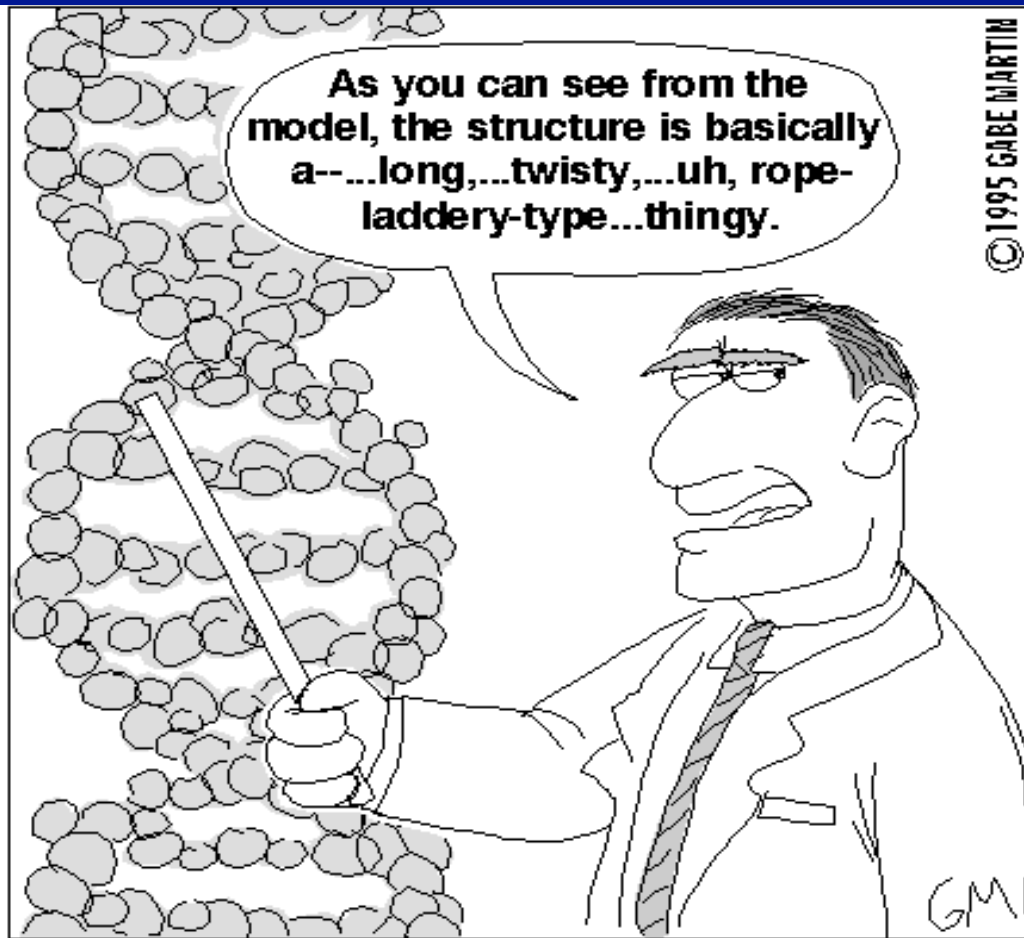


Biology 30 Unit 1

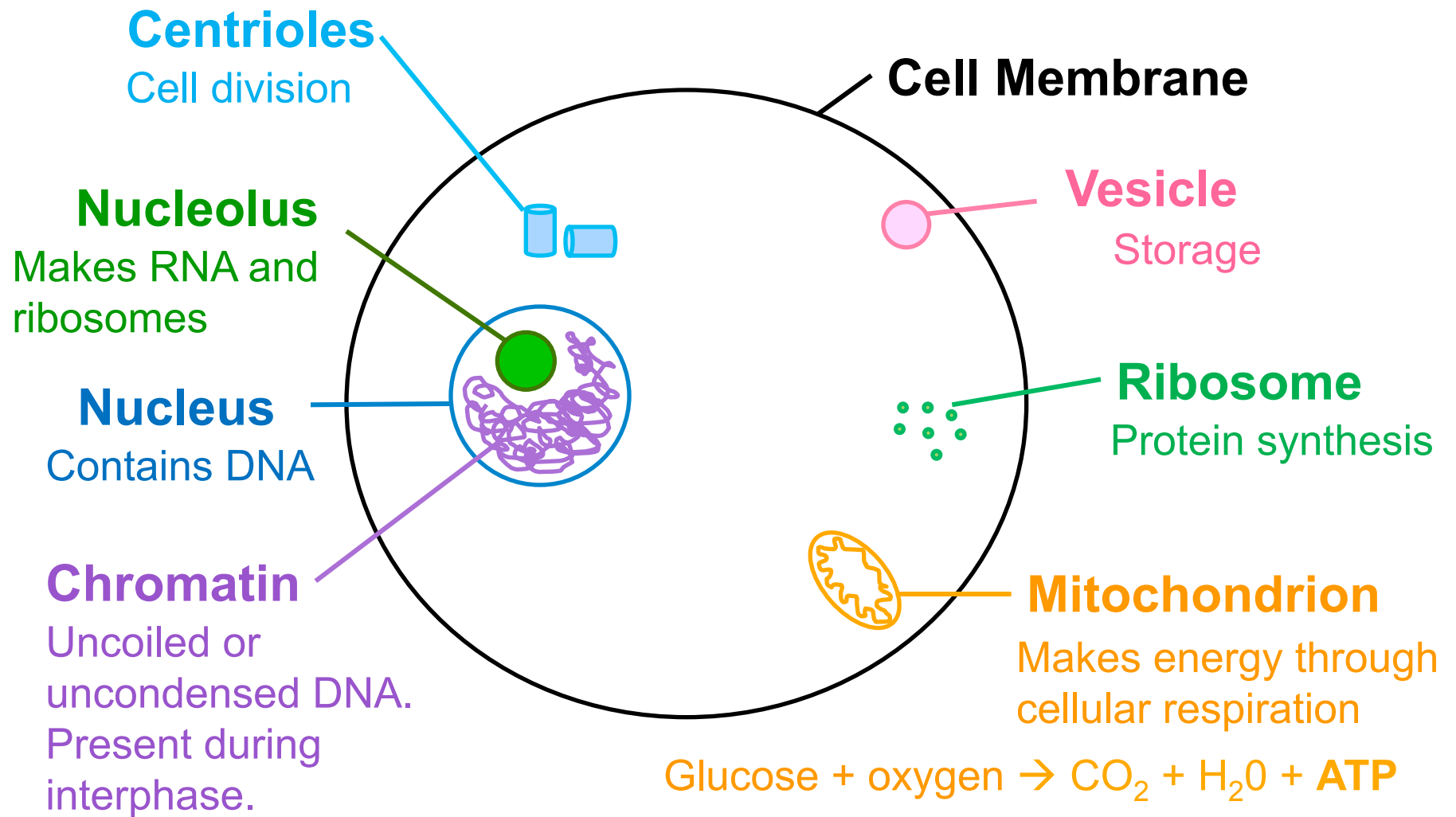
Introduction to Cell Division



1953: The structure of the DNA molecule is first described.

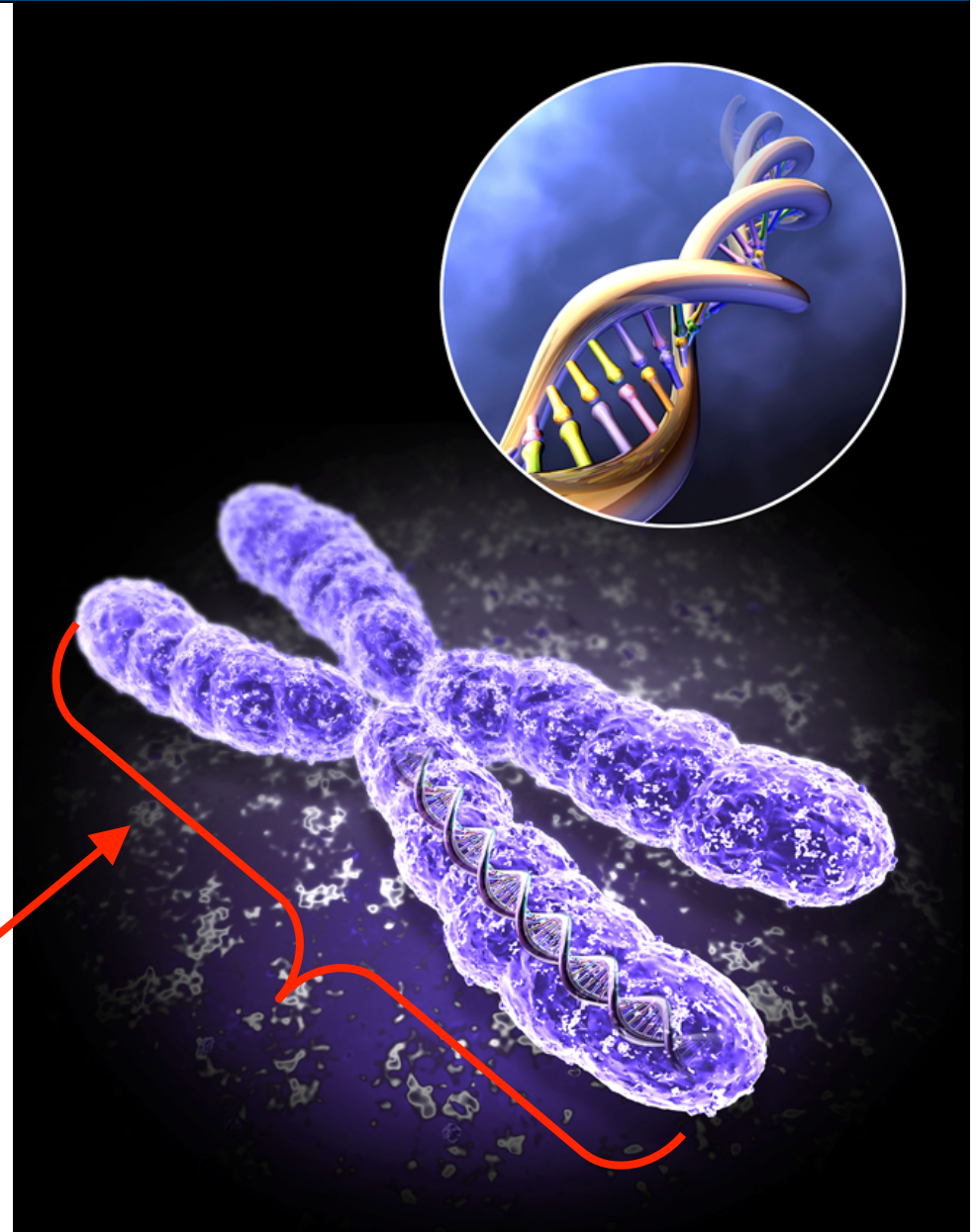


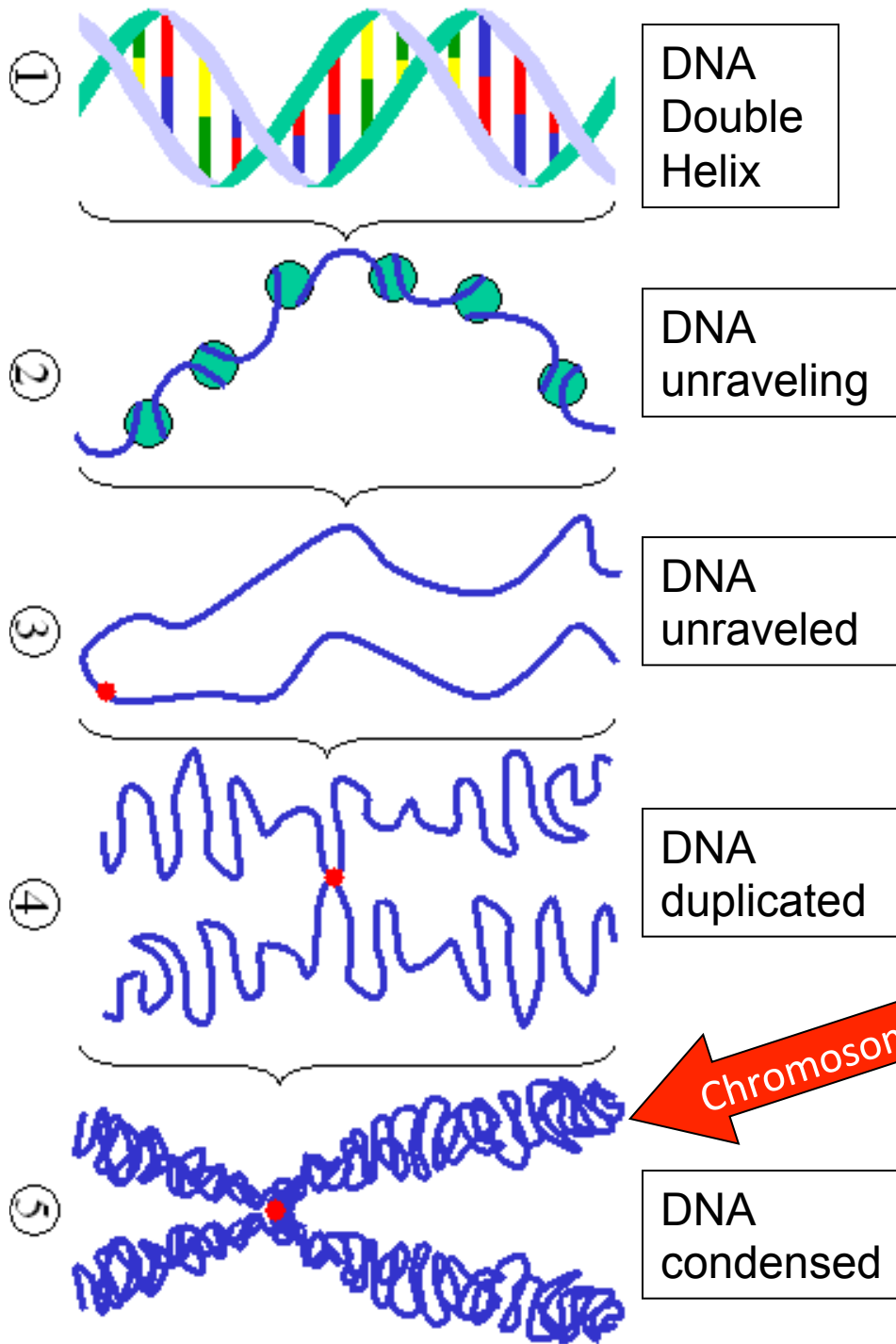
Animal Cell



Chromosome

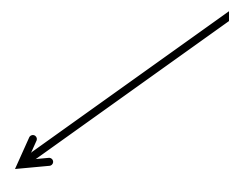
- The genetic information of a cell is contained in its DNA in the nucleus
- When a cell is preparing to divide, DNA is coiled around a histone protein and then condensed and packaged to form a chromosome





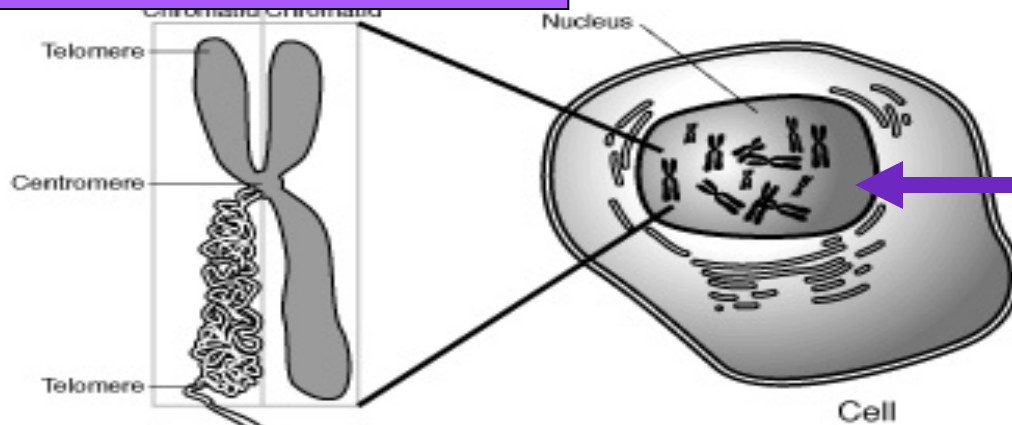
Chromosomes

- long threads of **DNA** wrapped around a bead of protein (a **histone**) to form **chromatin** (threadlike)



- When a cell is getting ready to divide the **chromatin coils up and forms thicker strands of chromosomes** and later replicate to look like X's.

