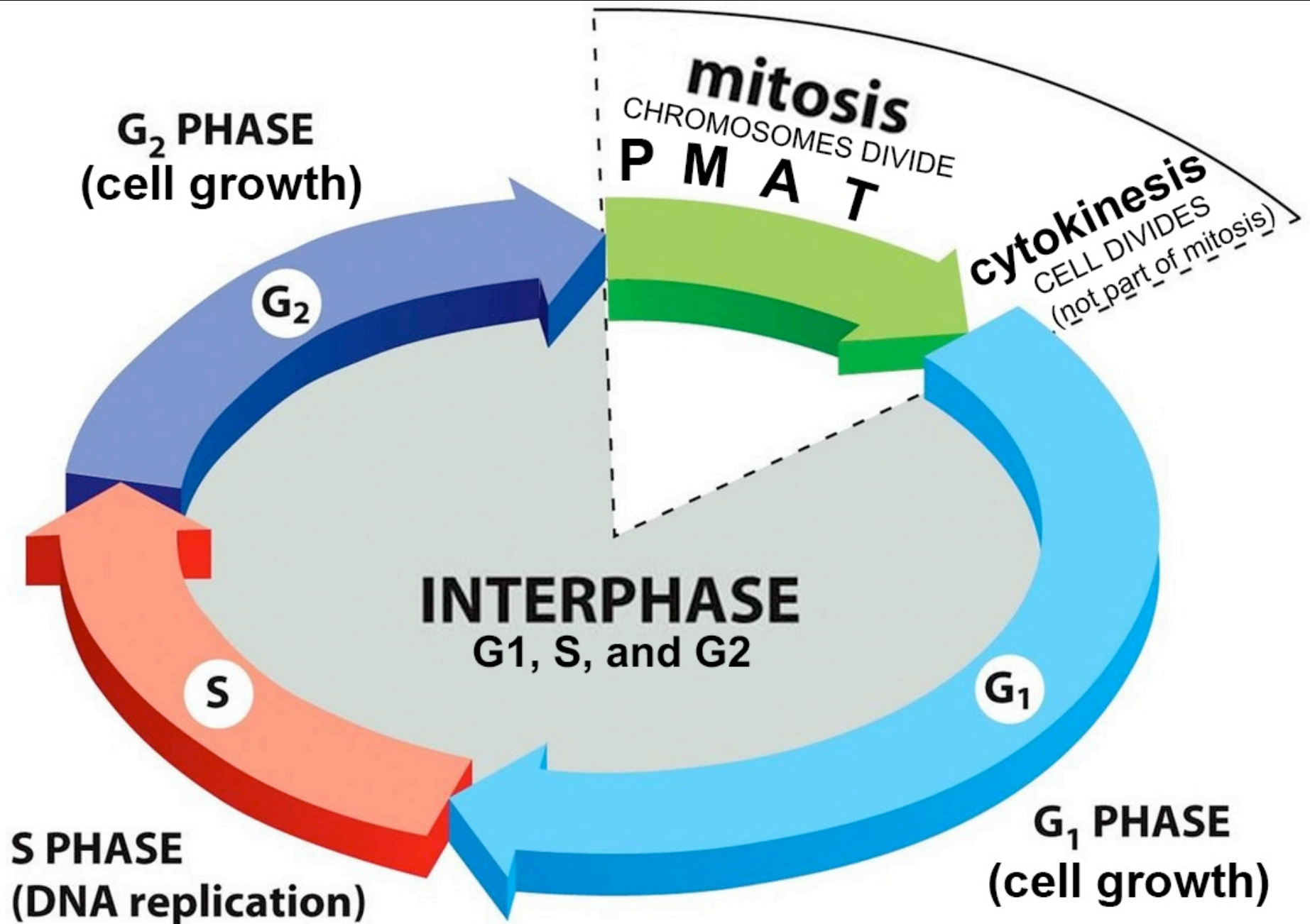
### Cell Specialization

Some cells leave the cell cycle – do not continue to divide. (like red blood cells)

DNA synthesis is necessary so the chromosome numbers stay the

1. Interphase

# The Cell Cycle



# The Cell Cycle

IMPORTANT NOTES ON THE CELL CYCLE:

## 3 PHASES:

**Interphase** – the longest phase including growth and DNA duplication

**Mitosis** - division of the duplicated DNA

**Cytokinesis** – separation into TWO identical cells

**After cytokinesis** some cells do not go back into the cell cycle. A cell can...

- a. go back into the cell cycle
- b. Specialize...perform a specific function like BLOOD CELLS

**PLAY ME**

# INTERPHASE: Stage prior to Mitosis

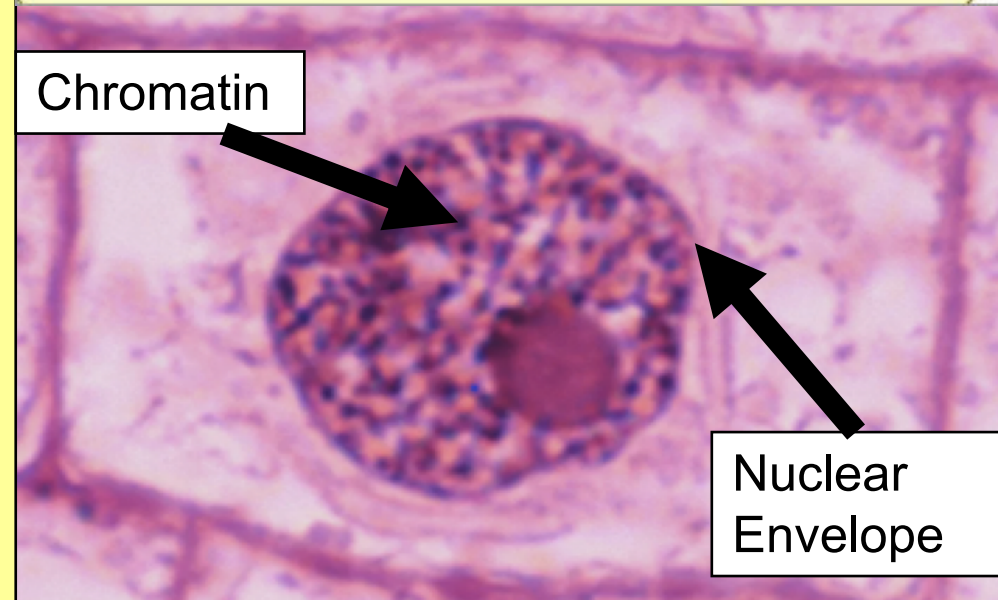
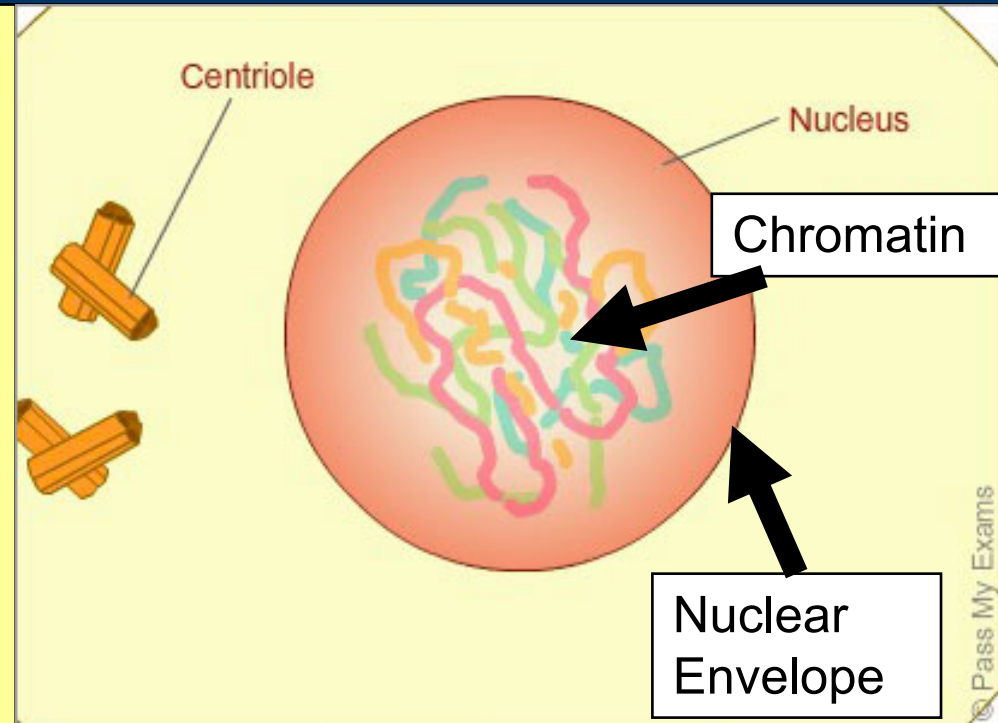
**-Chromosomes not visible.**

**-DNA is in form of chromatin.**

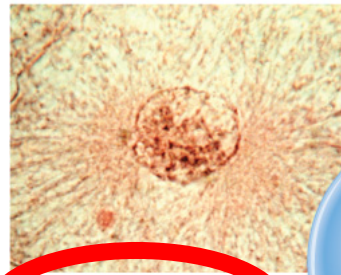
## **Main Events:**

1. **G1 (growth / protein synthesis),**
2. **S- DNA Replication (sister chromatids form) and**
3. **G2 (growth / protein synthesis)**

[http://www.youtube.com/watch?v=-G-3BDlnK58&safe=active&safety\\_mode=true](http://www.youtube.com/watch?v=-G-3BDlnK58&safe=active&safety_mode=true)

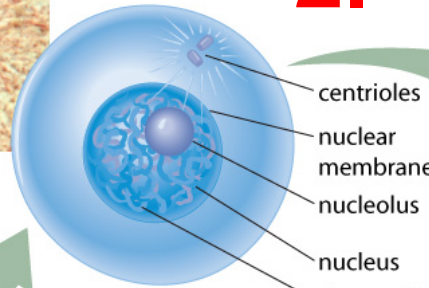


# Preview of Mitosis



**A Interphase**  
Precedes mitosis.

1.



2.