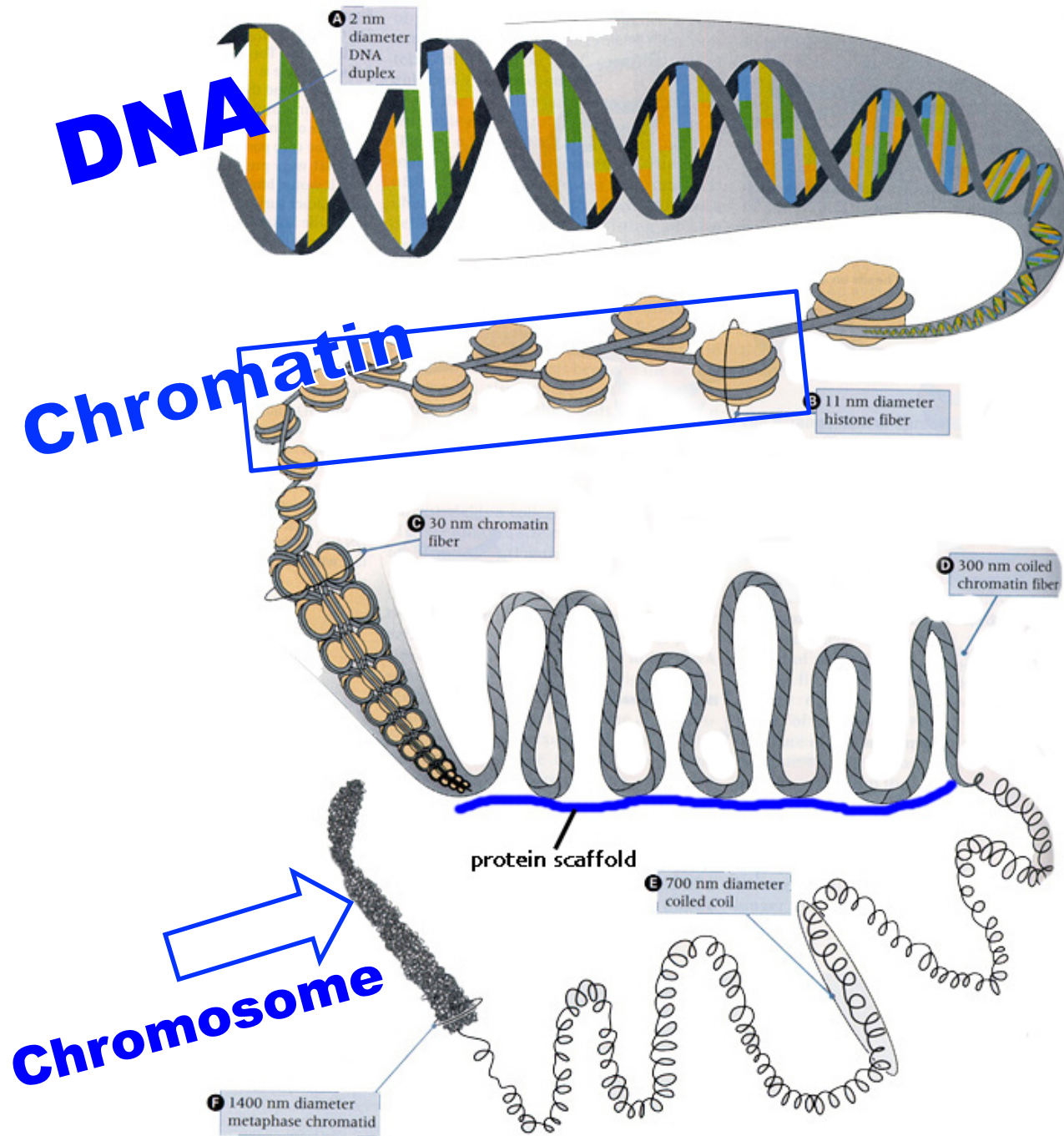
Chromosome



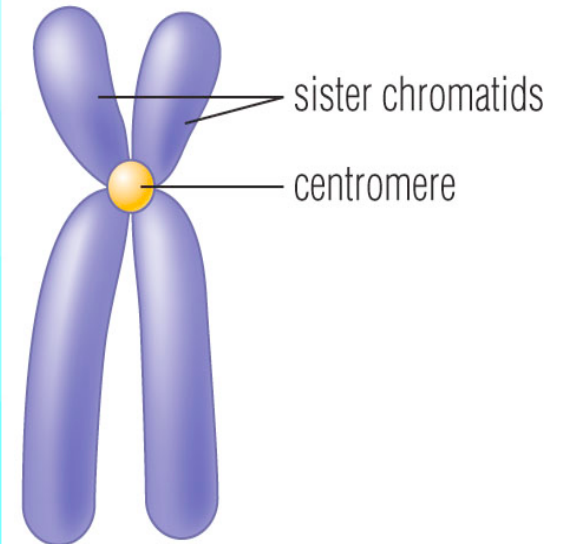
Nucleus

Chromatin
(thin strands)

DNA



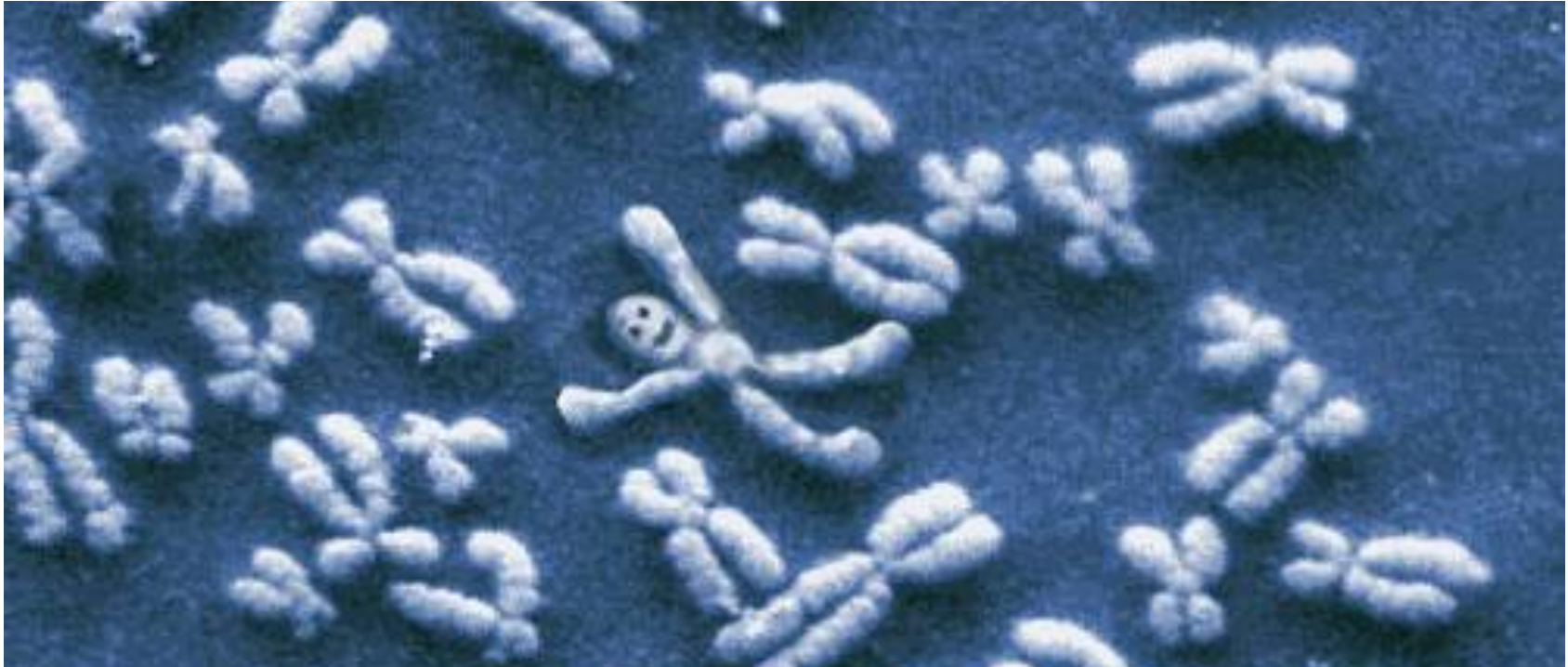
Chromosomes depicted in this X-shaped form



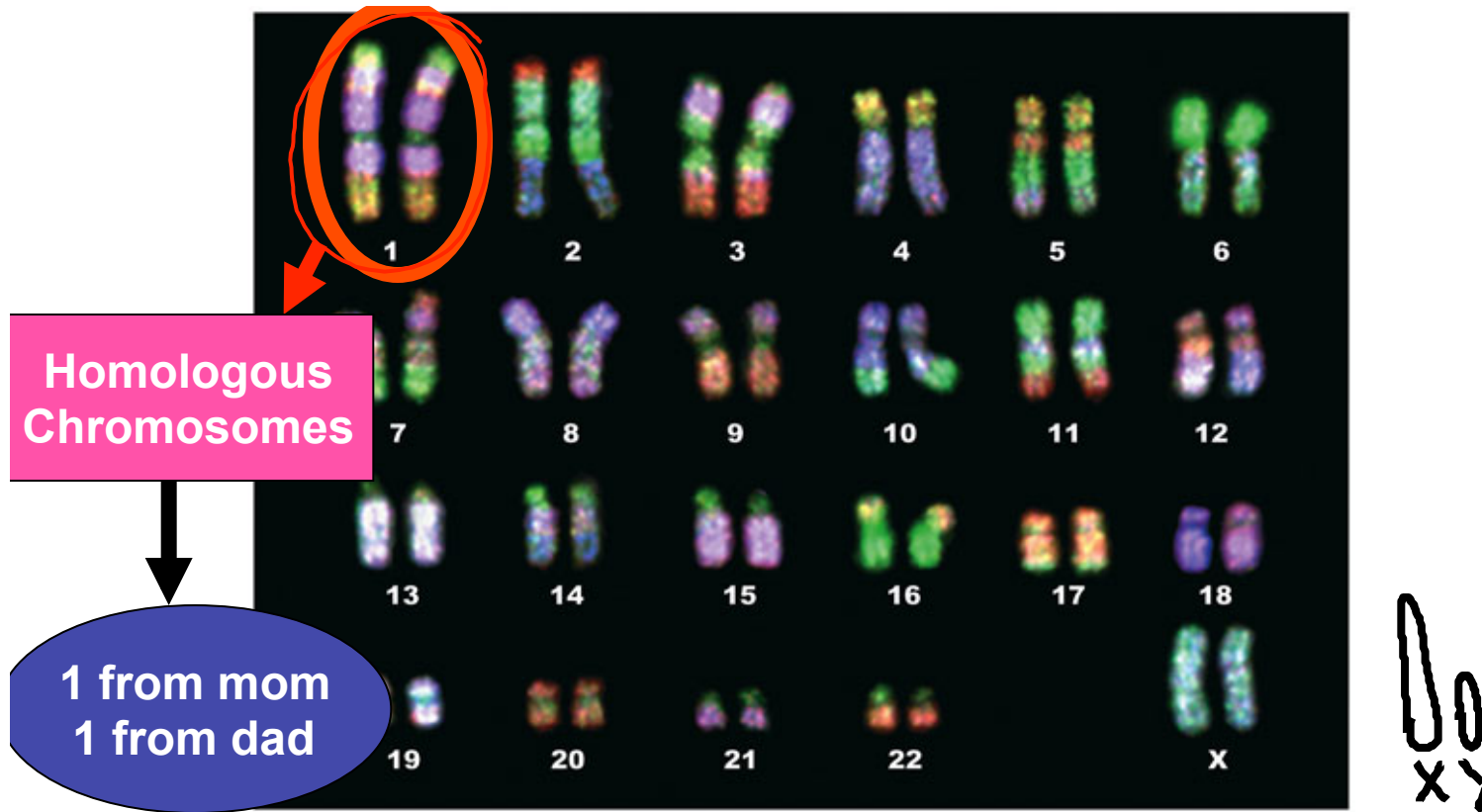
...have already been duplicated in preparation for mitosis (or meiosis).

The two identical copies (sister chromatids) are connected at the centromere.

- DNA is found in chromatin / chromosomes
- Chromosomes = condensed(bundled) chromatin



**Chromosomes look like X's
only when they are replicated!**

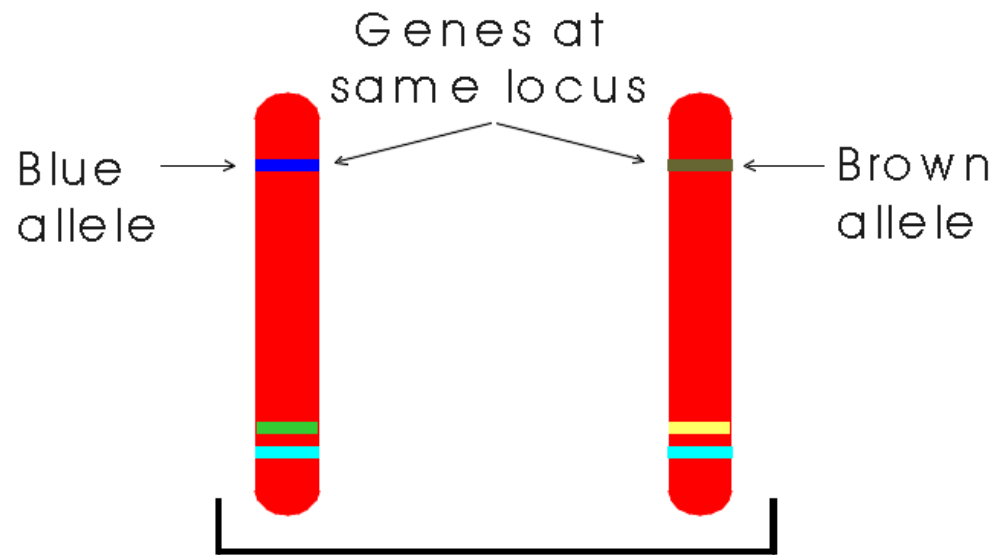


Humans have **46** chromosomes (**23 pairs**).
44 are **autosomes** (not sex controlling).
Autosomes are chromosomes #1-22.
2 are sex chromosomes (# 23 pair)

Females = XX Males = XY

Homologous Chromosomes

Homologous chromosomes carry the same genes at the same location or **locus**. One from mom and one from dad



Even though homologous chromosomes look alike they are **NOT IDENTICAL** because they carry different forms or **alleles** of the same gene.

-but essentially they are “talking” about the same thing

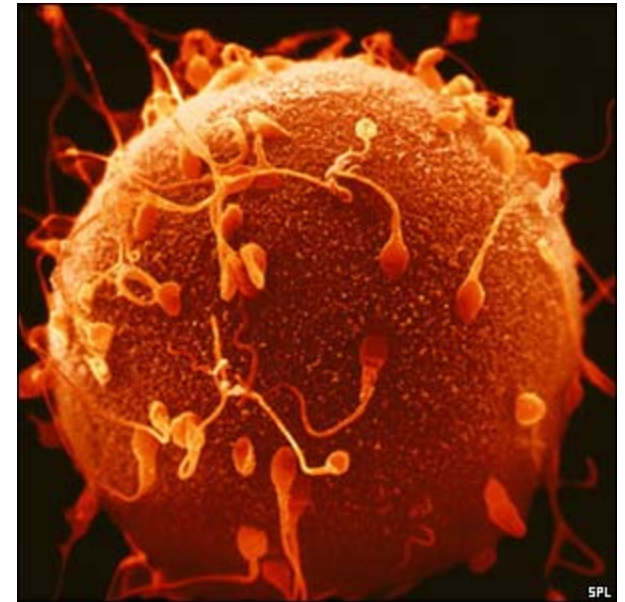
Diploid (2n)

- Total number of chromosomes in every **somatic (body) cell** of an organism
- Organisms obtain $\frac{1}{2}$ their chromosomes from their mom(**n**) and $\frac{1}{2}$ from dad (**n**)
- In humans,
 - The **diploid number is 46**

$$2n=46$$

Haploid (n)

- Total number of chromosomes in the **gametes** (egg or sperm) of an organism
- In humans,
 - sperm have 23 chromosomes
 - eggs have 23 chromosomes
 - Therefore, the **haploid (n) number is 23**



$$n=23$$

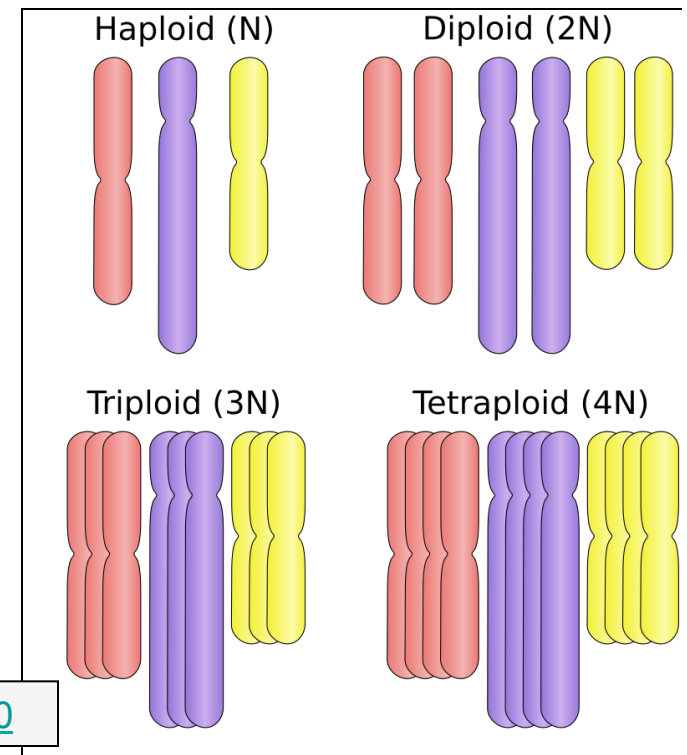
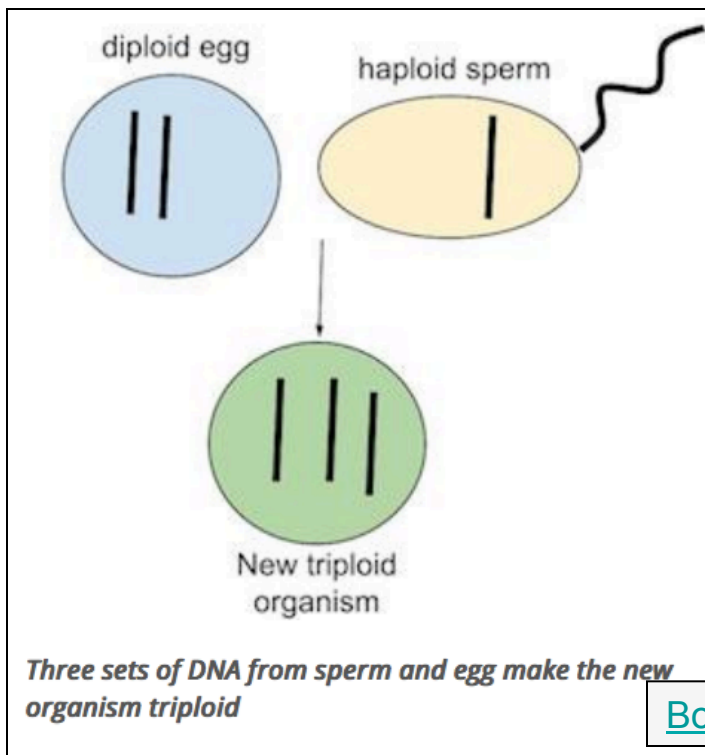
Diploid Numbers Are Unique

- All organisms have a unique diploid number
- Just because two organisms have the same diploid number DOES NOT mean that they are related
- Diploid numbers DO NOT indicate the complexity of an organism!!

Organism	Diploid Number (2N)	Haploid Number (N)
Dog	78	39
Cat	38	
Shrimp		2
Scorpion	256	
Green Ash Tree		23
Human	46	

Ployploidy

- Some organisms are polyploid, meaning that **they have more than $2n$ chromosomes (plants)**
 - Tetraploid = **$4n$** (4 homologous chromosomes)
 - Triploid = **$3n$** (3 homologous chromosomes)
 - Octaploid = **$8n$** (8 homologous chromosomes)

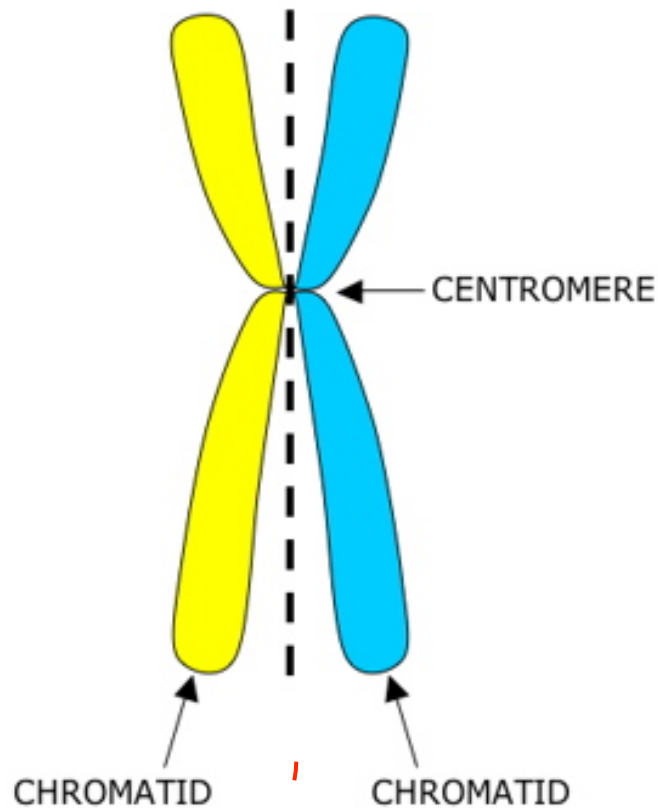


Polyploidy examples

Organism	Haploid (N)	Chromosome number	Ploidy
Oats	7	42	
Peanut		40	4n
Sugar Cane	10		8n
Potato	12	48	
Cotton		52	4n
Apple	17		3n

Chromosomes

Replicated chromosome

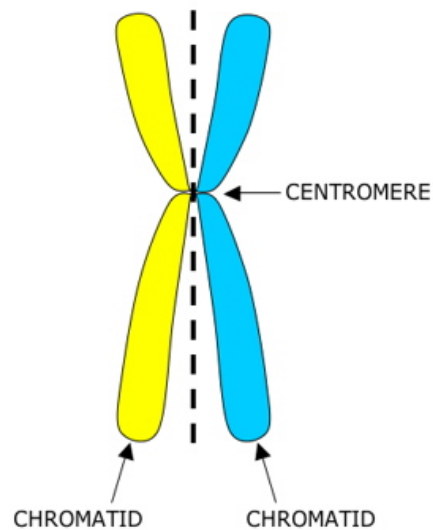


Chromosomes **MUST** replicate themselves prior to cell division. The two sister chromatids shown are identical to each other and were created during DNA synthesis!

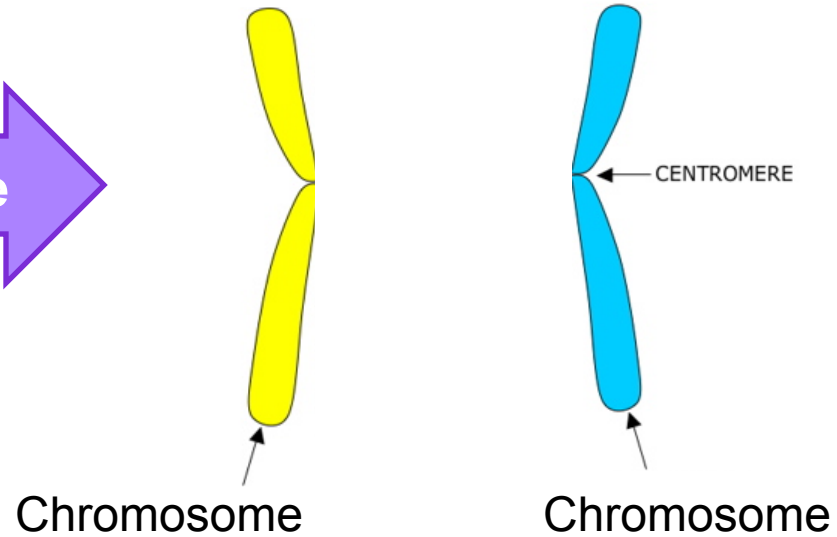
A chromatid is $\frac{1}{2}$ of a replicated chromosome. It's only called a chromatid while it is attached by the centromere to its sister chromatid.

Chromatids → Chromosomes

Replicated chromosome



Anaphase



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

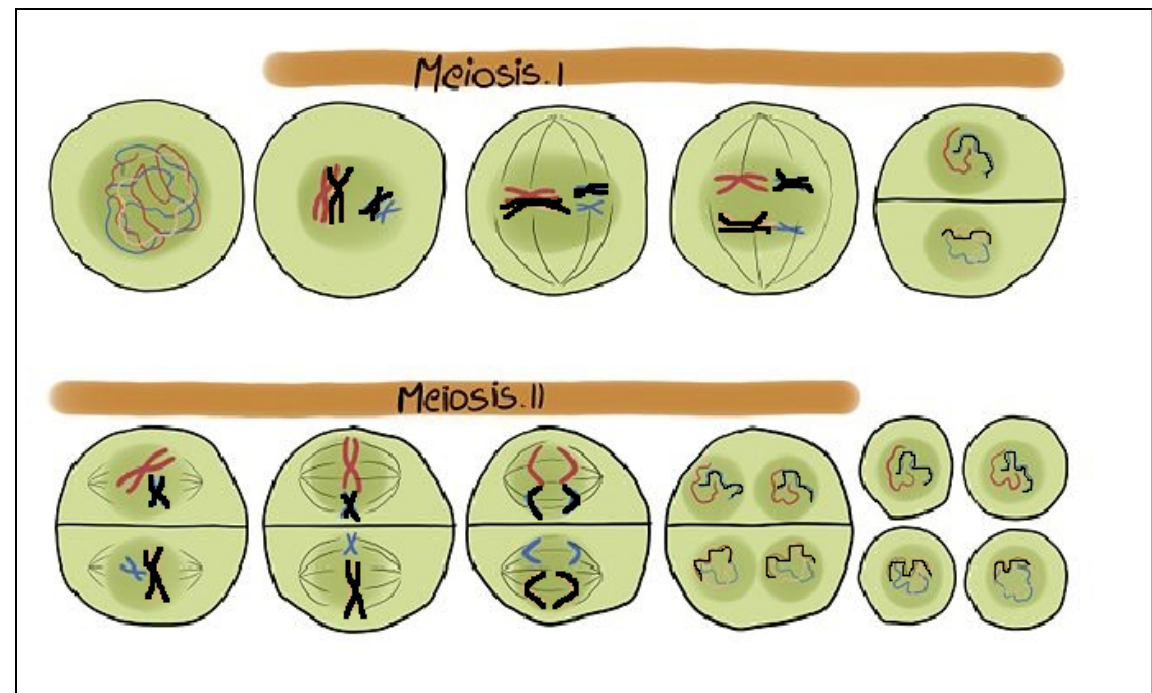
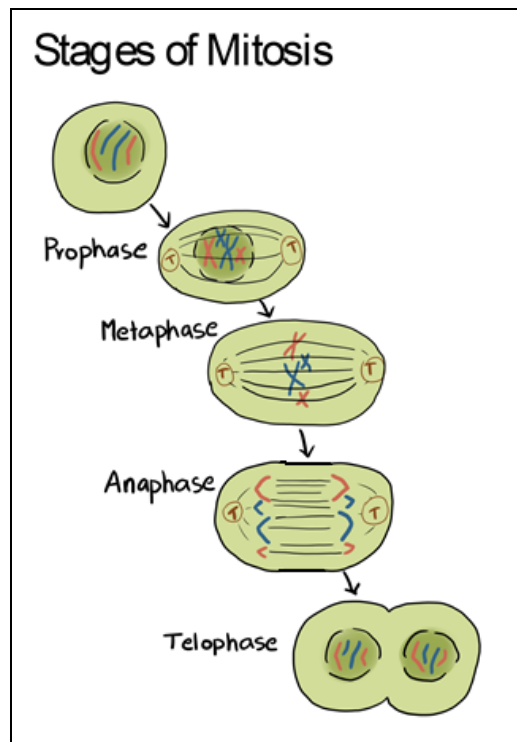
Cell Division

- 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



Mitosis and Meiosis

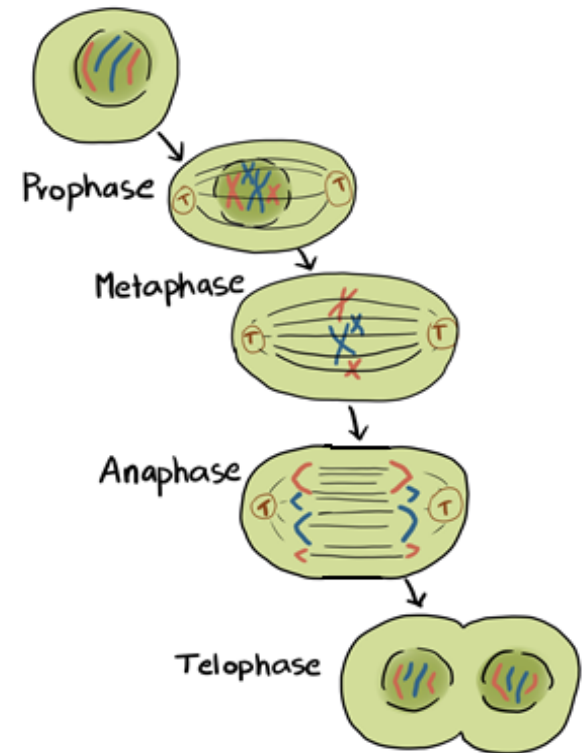
- There are two types of cell division: **mitosis** and **meiosis**. Most of the time when people refer to “cell division,” they mean mitosis, the process of making new body cells. Meiosis is the type of cell division that creates egg and sperm cells.