**B Prophase**  
The chromatin coils to form visible chromosomes.

growing spindle fibres

centrioles

nuclear membrane

nucleolus

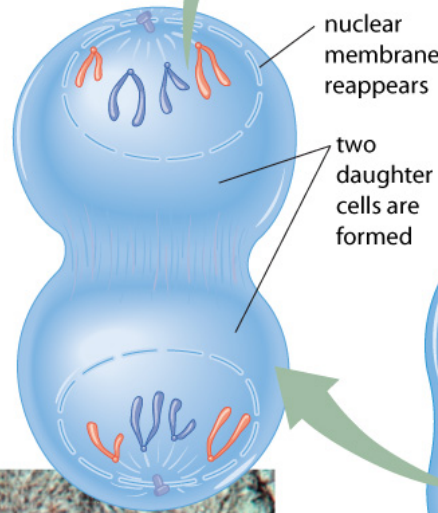
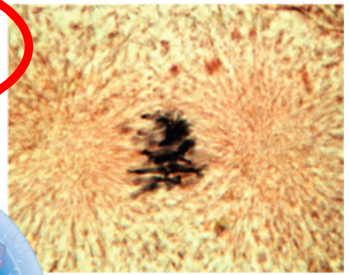
nucleus

chromatin

centrioles migrate toward poles

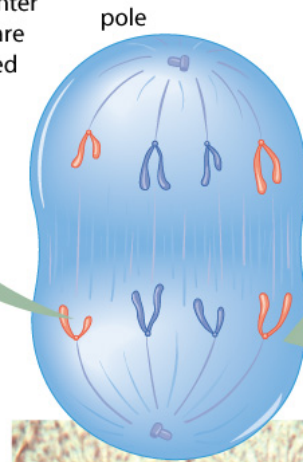
replicated chromosome

disappearing nuclear membrane



**E Telophase**  
Two daughter cells are formed. The cells divide as the cell cycle proceeds into cytokinesis. Both daughter cells then proceed into the next interphase.

5.



**D Anaphase**  
The centromeres split and the sister chromatids are pulled apart to opposite poles of the cell.

4.

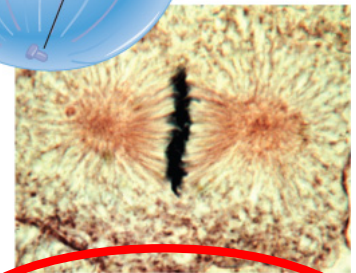
centrioles now at poles

centromere

sister chromatids

3.

**C Metaphase**  
The chromosomes move to the equator of the cell.



**Figure 16.8** These illustrations and micrographs show what happens inside a cell during interphase (A) and mitotic cell division (B to E).

Mitosis Animation (McGraw-Hill)

[http://highered.mcgraw-hill.com/sites/0072495855/student\\_view0/chapter2/animation\\_mitosis\\_and\\_cytokinesis.html](http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter2/animation_mitosis_and_cytokinesis.html)

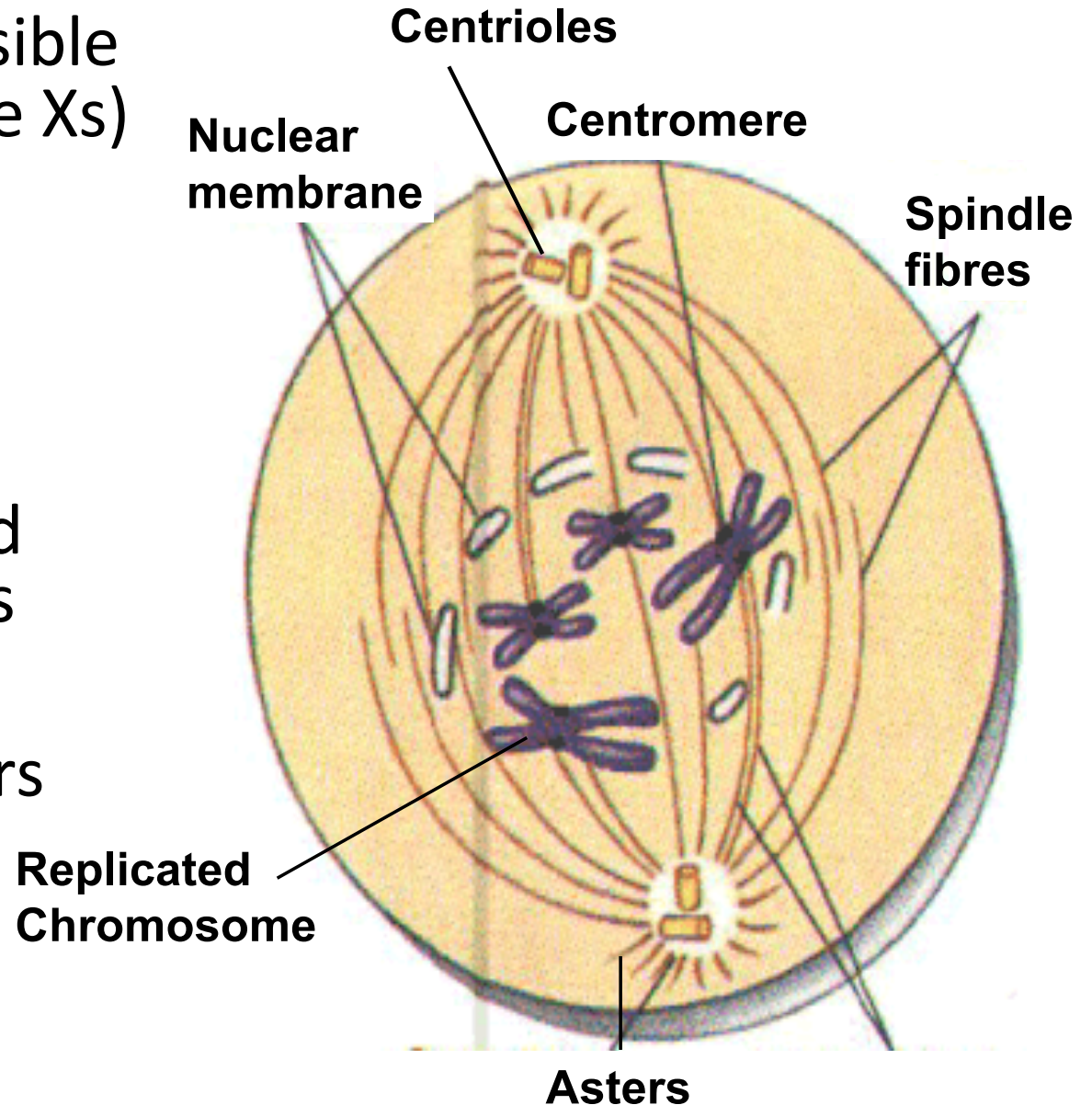
# WHAT IS MITOSIS?

Mitosis is simply the division of DNA

[PLAY ME: Stages of Mitosis](#)

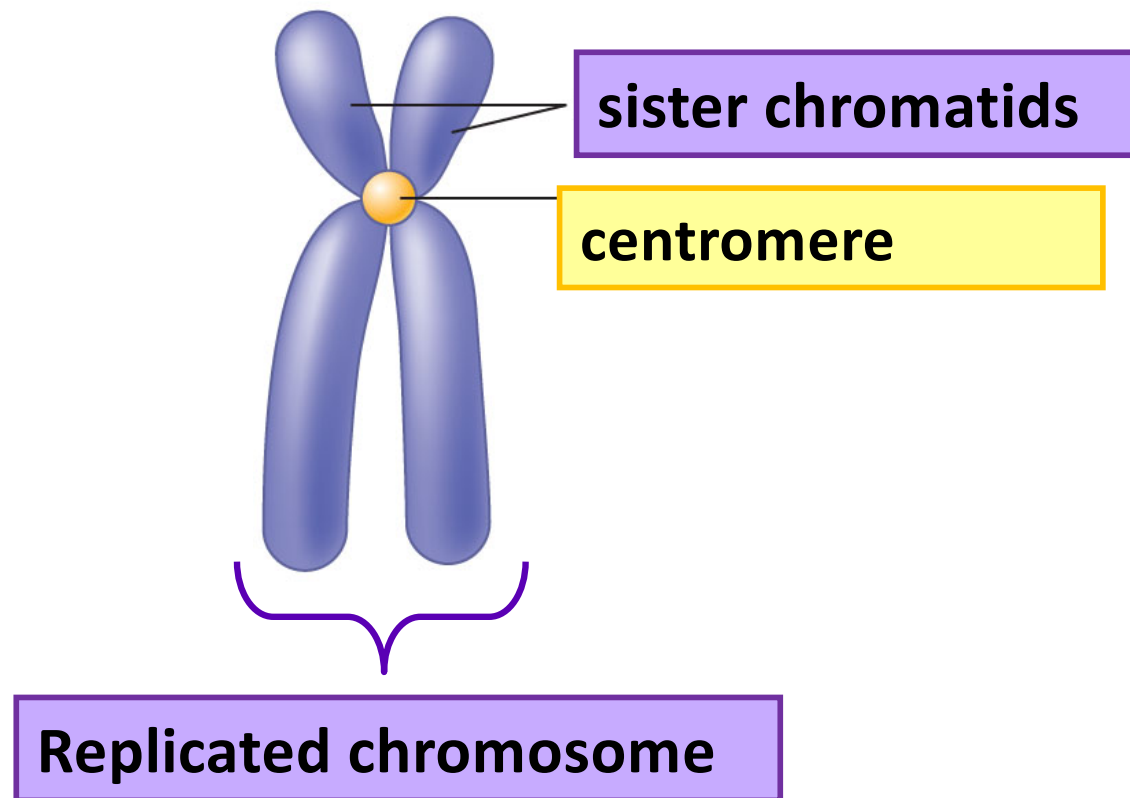
# Prophase (PREPARE)