Mitosis Versus Meiosis

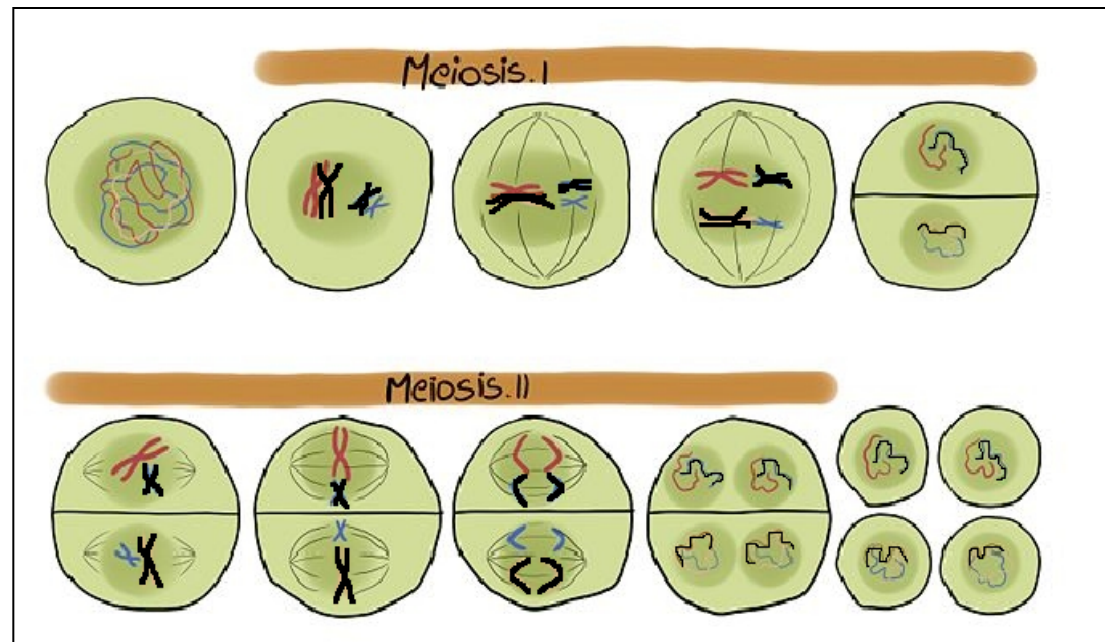
- Mitosis is a fundamental process for life. During mitosis, a cell duplicates all of its contents, including its chromosomes, and splits to form two identical daughter cells. Because this process is so critical, the steps of mitosis are carefully controlled by a number of genes. When mitosis is not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

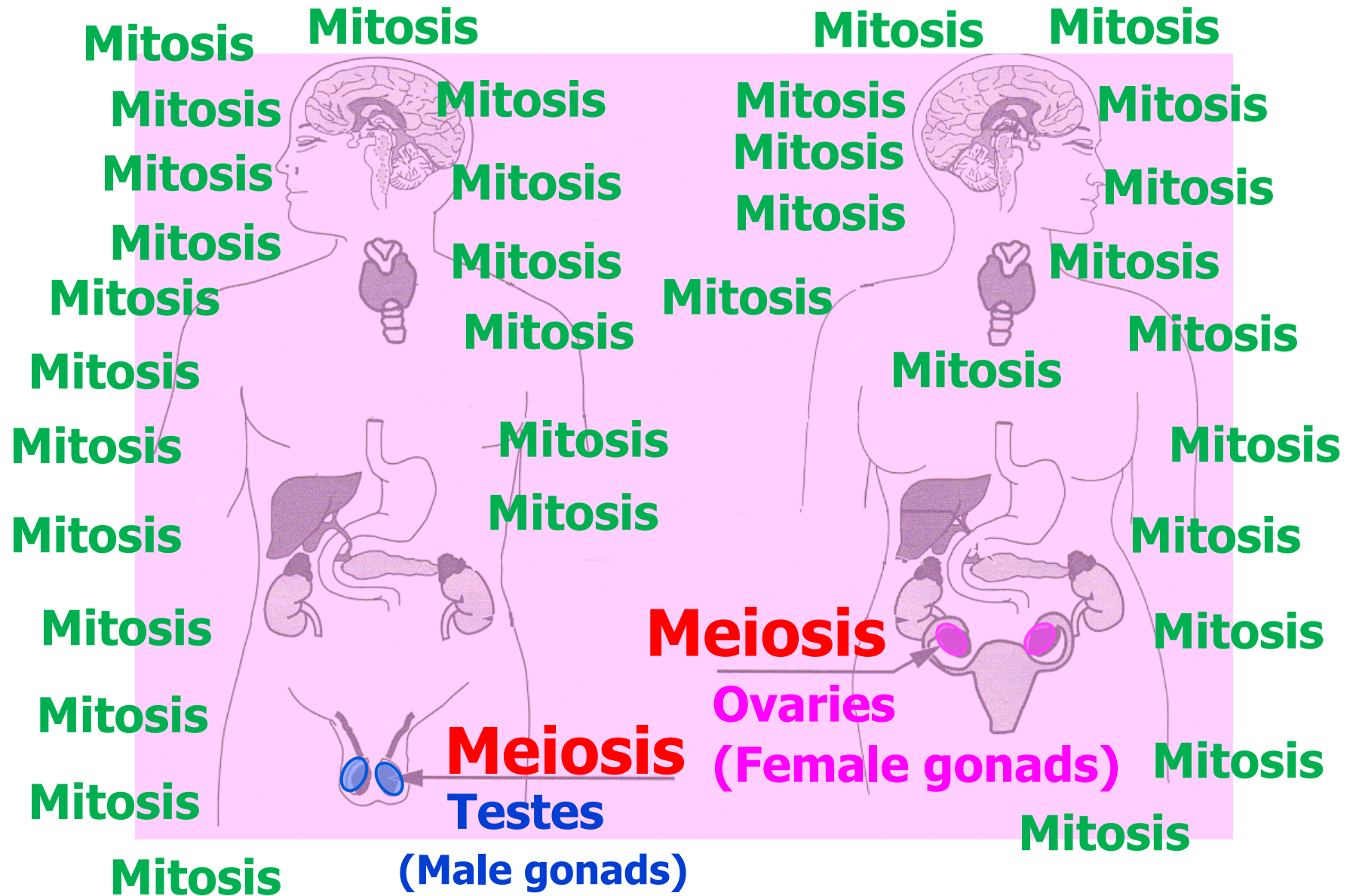
Stages of Mitosis

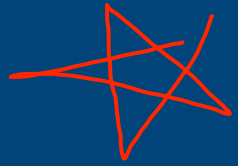


Mitosis Versus Meiosis

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.



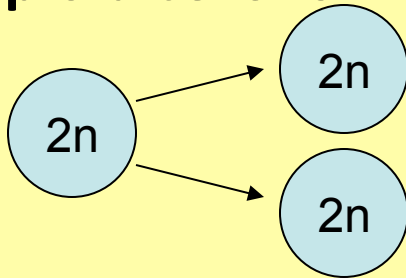




Two Types of Cell Division

MITOSIS (IPMAT)

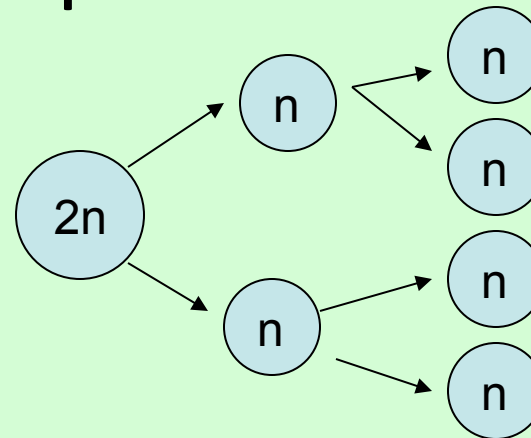
- For growth, maintenance & repair
- $2n$ cell \rightarrow $2n$ cells
(46 chromosomes \rightarrow 46 chromosomes) *Diploid*
- 2 diploid cells form



- Occurs in somatic cells in the human body!

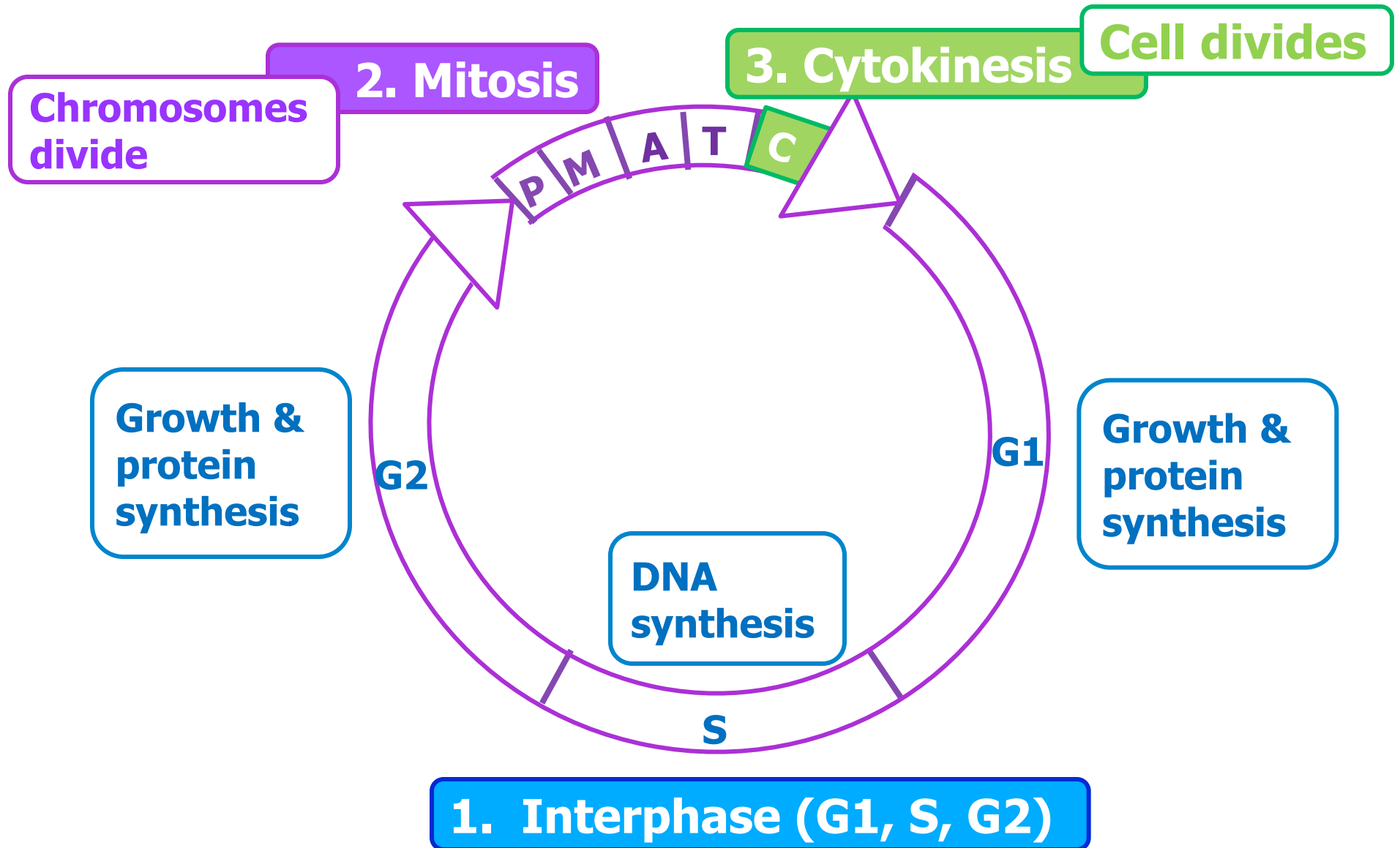
MEIOSIS (IPMATPMAT)

- 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

Cell cycle – 3 phases: **Interphase, Mitosis, and Cytokinesis**

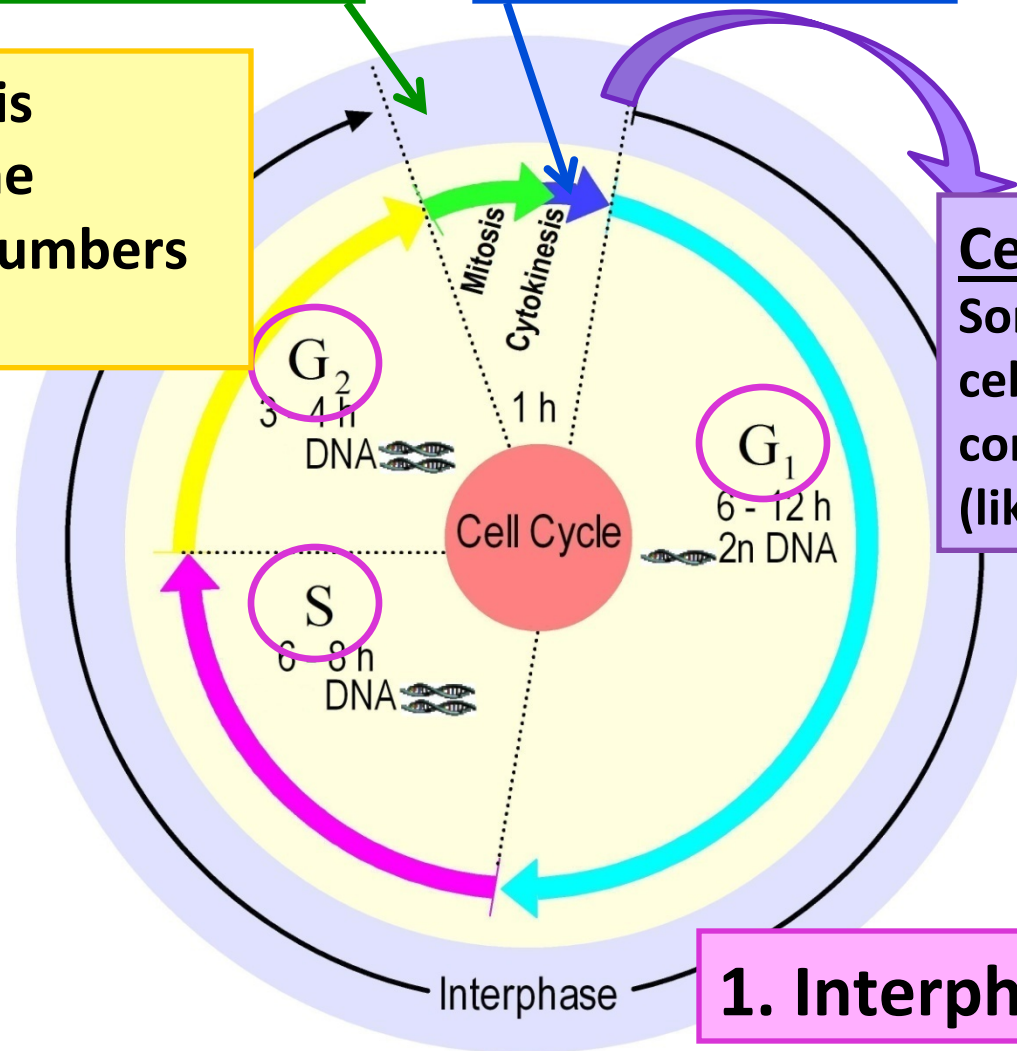


The Cell Cycle – 3 Phases

2. Mitosis

3. Cytokinesis

DNA synthesis is necessary so the chromosome numbers stay the same.