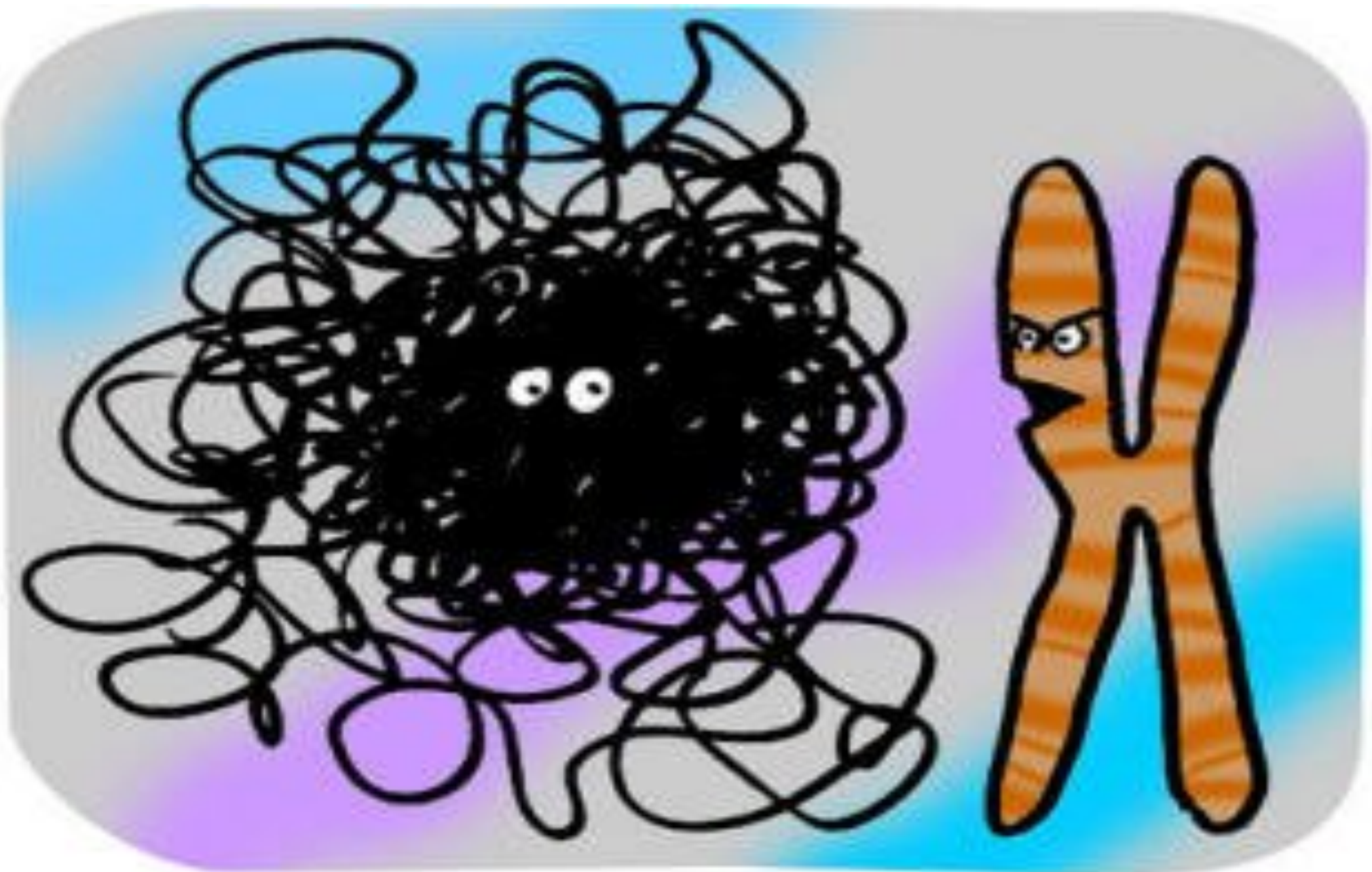
- Chromatin becomes visible chromosomes (look like Xs)
- nuclear membrane disappears
- Centrioles separate and move to opposite poles
- Spindle fibers and asters form





# Chromosomes during Prophase and Metaphase

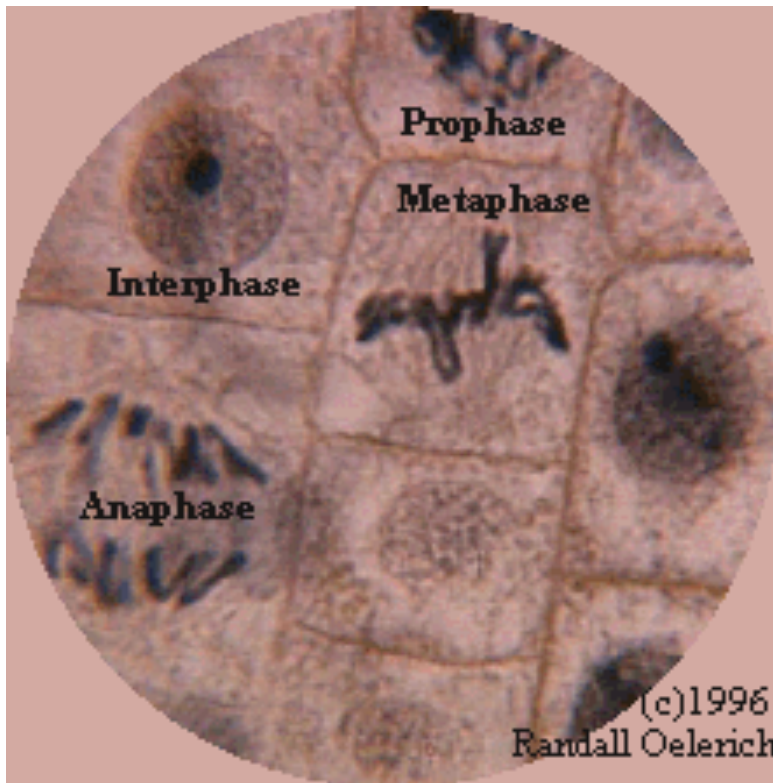




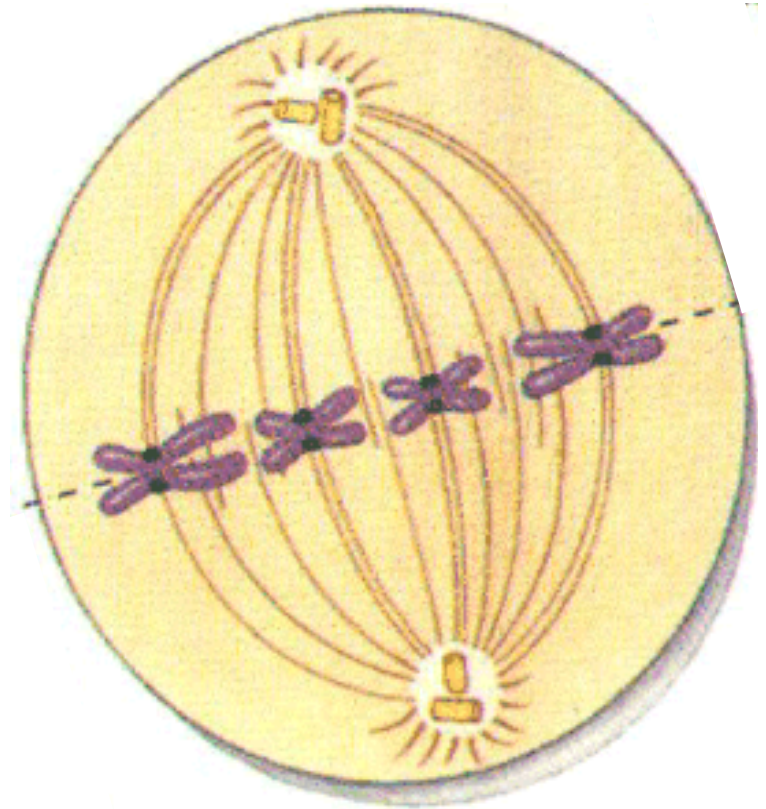
Dude, mitosis starts in five minutes...  
I can't believe you're not condensed yet.

# Metaphase (MIDDLE)

- Replicated chromosomes line up along the metaphase plate (equator)
- Individual chromosomes can be seen since they are lined up

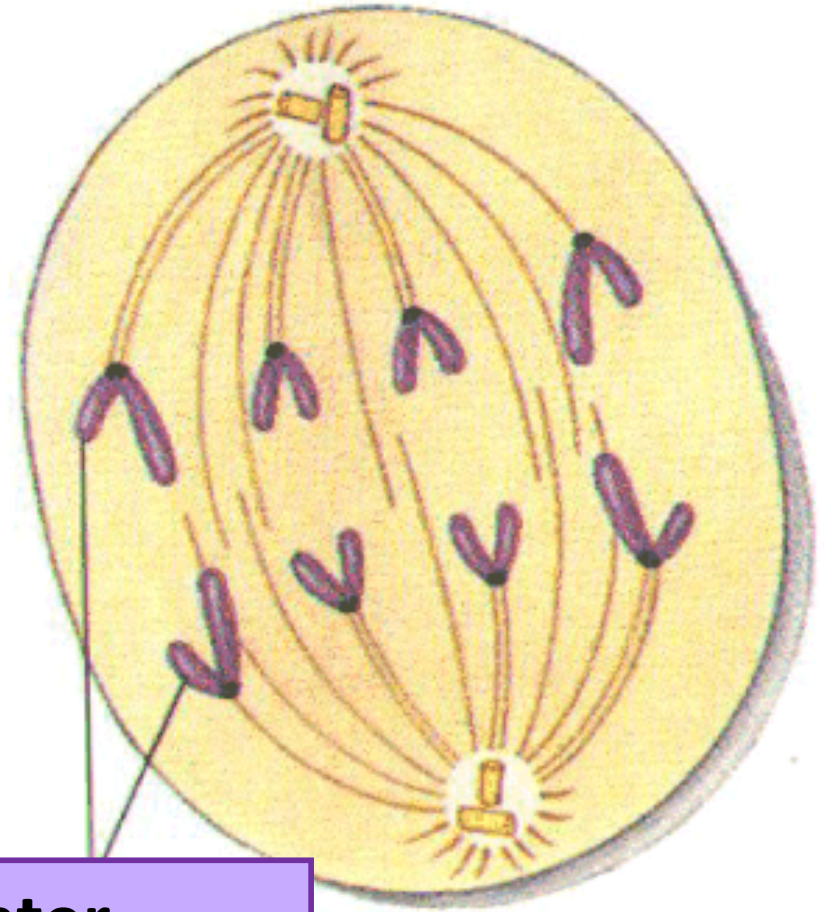
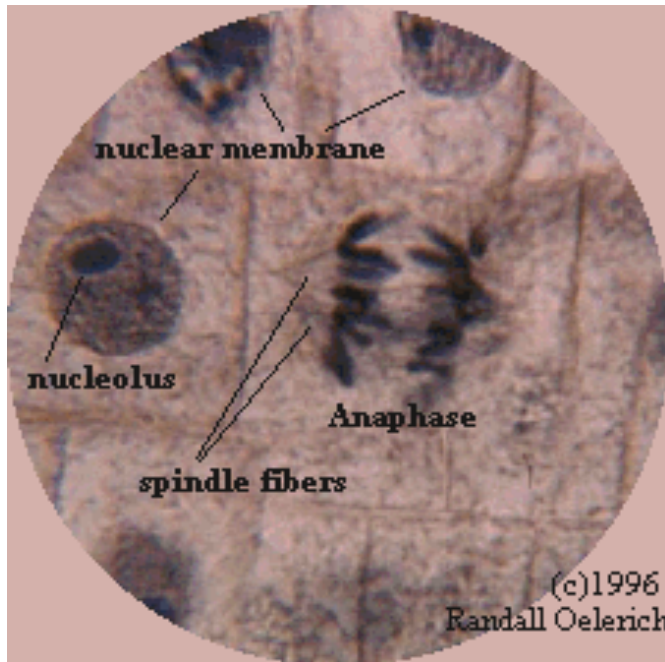