Cell Specialization

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

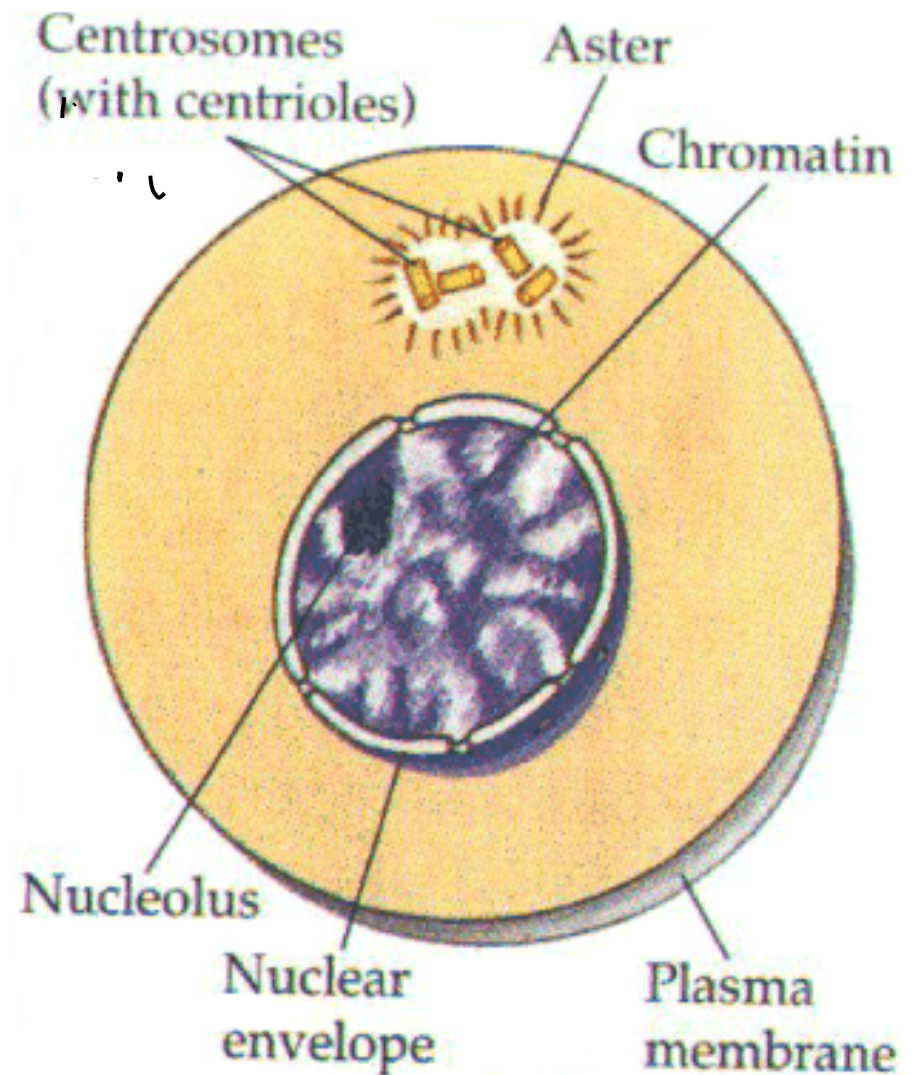
1. Interphase

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-3BDInK58&safe=active&safety_mode=true

Preview of Mitosis

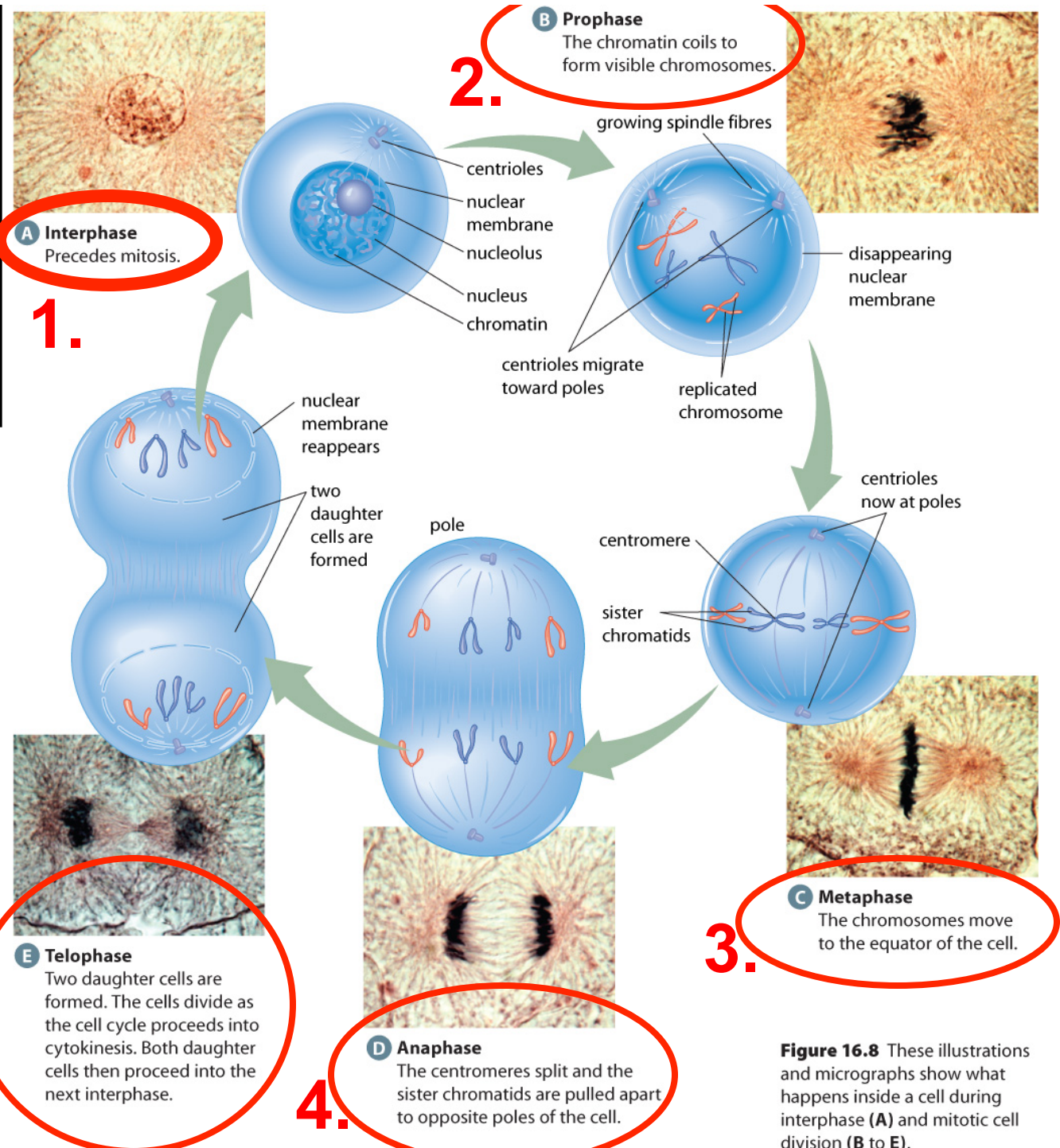


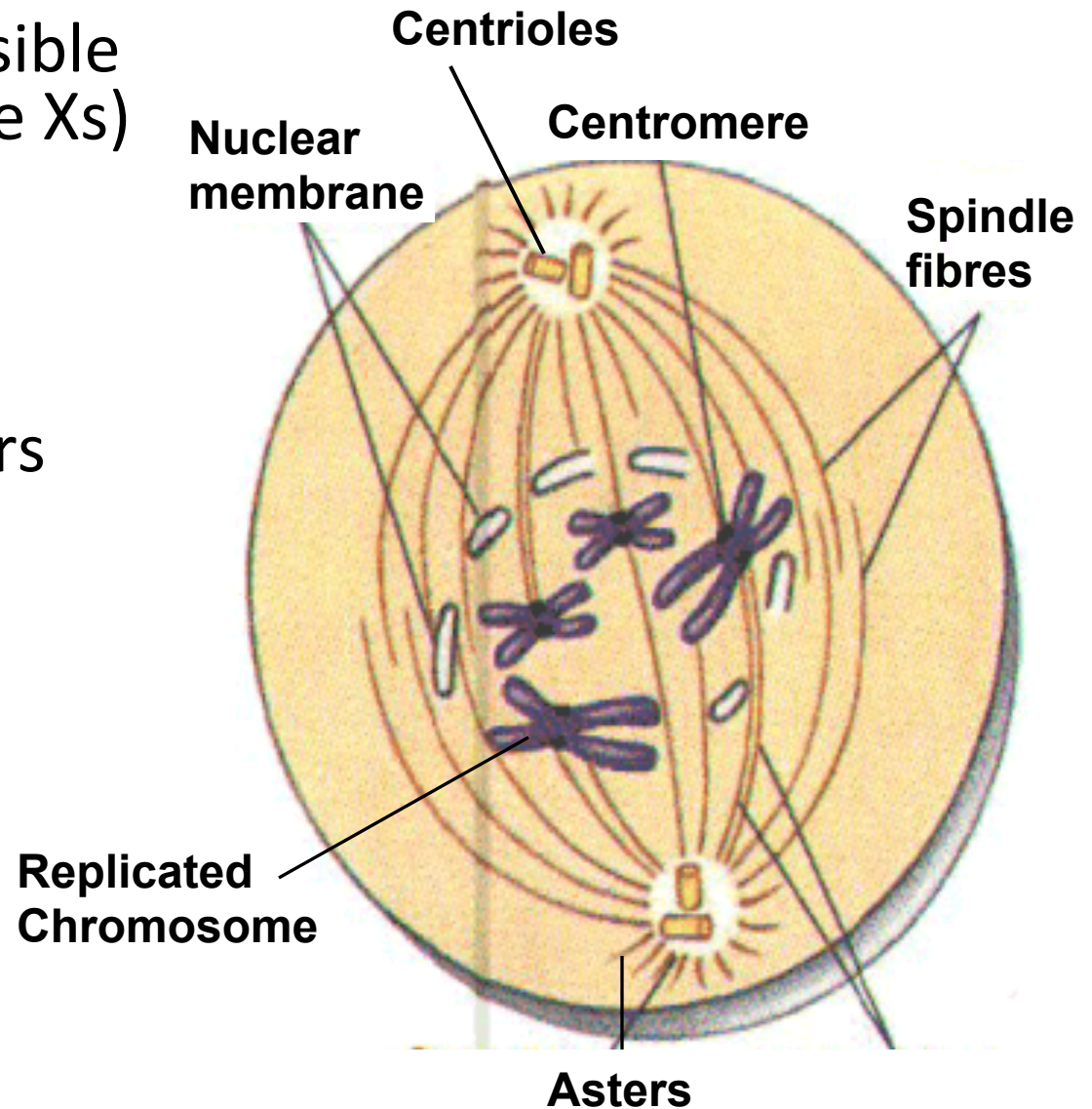
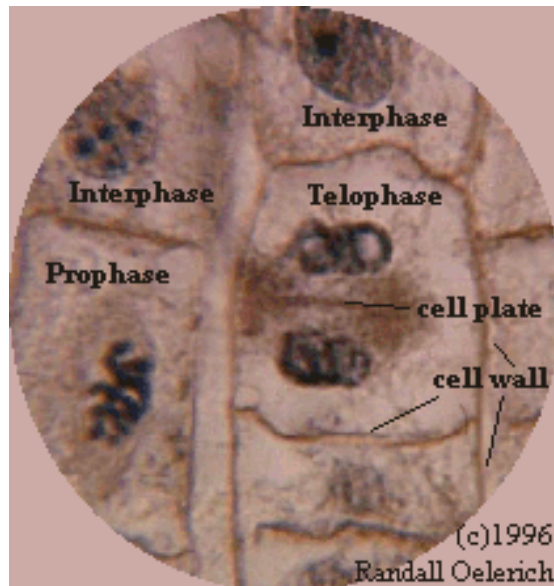
Figure 16.8 These illustrations and micrographs show what happens inside a cell during interphase (A) and mitotic cell division (B to E).

Mitosis Animation
(McGraw-Hill)

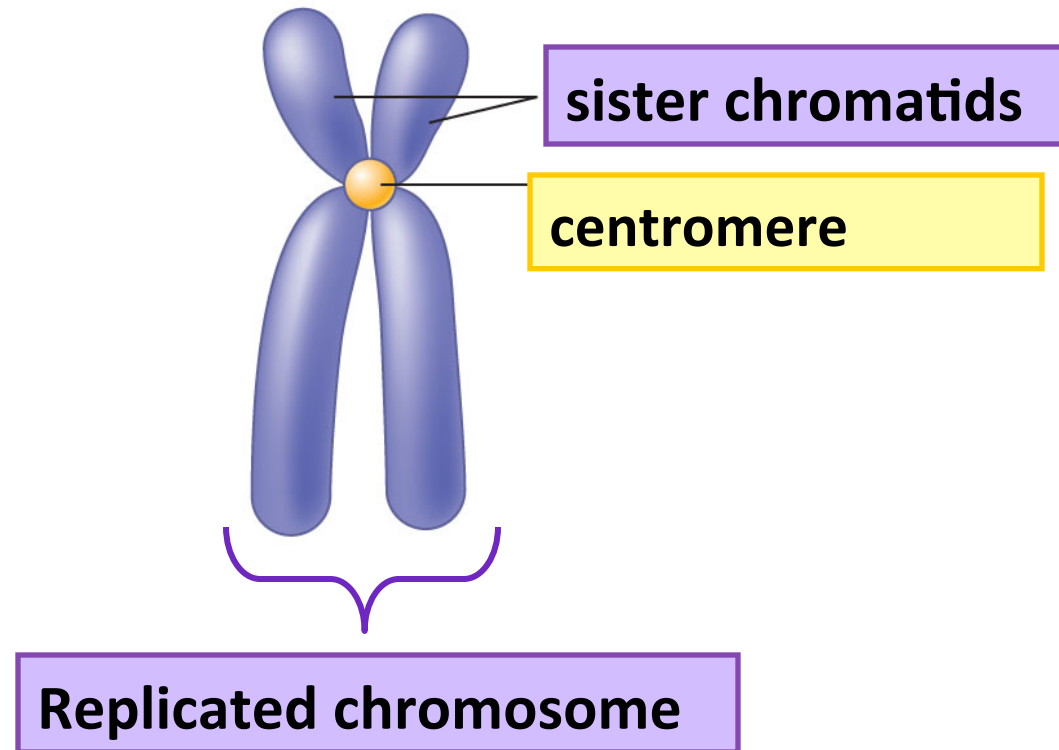
http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter2/animation_mitosis_and_cytokinesis.html

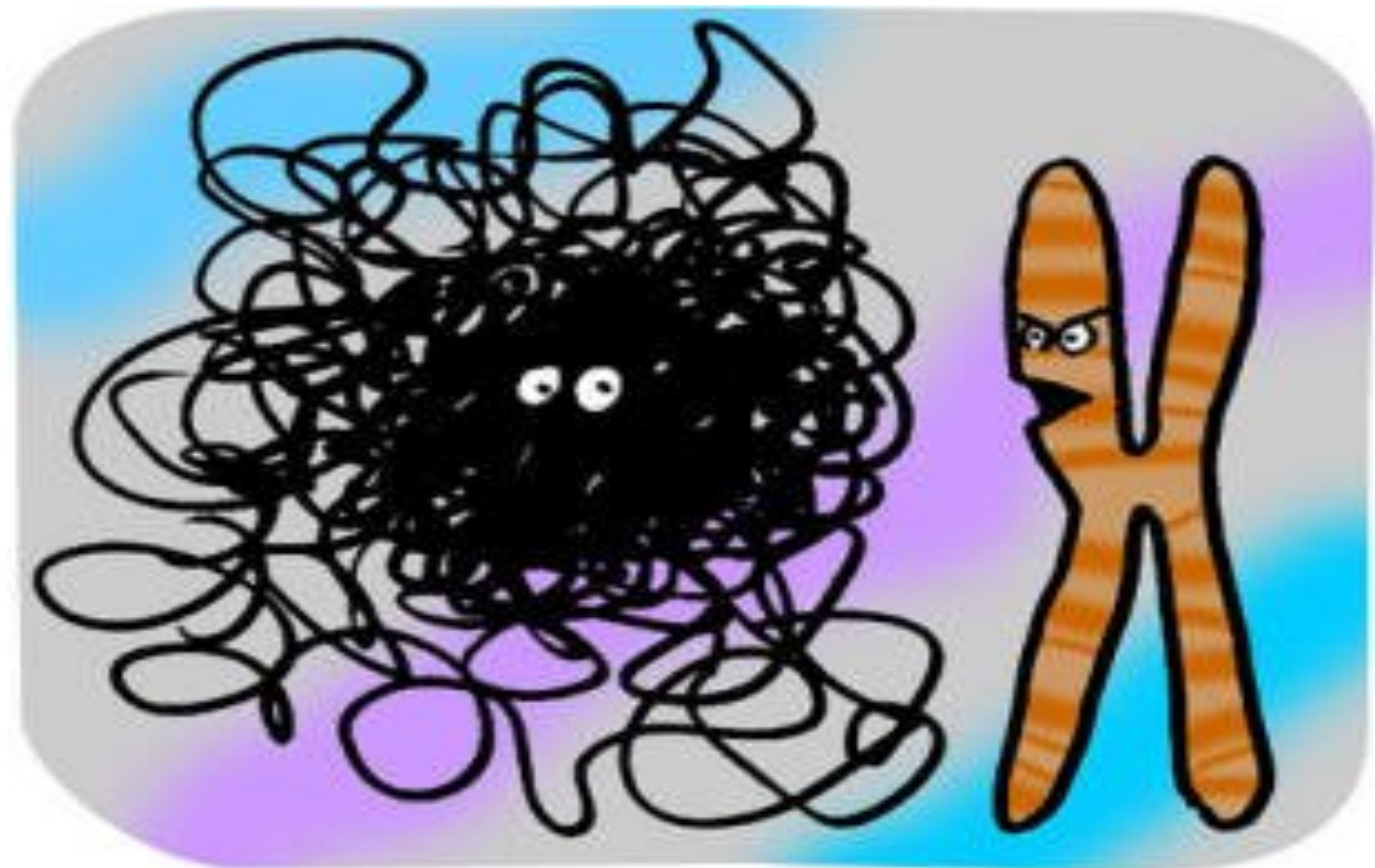
Prophase (PREPARE)

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



Chromosomes during Prophase and Metaphase

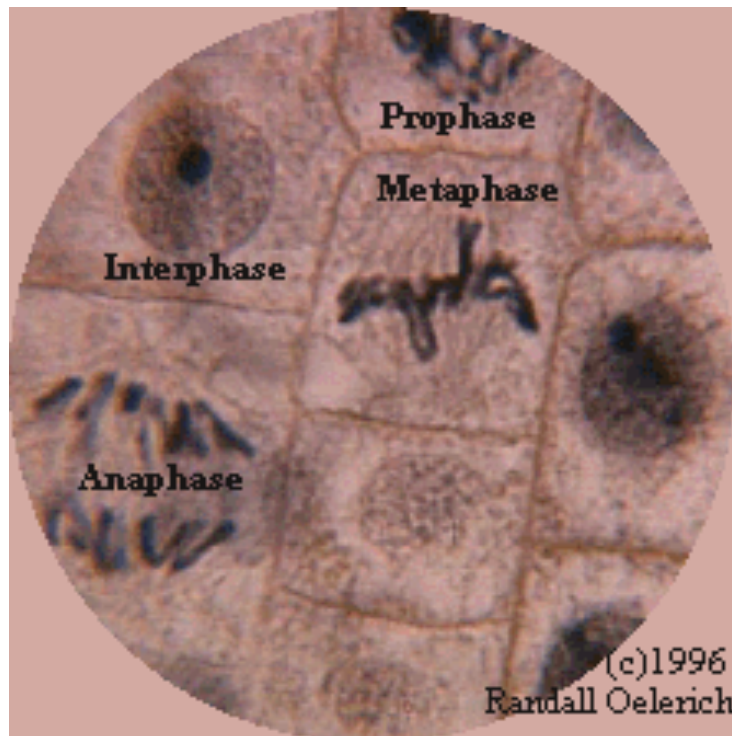




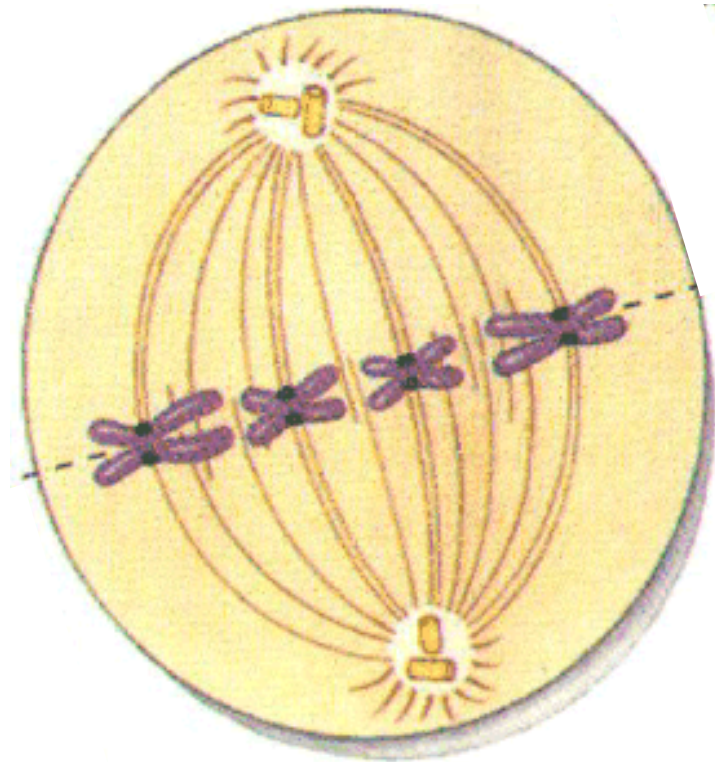
Dude, mitosis starts in five minutes...
I can't believe you're not condensed yet.

Metaphase (MIDDLE)

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

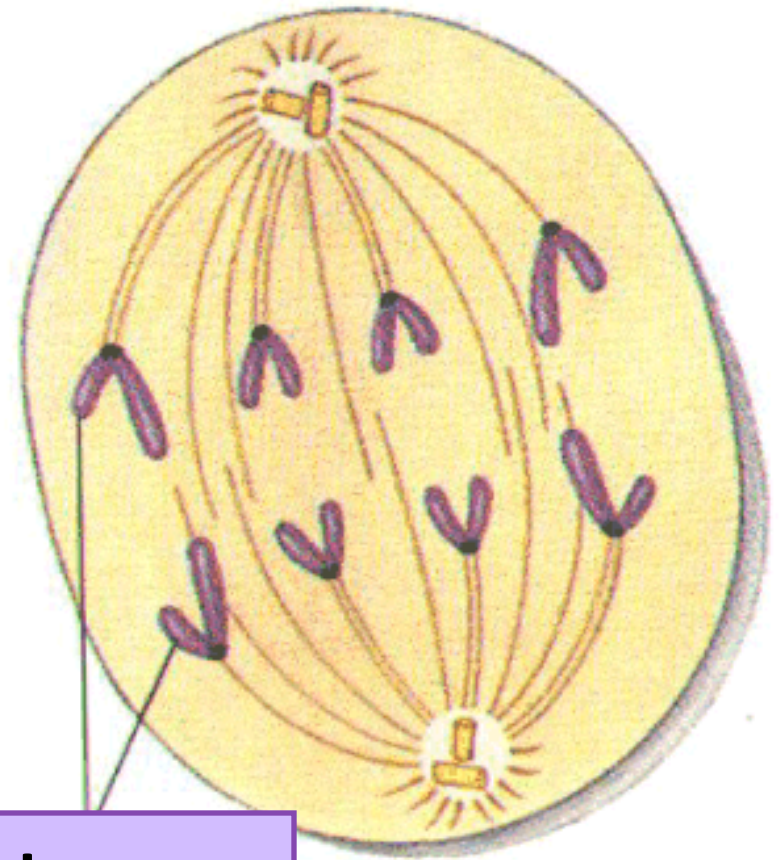
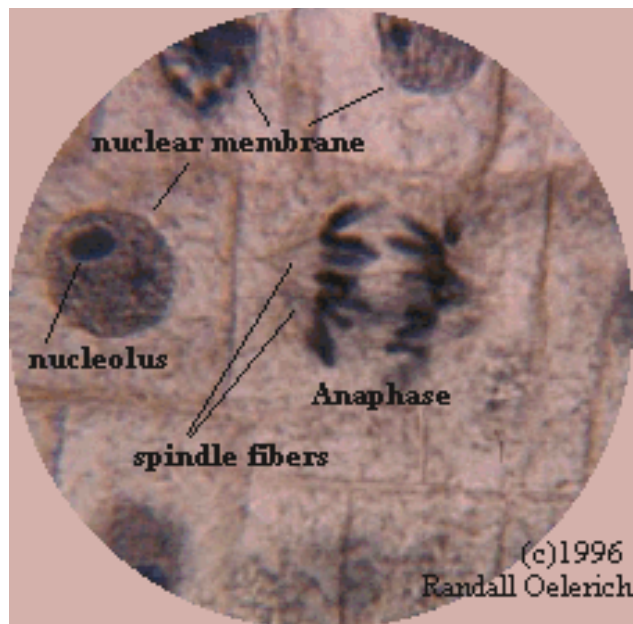


Metaphase
plate



Anaphase (APART)

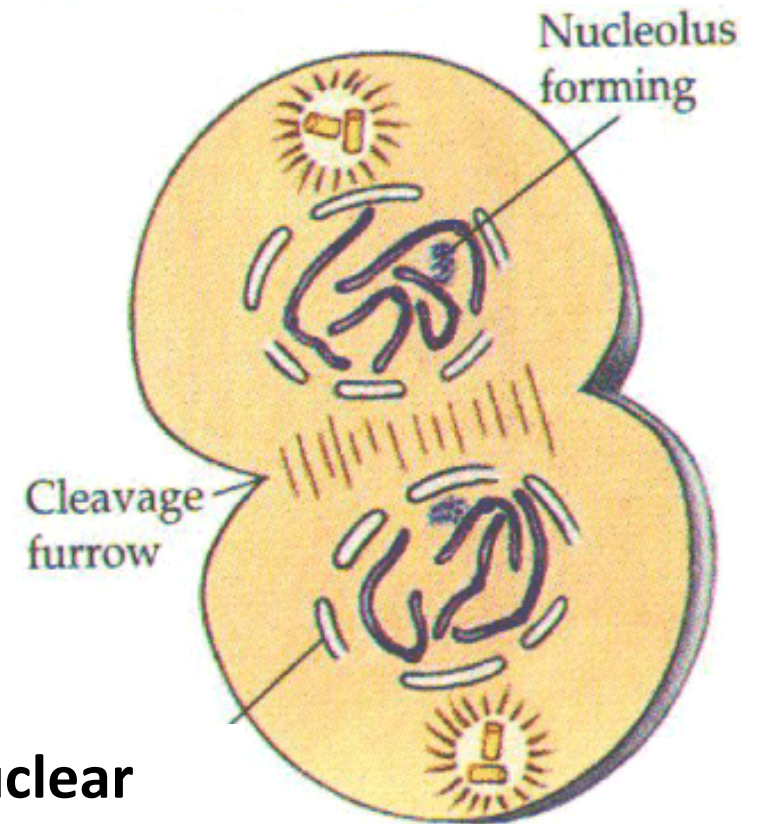
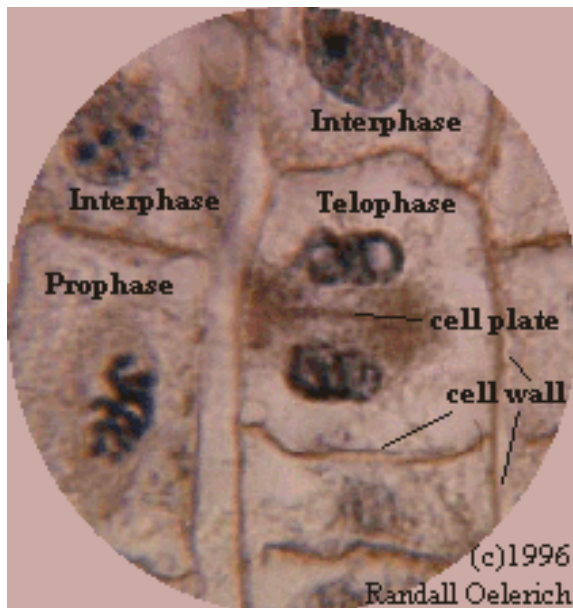
- Action!
- Centromeres divide
- **chromosomes** move to opposite poles



**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 r
t o
e p
r h
p a
h s
a s
e 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)

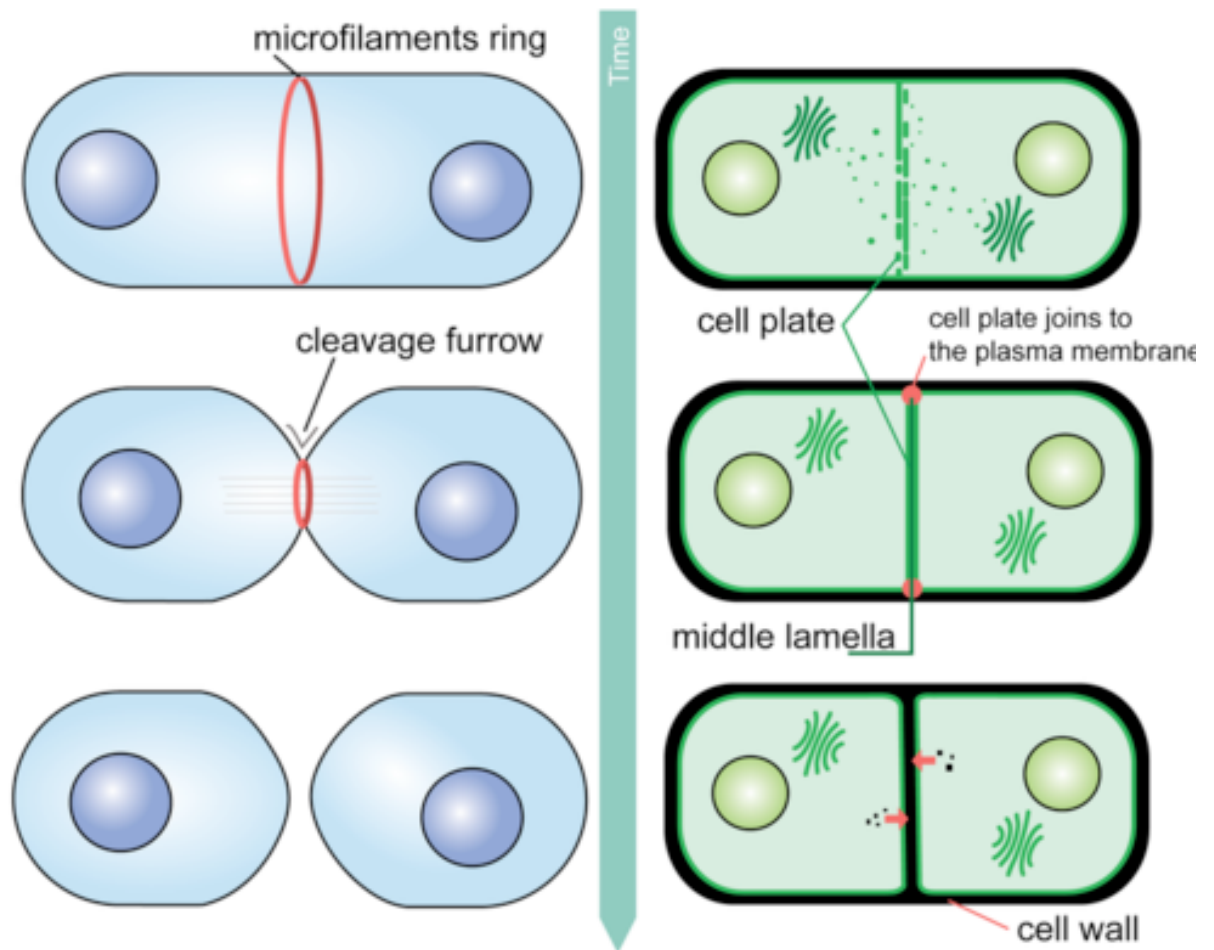
- **ANIMAL CELLS:** Cytoplasm pinches in or **invaginates**
- **PLANT CELLS:** Cell plate is formed in plant cells
 - Cell plate eventually becomes cell wall (**made of cellulose**)