Metaphase  
plate



# Anaphase (APART)

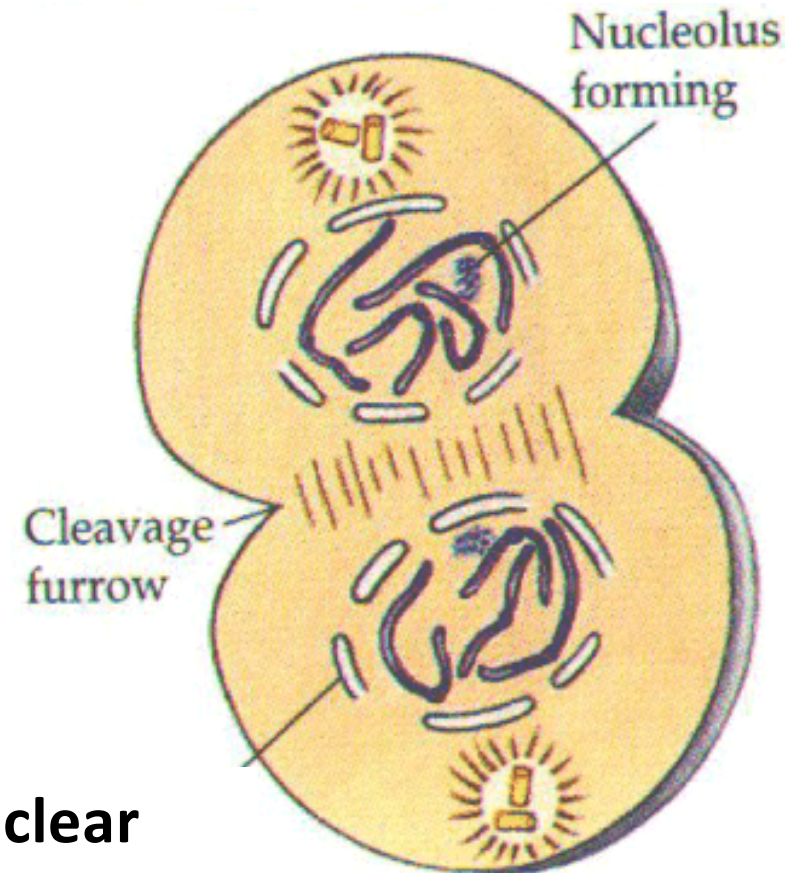
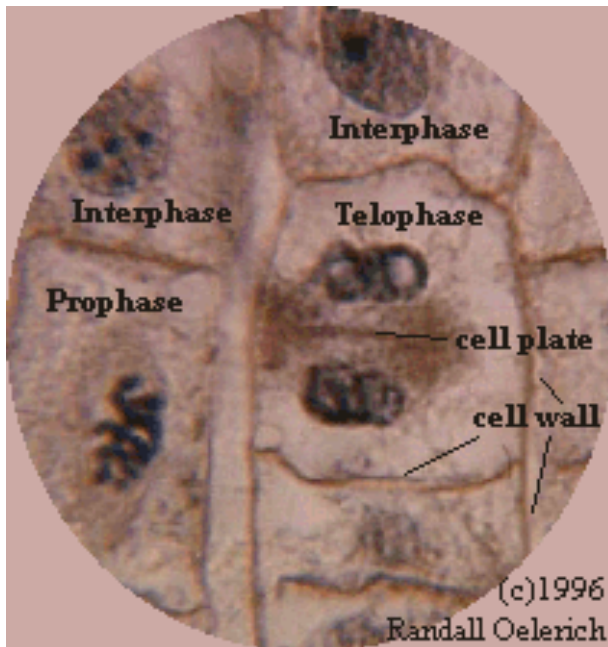
- Action!
- Centromeres divide
- **chromosomes** move to opposite poles



Daughter  
chromosomes

# Telophase (TEAR into two)

- Chromosomes reach opposite poles
- Chromosomes begin to lengthen out again becoming chromatin
- Spindle fibers dissolve
- Nuclear membrane reappears



**Nuclear  
membrane  
forming**

# I Propose Men Are Toads

I Prepare

n  
t  
e  
r  
p  
h  
a  
s  
e

Middle

e  
t  
a  
p  
h  
a  
s  
e

Apart

n  
a  
p  
h  
a  
s  
e

Tear in two

e  
l  
o  
p  
h  
a  
s  
e

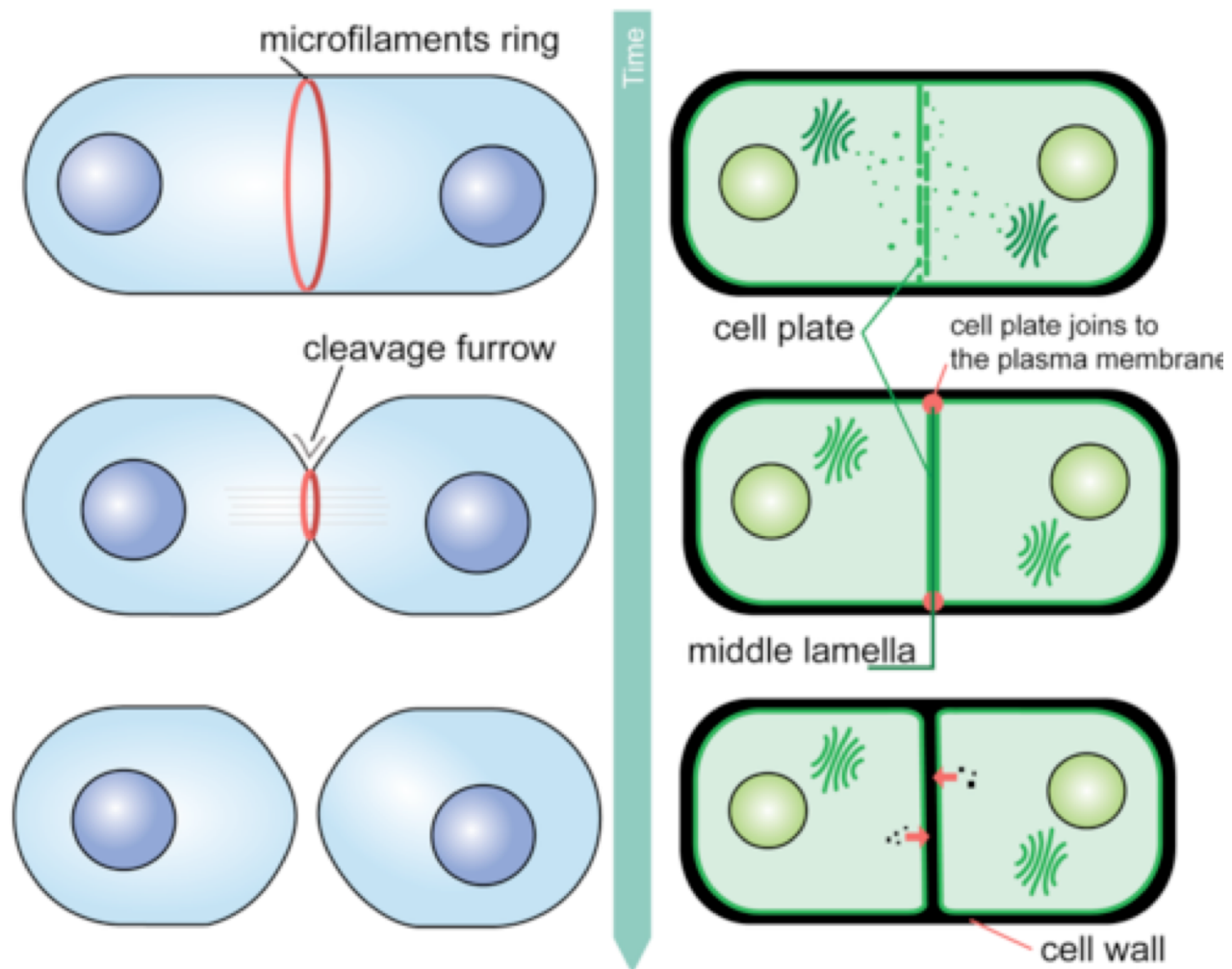
# Cytokinesis (cytoplasm divides)

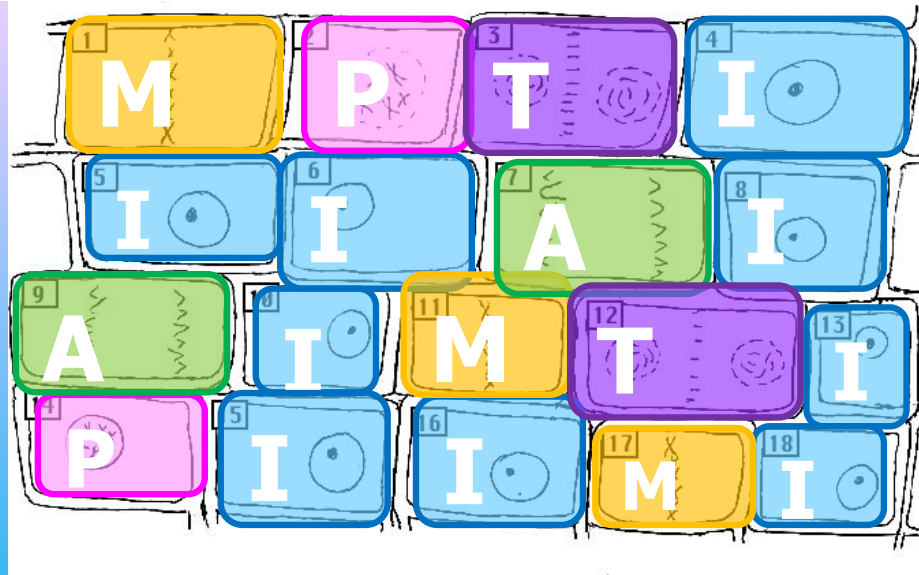
- **ANIMAL CELLS:** Cytoplasm pinches in or **invaginates**
- **PLANT CELLS:** Cell plate is formed in plant cells
  - Cell plate eventually becomes cell wall (**made of cellulose**)