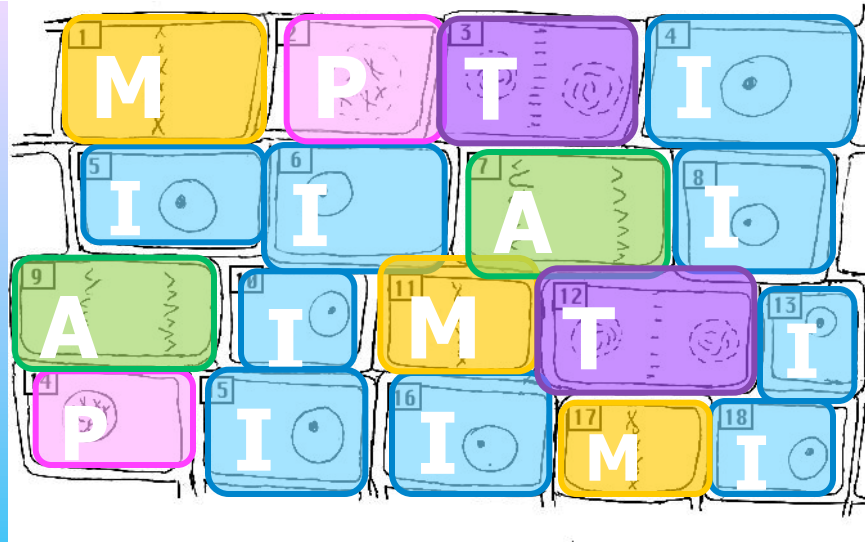
Mitosis animations

<http://www.johnkyrk.com/mitosis.html>

http://www.youtube.com/watch?v=cvlpmmvB_m4&safety_mode=true&safe=active&persist_safety_mode=1

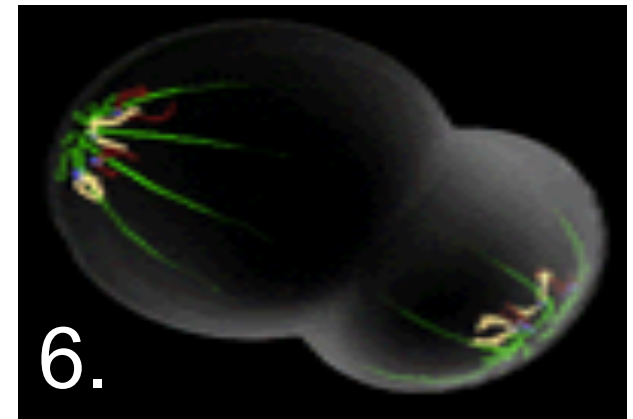
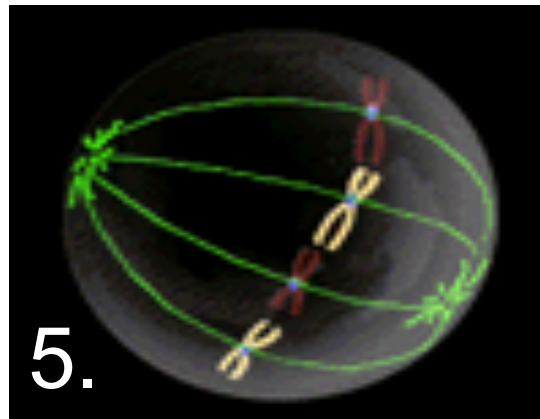
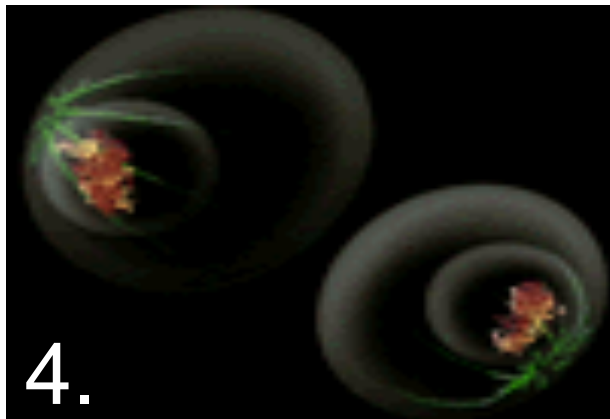
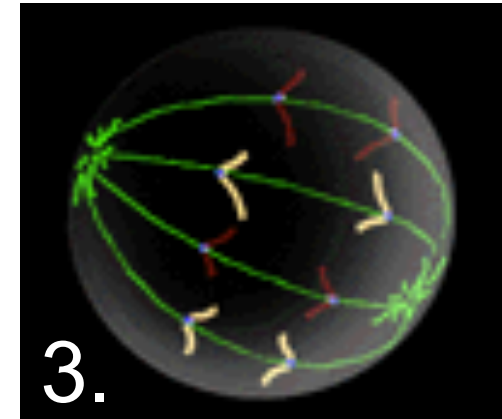
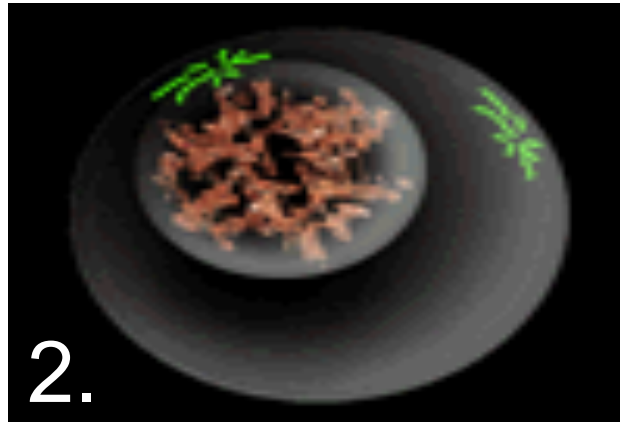
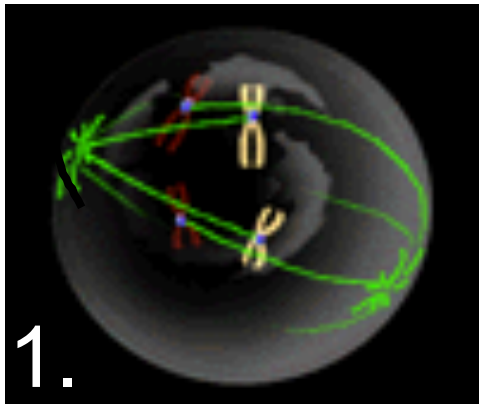
[Bozeman Mitosis \(13:35\)](#)-watch





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

Identify the stages!



1. Prophase

2. Interphase

3. Anaphase

4. Cytokinesis

5. Metaphase

6. Telophase

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)

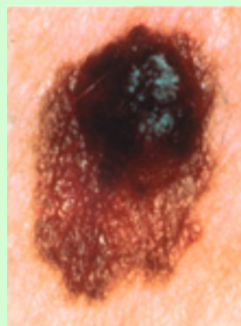
Cytokinesis

Anaphase

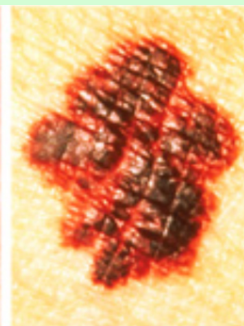
Interphase

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)



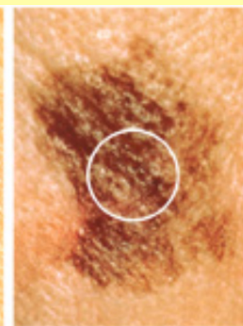
Asymmetry



Border
irregularity



Color



Diameter:
 $\frac{1}{4}$ inch or
6mm

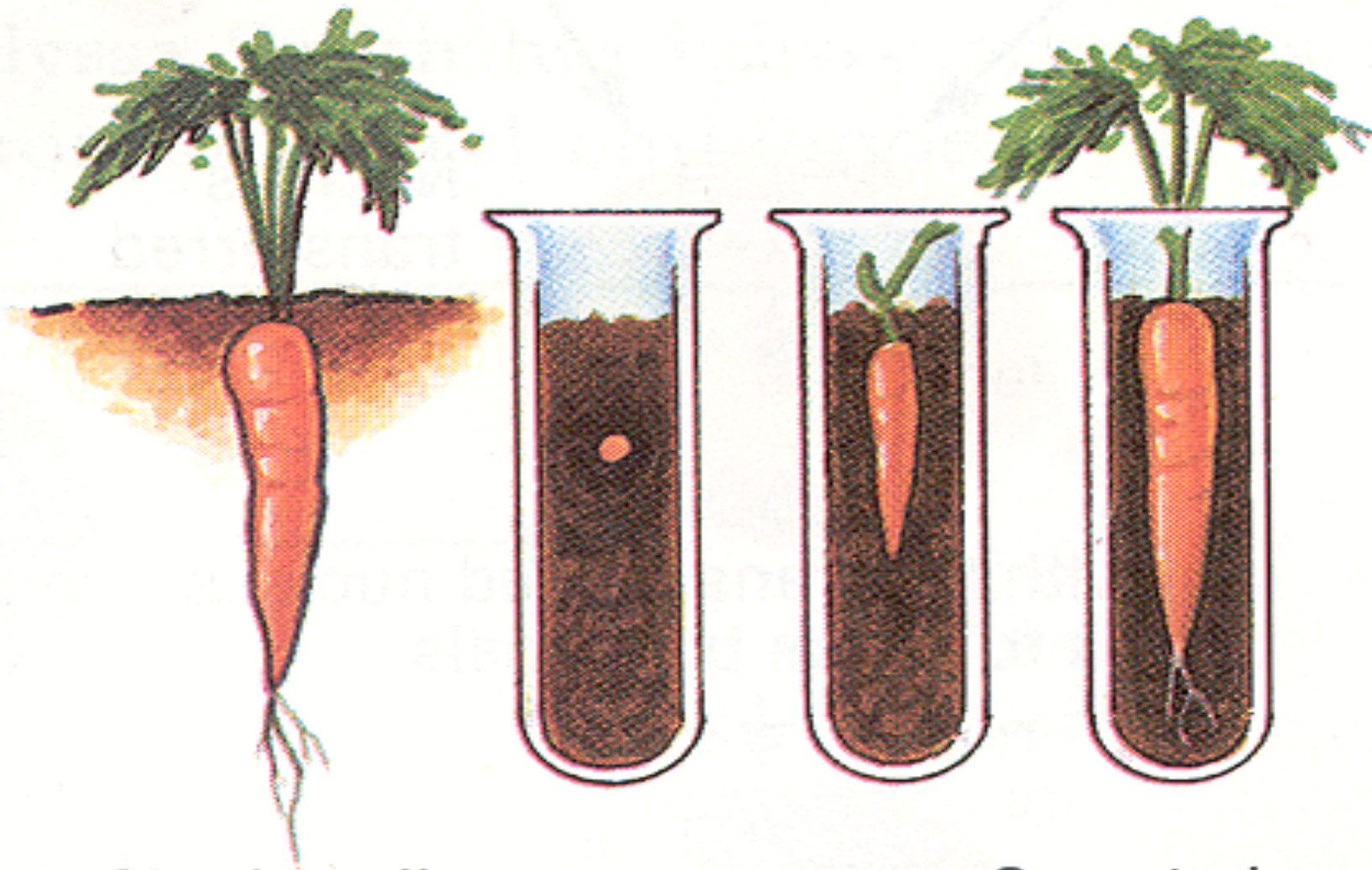
Interesting
thing about
cancer
telomeres...

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



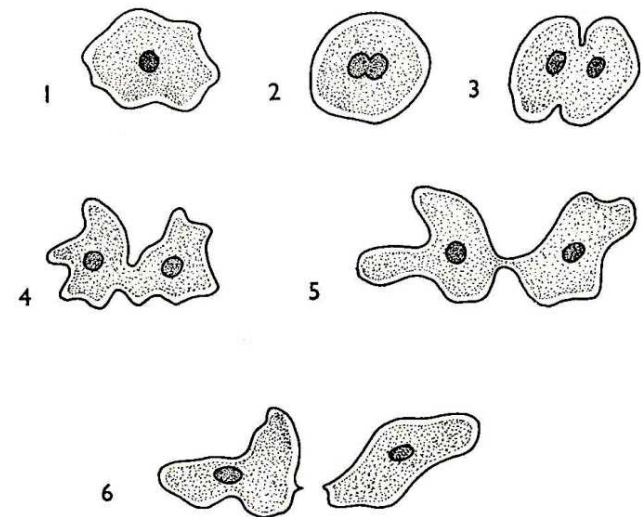
Single cell
extracted from
carrot

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



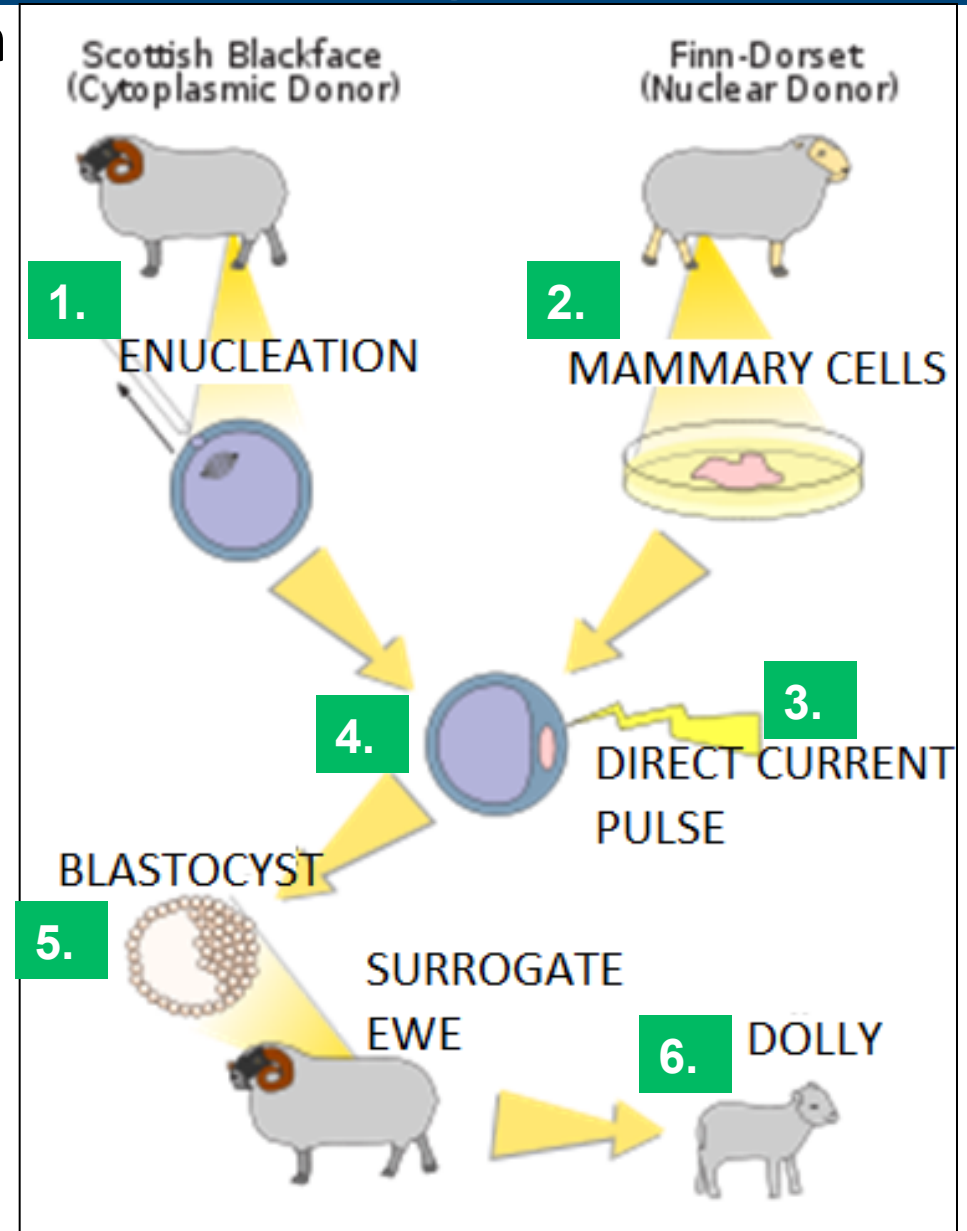
Find some more c
that reproduce th



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?