Mitosis animations

[http://www.youtube.com/watch?v=cvlpmmvB\\_m4&safety\\_mode=true&safe=active&persist\\_safety\\_mode=1](http://www.youtube.com/watch?v=cvlpmmvB_m4&safety_mode=true&safe=active&persist_safety_mode=1)

[Bozeman Mitosis \(13:35\)-watch](#)

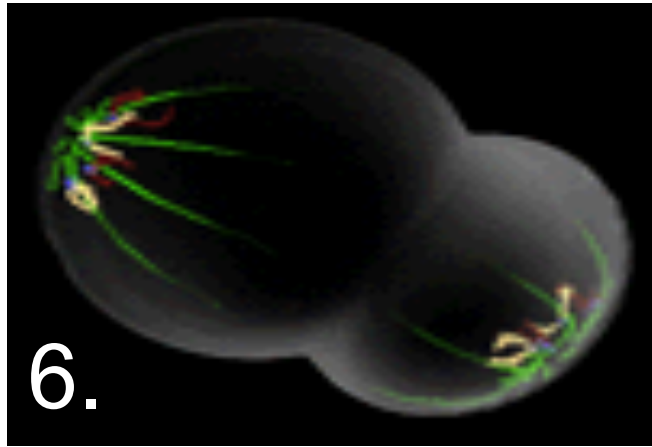
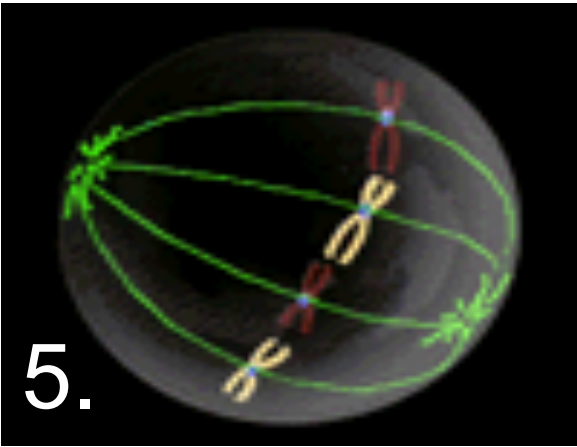
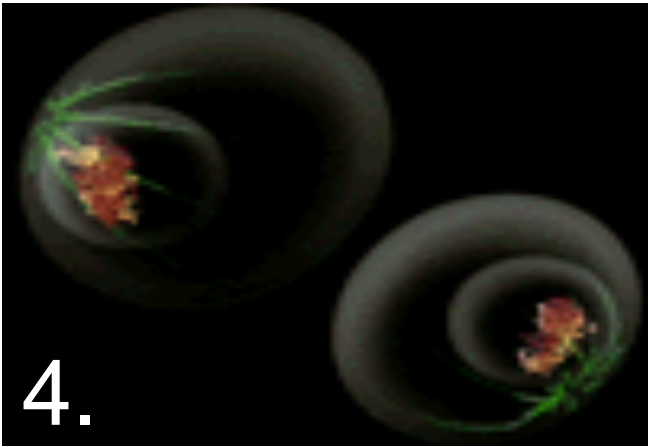
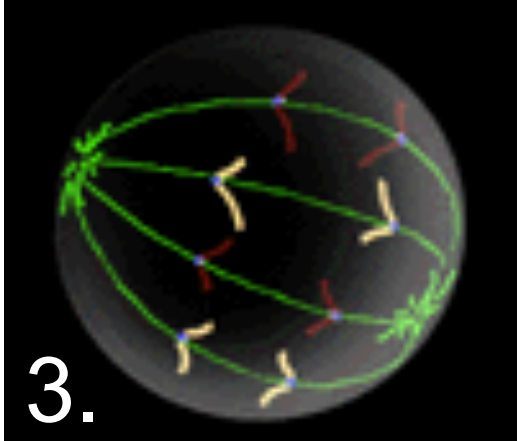
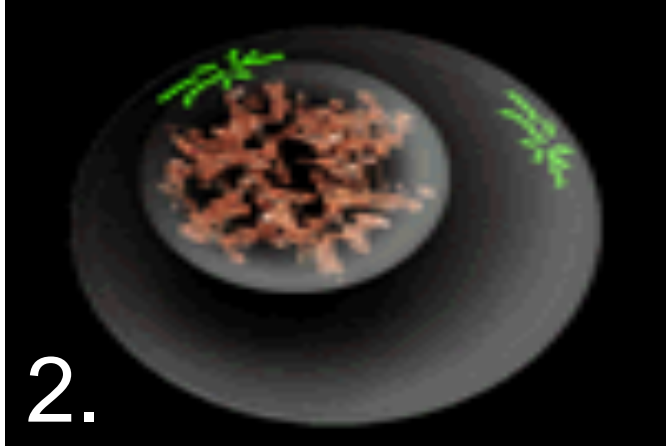
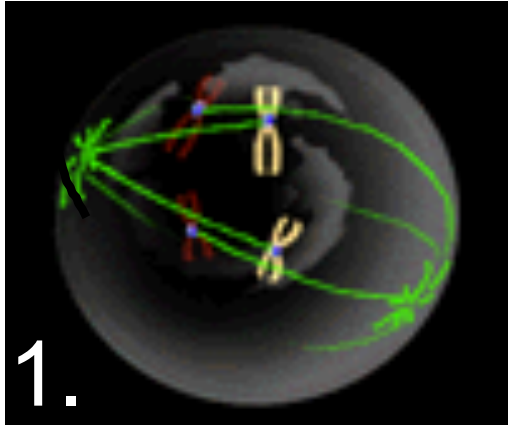




Stage	Number of Cells	Time
Interphase	9	50%
Prophase	2	11%
Metaphase	3	17%
Anaphase	2	11%
Telophase	2	11%



# Identify the stages!



1.

2.

3.

4.

5.

6.

Cell division in pig kidney epithelial cells

# What is the phase?

1. Chromosomes appear

**prophase**

2. Chromatin is present

**interphase**

3. Chromosomes line up at equator

**metaphase**

4. Cleavage furrow

**telophase**

# What is the phase?

5. Spindle fibres appear

**prophase**

6. Spindle fibres disappear

**telophase**

7. Centromeres divide

**Anaphase**

8. Chromosomes move to opposite poles

**Anaphase**

# What is the phase?

9. Protein synthesis

10. Cell divides into two

11. Chromosomes divide

12. DNA replicates

**Interphase (G1 & G2)**

**Cytokinesis**

**Anaphase**

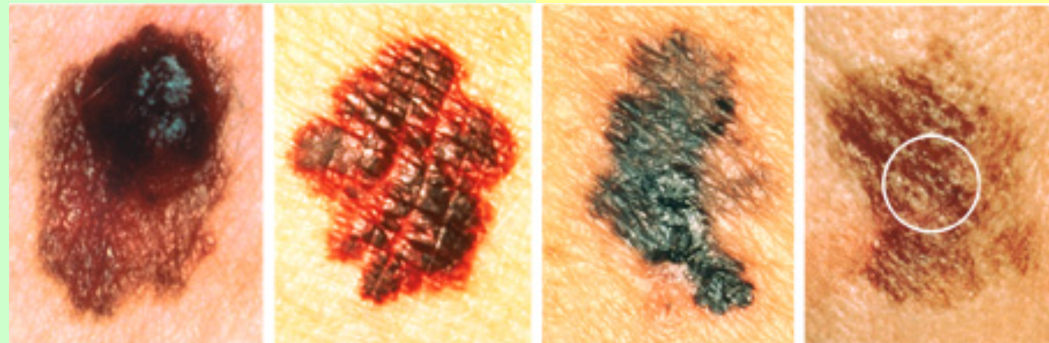
**Interphase**

# WORKBOOK

Pages 4,5,6(left side)

# Normal cells vs. Cancer cells

- Reproduce exactly and stop reproducing when they are supposed to
  - If damaged – are destroyed (or repaired)
  - Stick together in the correct place and specialize/mature properly
- **Keep reproducing** – don't know when to stop – Abnormal Mitosis
  - **Don't die** if moved to another part of the body (metastasis)
  - Don't stick together and don't **specialize** (they stay immature)



Asymmetry

Border  
irregularity

Color

Diameter:  
¼ inch or  
6mm

Interesting  
thing about  
cancer  
telomeres...

# Cloning: an application of mitosis

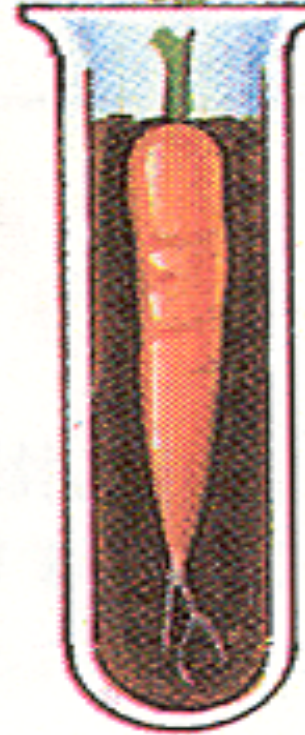
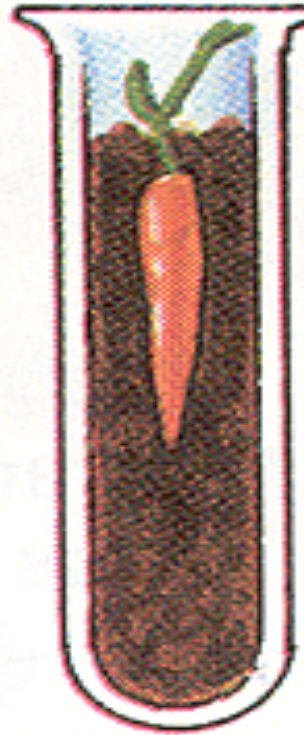
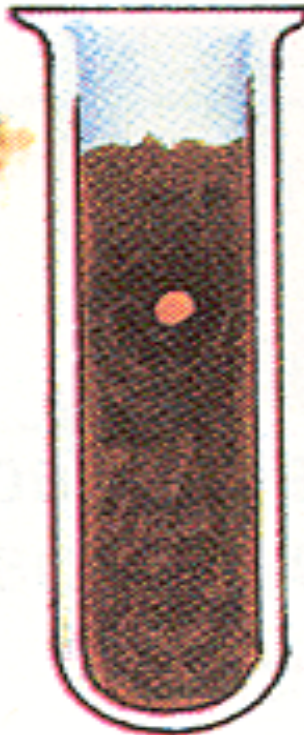
- Identical offspring forms from a **single** parent cell
- A form of **asexual** reproduction
- Originally done by taking **plant** cuttings
- Advantageous: parent provides nutrition, quick, doesn't require a **partner**
- Disadvantages: limited gene pool and genetic variation (**mutations** are passed on)



Plant tissue culture  
and cloning  
laid groundwork for  
**genetic engineering**



Single cell  
extracted from  
carrot



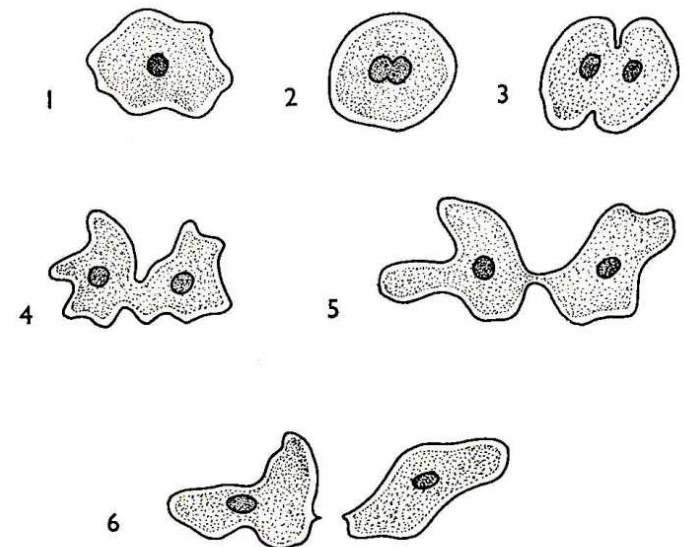
Carrot cloned

**Simple cloning**



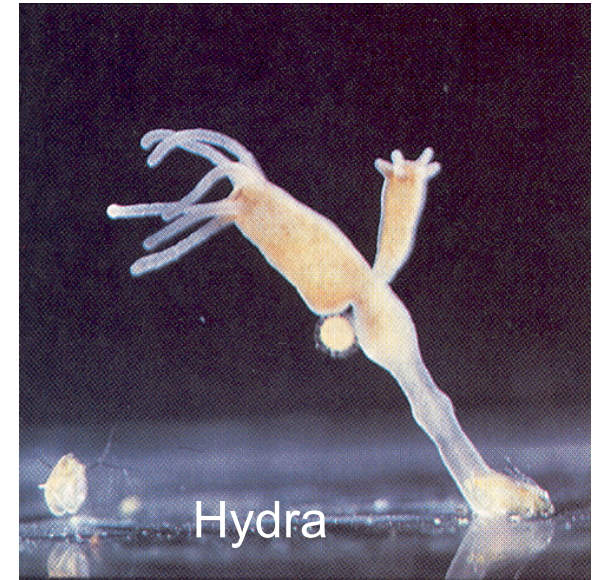
# Asexual Reproduction

- This is very common in plants
- The offspring are always genetically **IDENTICAL** to the parent.
- Examples:
  - **Strawberry** plants can reproduce by sending out runners
  - Removed **willow** branches send out roots when immersed in water
  - **Amoebas** divide into two (binary fission)



# Asexual Reproduction

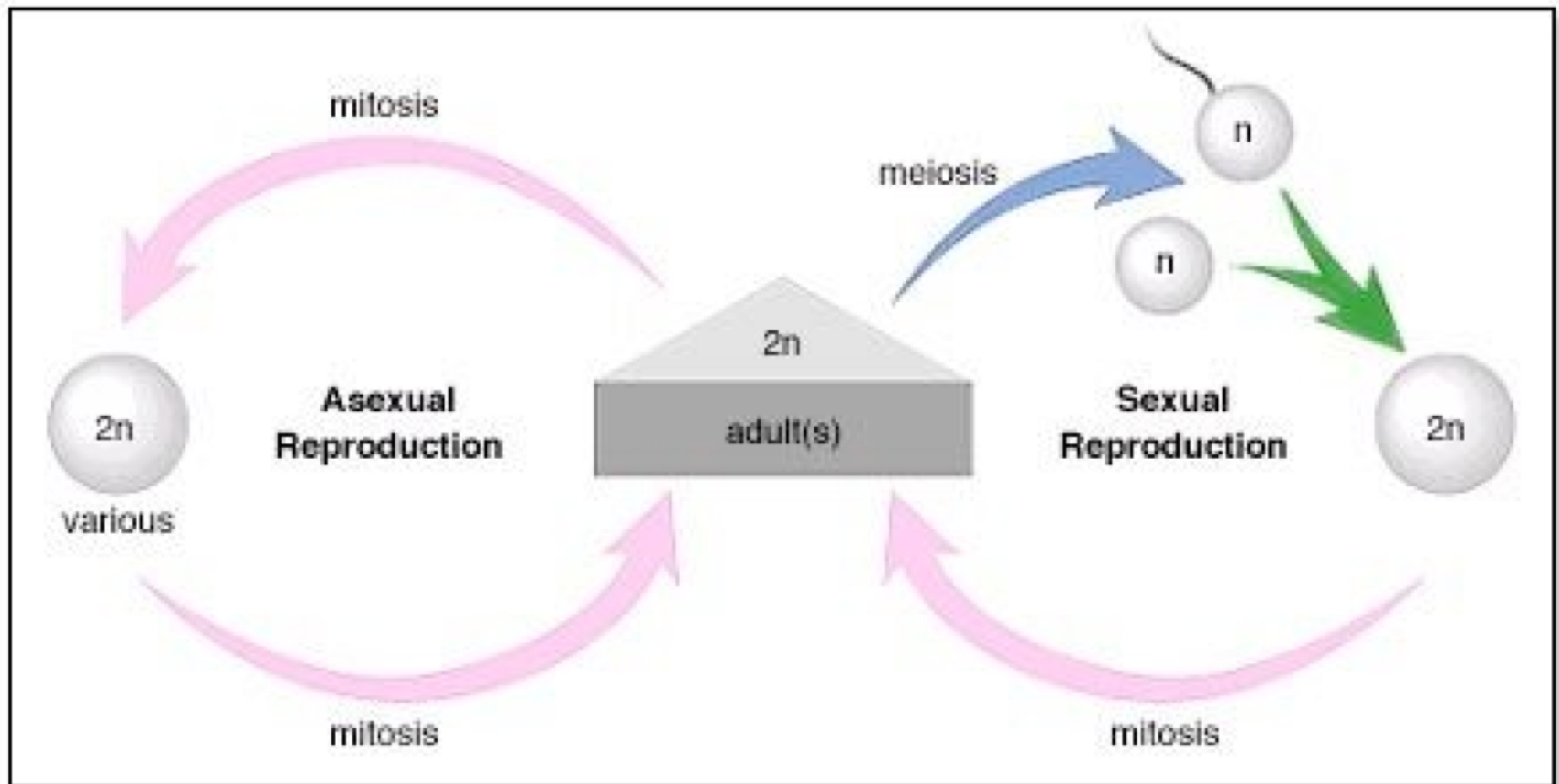
- Examples:
  - hydra form new hydra by **budding**
  - Some animals can reproduce by **parthenogenesis (unfertilized egg)**
  - mushrooms can release **spores**
- Asexual reproduction brought upon the first ideas of simple cloning experiments



Find some more examples of animals that reproduce through asexual reproduction.