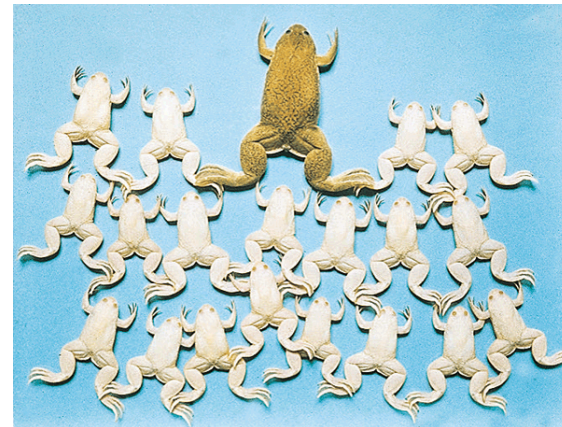
- No!
- Cloning is only possible with **totipotent** cells

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.



<http://learn.genetics.utah.edu/content/cloning/whatiscloning/>



Identical vs. Fraternal Twins

Twins

Identical

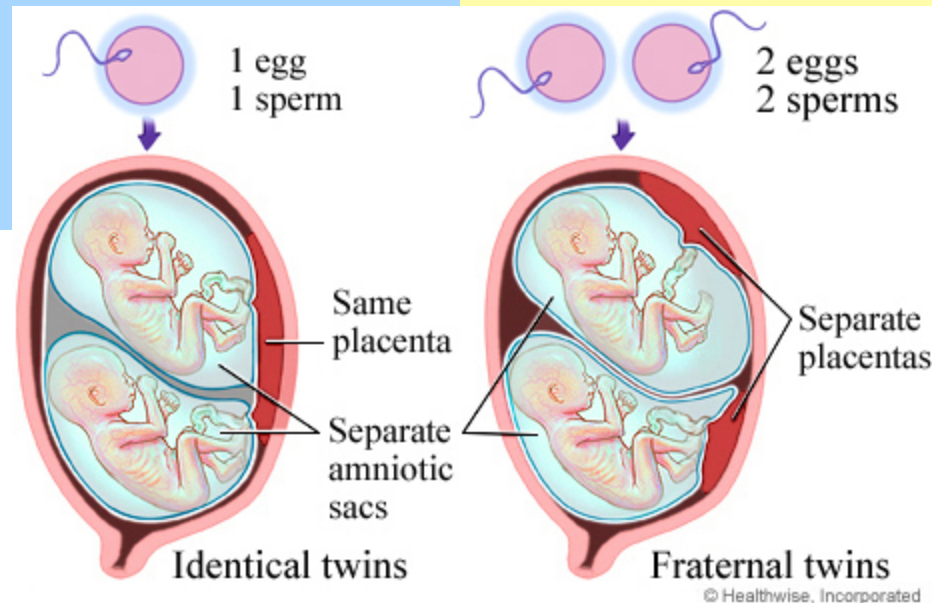
Clones

- 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

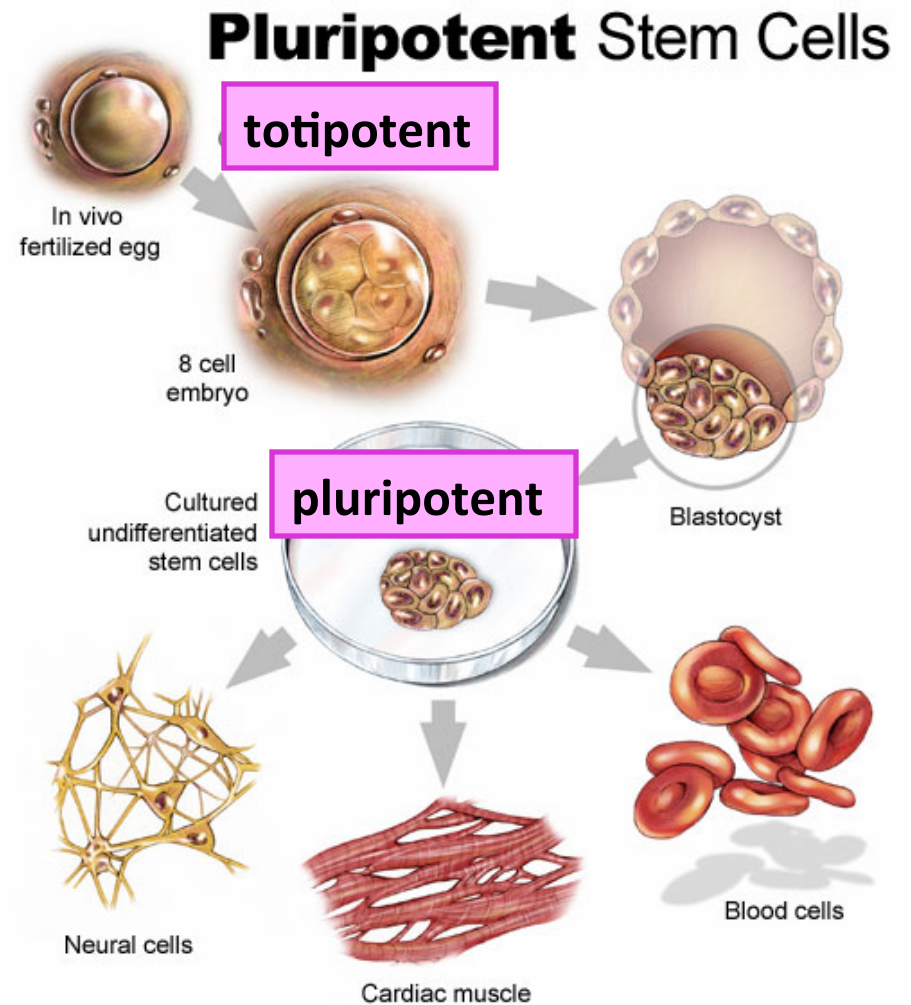


Stem Cell Research

- 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

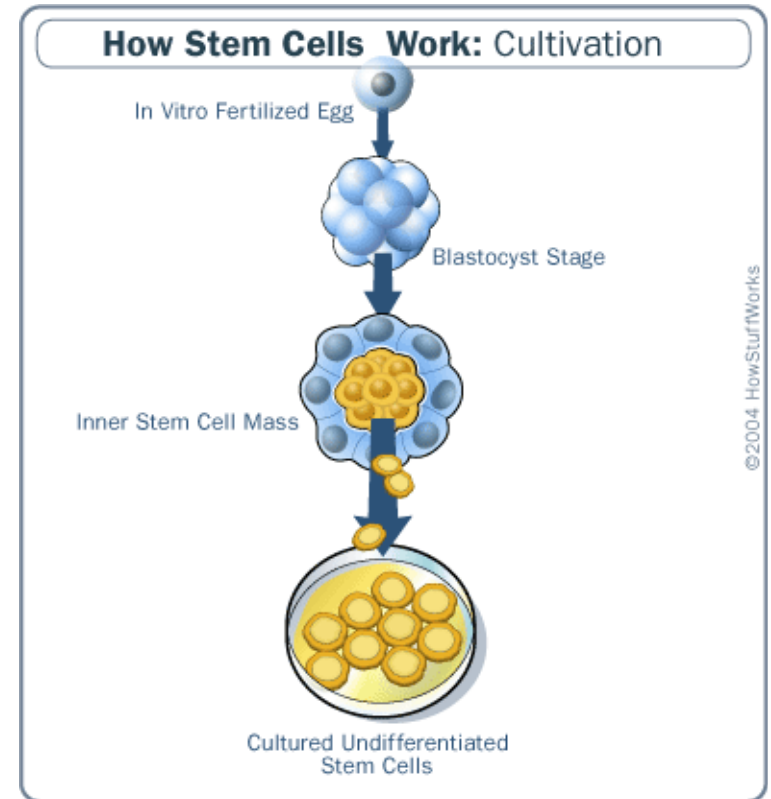
[Stem Cells in Our Bodies](#)



Stem Cells

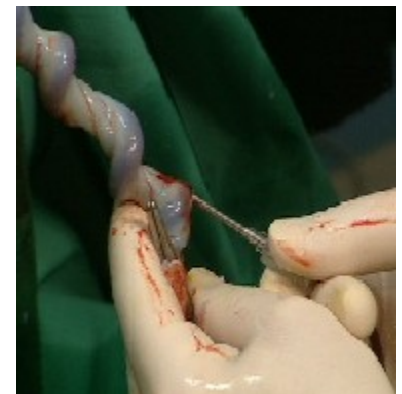
Stem cells can be derived from:

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



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

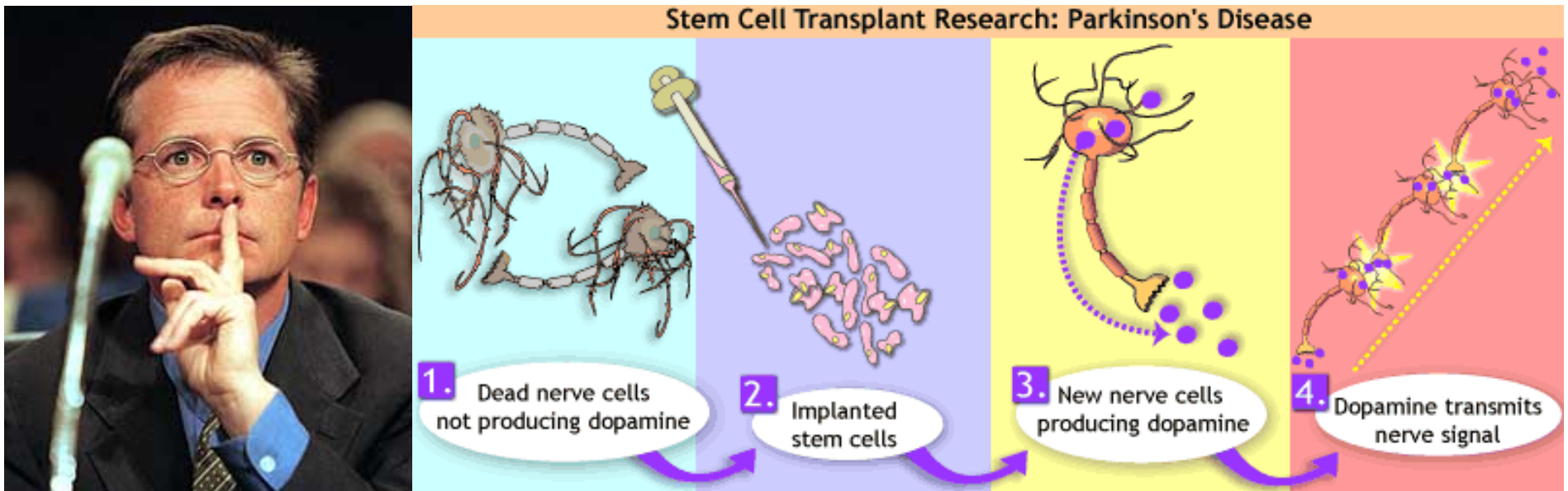
<http://learn.genetics.utah.edu/content/stemcells/>



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?

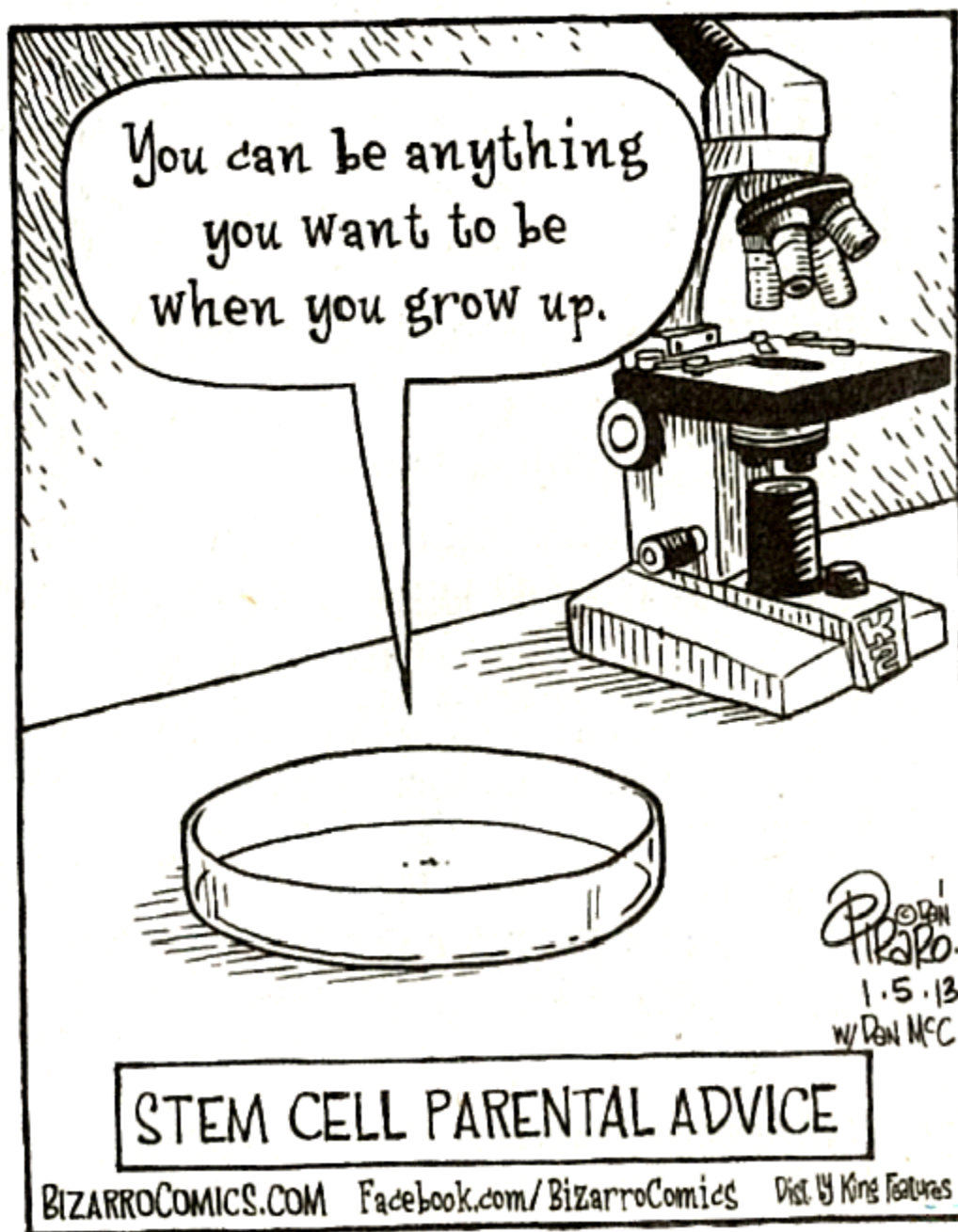
- Embryonic stem cells
 - How do we obtain stem cells?
- **Cost?**
- Can we use this to clone humans or just to treat disease?



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

BIZARRO

by Dan Piraro



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GARY MARKSTEIN

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Coping with Death



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

I WAS THE
EMBRYO

Garry Shuey
THE INDIANAPOLIS STAR
QUICK CARTOONS