# Asexual vs Sexual Reproduction



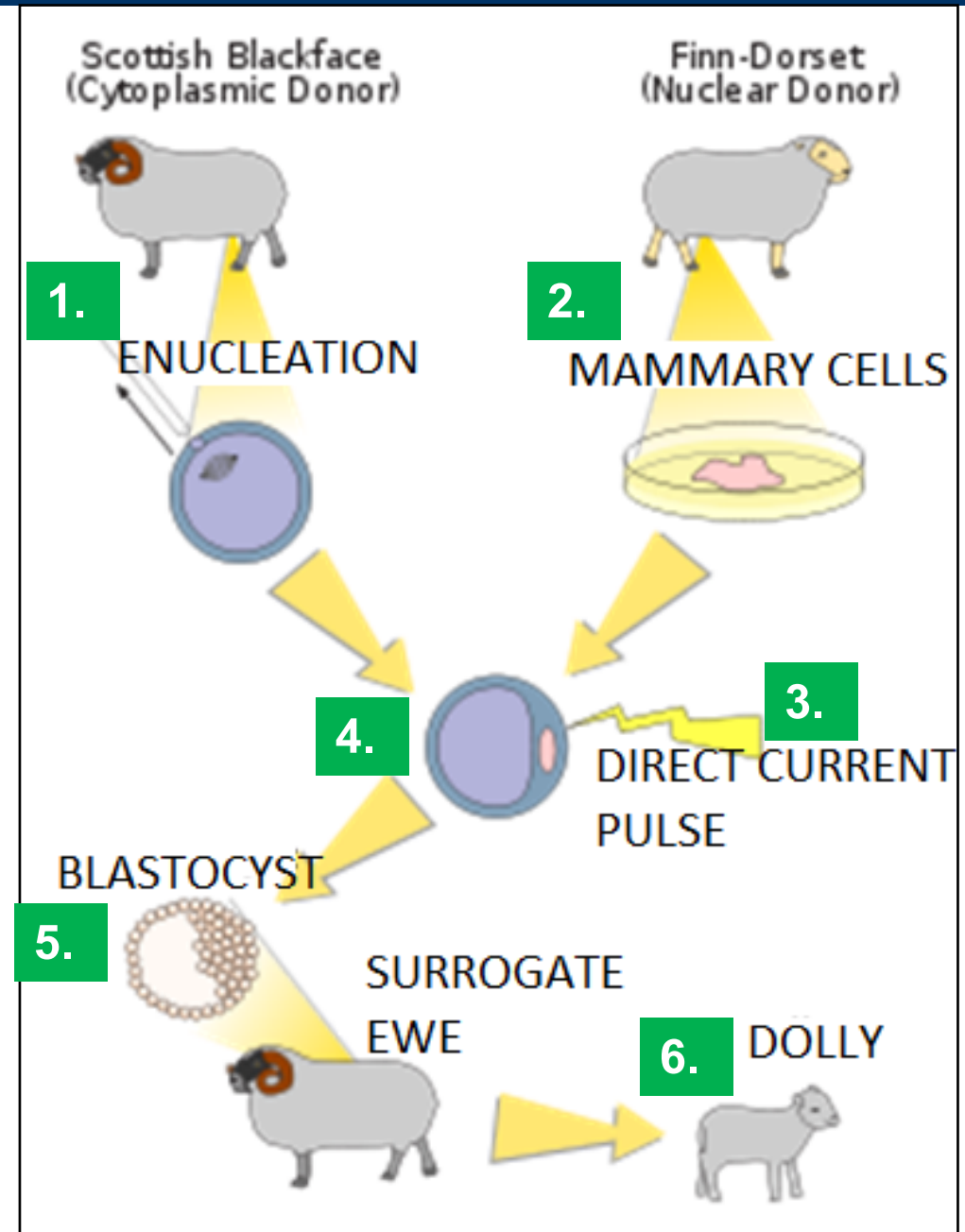
No genetic variation

Genetic variation

# Cloning of Sheep

1. **Haploid nucleus removed** from egg cell of surrogate sheep (**enucleated egg**)
2. **Diploid mammary cell nucleus** from animal to be cloned is inserted into **enucleated egg**
3. Electric shock is used to trigger cell division
4. Embryo develops **in vitro** (outside of womb)
5. **Blastula** stage implanted into surrogate
6. Genetically identical sheep are developed

[Clone your own mouse!](#)



# Cloning of Dolly and other mammals?

## Can you clone yourself using a hair cell?

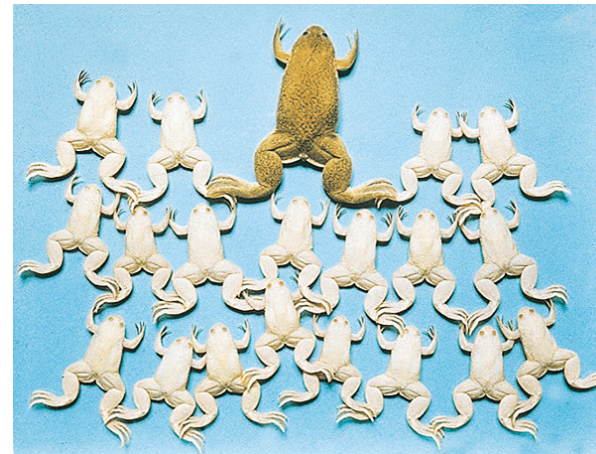
- No!
- Cloning is only possible with **totipotent** cells

**TOTIPOTENT = unspecialized or undifferentiated...**

**...so can turn into ANY body cell plus extraembryonic or placental cells**

- Totipotent cells are obtained from the morula or blastula of a **developing embryo**

What is cloning? Natural fertilization vs. somatic nucleus transfer.





# Identical vs. Fraternal Twins

# Twins

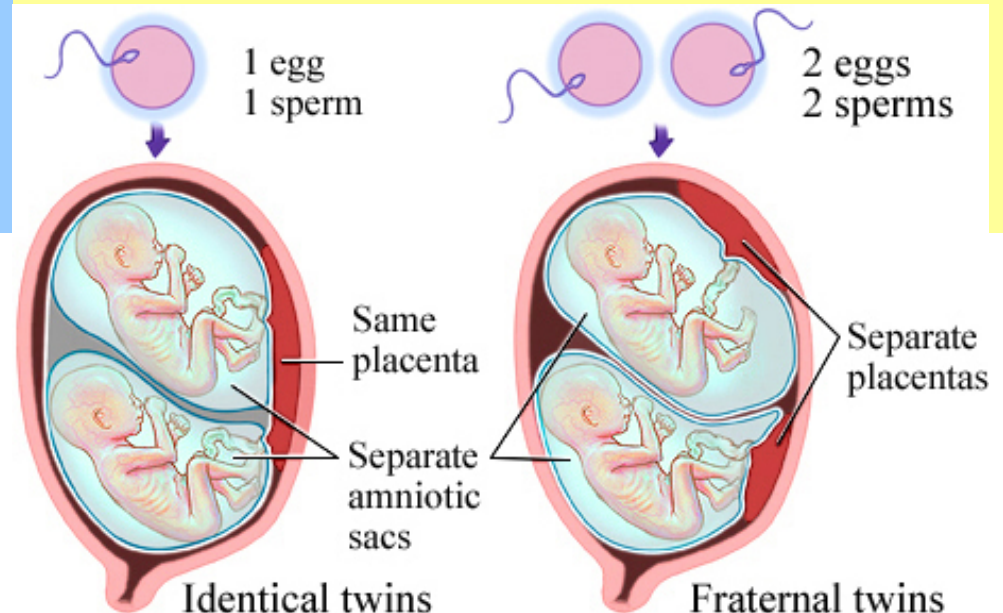
## Identical Clones

- 1 egg fertilized by 1 sperm
- During mitosis a single cell breaks free and a second embryo develops
- Same sex, blood type and genetic make up

## Fraternal Not clones

- 2 different eggs and 2 different sperm
- Do not have the same genetic make up (genes)
- No more similar than regular siblings but share uterus

**Remember:** less or more than 46 chromosomes in a cell can lead to major developmental problems or not a viable zygote at all



# Twins

**Here's an interesting thought...**

**If male identical twins produced offspring with female identical twins....**

**Genetically, the relations of the offspring would be closer to being siblings than being cousins.**

**Siblings share about 50% of their genetics while first cousins share about 12.5%**

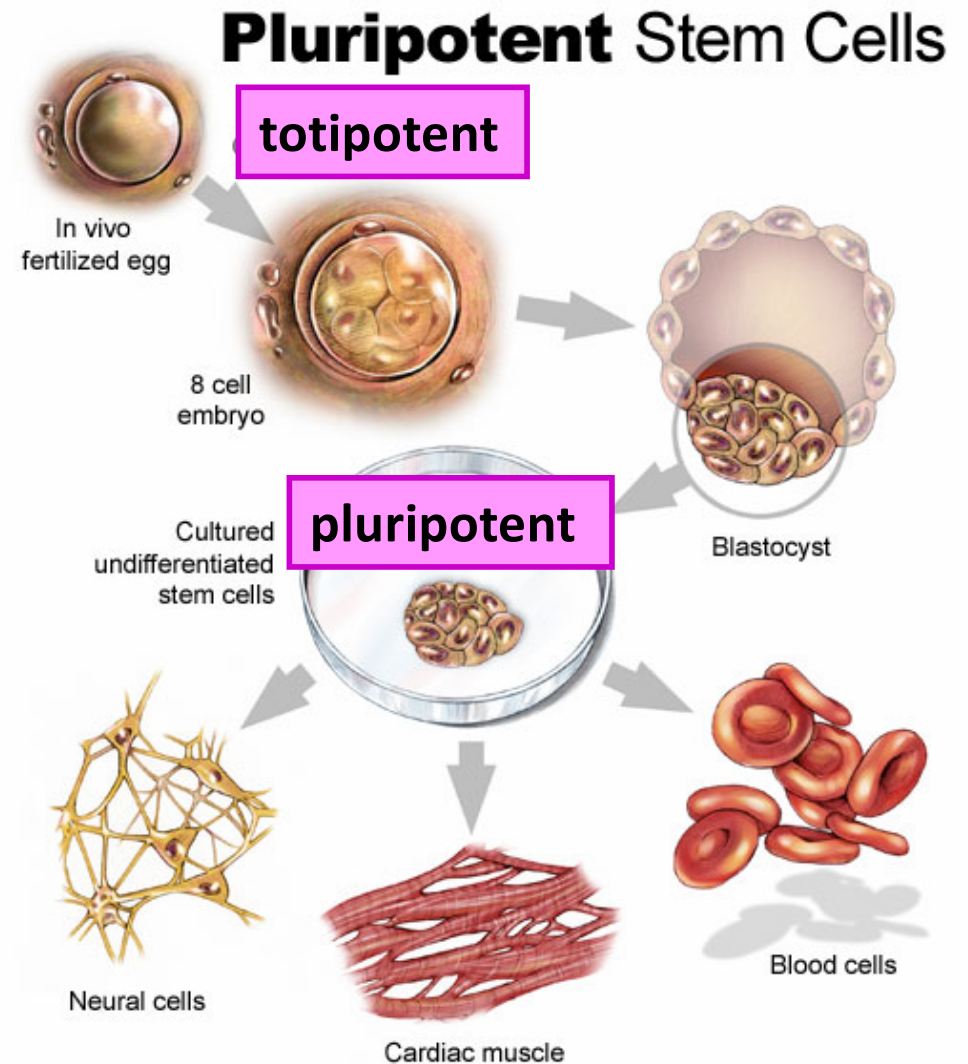




# Stem Cell Research

- Stem cells are cells that are capable of replicating and **differentiating** into many **different cells**, such as a skin cell, muscle cell or nerve cell

**PLURIPOTENT-** cells that can turn into ANY BODY cell

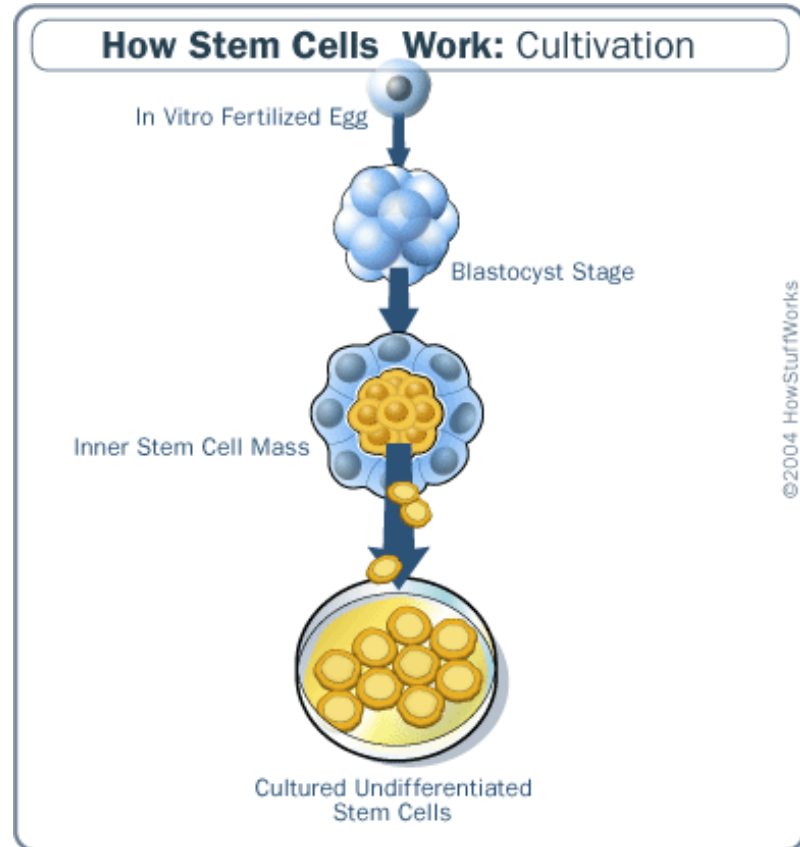


[Stem Cells in Our Bodies](#)

# Stem Cells

Stem cells can be derived from:

1. **Embryonic Stem Cells**  
(taken from **morula** or **the blastula**)
  - Either **totipotent** or **pluripotent**  
(Can become virtually any cell)
2. **Umbilical Cord Stem Cells** (found in blood and tissue)
3. **Adult Stem Cells**



**Where do Stem Cell come from?** For more information...

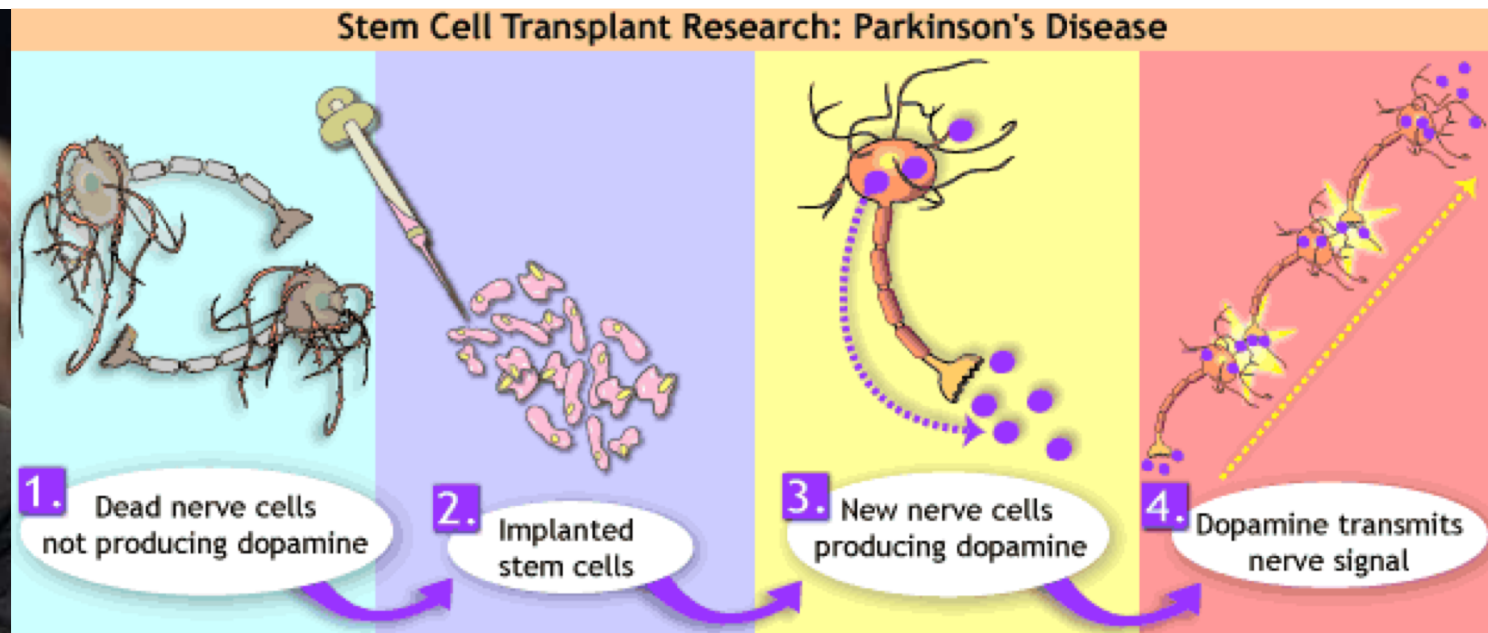
<http://learn.genetics.utah.edu/content/stemcells/>



# Stem Cells

- The goal of stem cell research is to **repair damaged tissue**
  - Ex. Parkinson's Disease
    - Stem cells are transplanted in the brain to produce functioning dopamine neurons
  - Bone marrow transplants provide new stem cells for patients battling **leukemia**

[Stem Cell Interactive Growth & Repair](#)

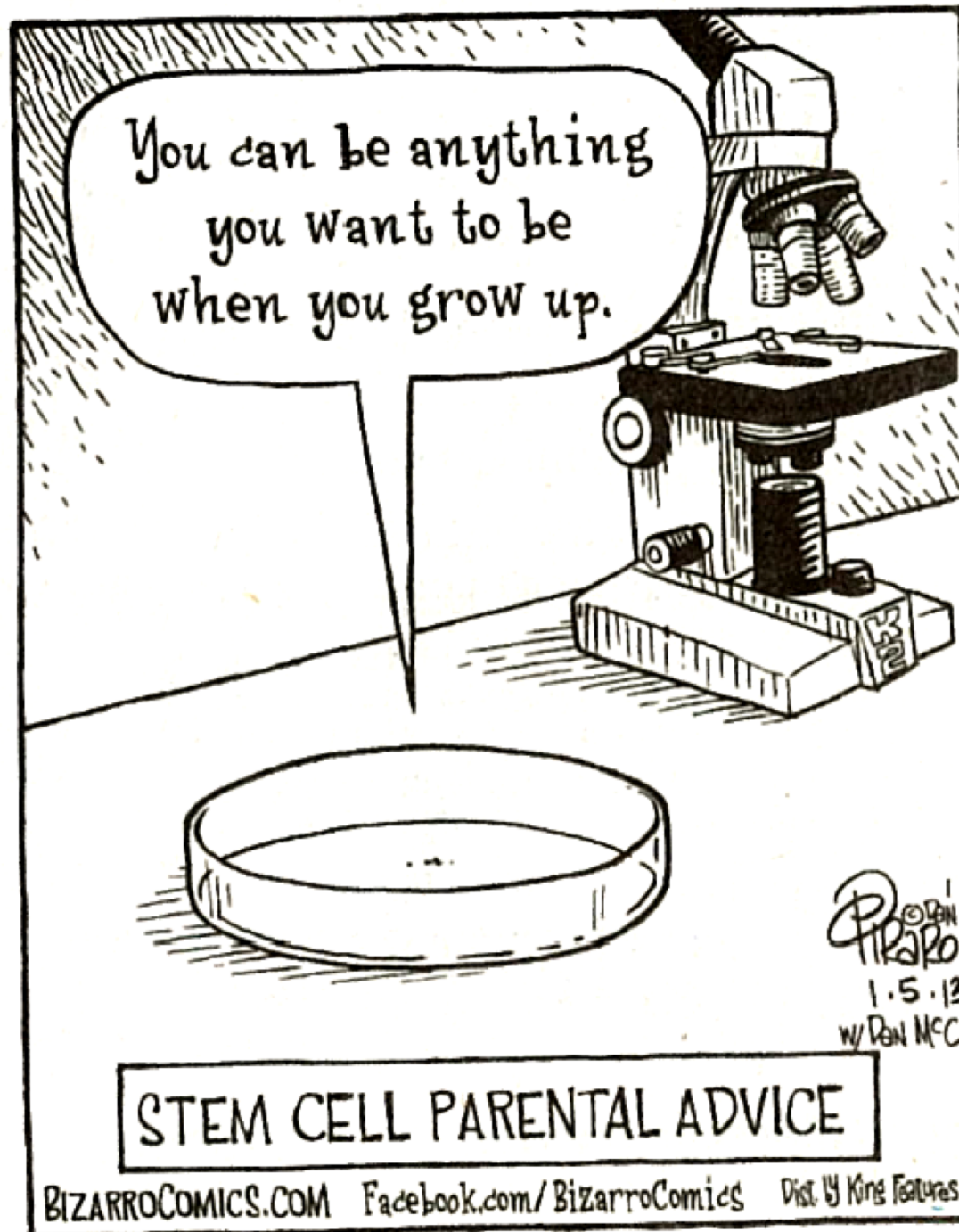


# What are some issues in stem cell research?

- Embryonic stem cells
  - How do we obtain stem cells?
- **Cost?**
- Can we use this to clone humans or just to treat disease?



“Went in for a simple blood test and got cloned by mistake.”



LIFE BEGINS  
AT THE PETRI  
DISH!

EVEN THE HUMAN  
EMBRYOS ARE  
DIVIDED...

CLONING FOR  
RESEARCH!

SCIENTIFIC  
RESEARCH



I DIED WAITING FOR  
EMBRYONIC STEM CELL  
RESEARCH TO FIND A CURE.  
WHAT ABOUT YOU?

I WAS THE  
EMBRYO

Garry Shandling  
THE ADAM CAROLIN STAR  
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