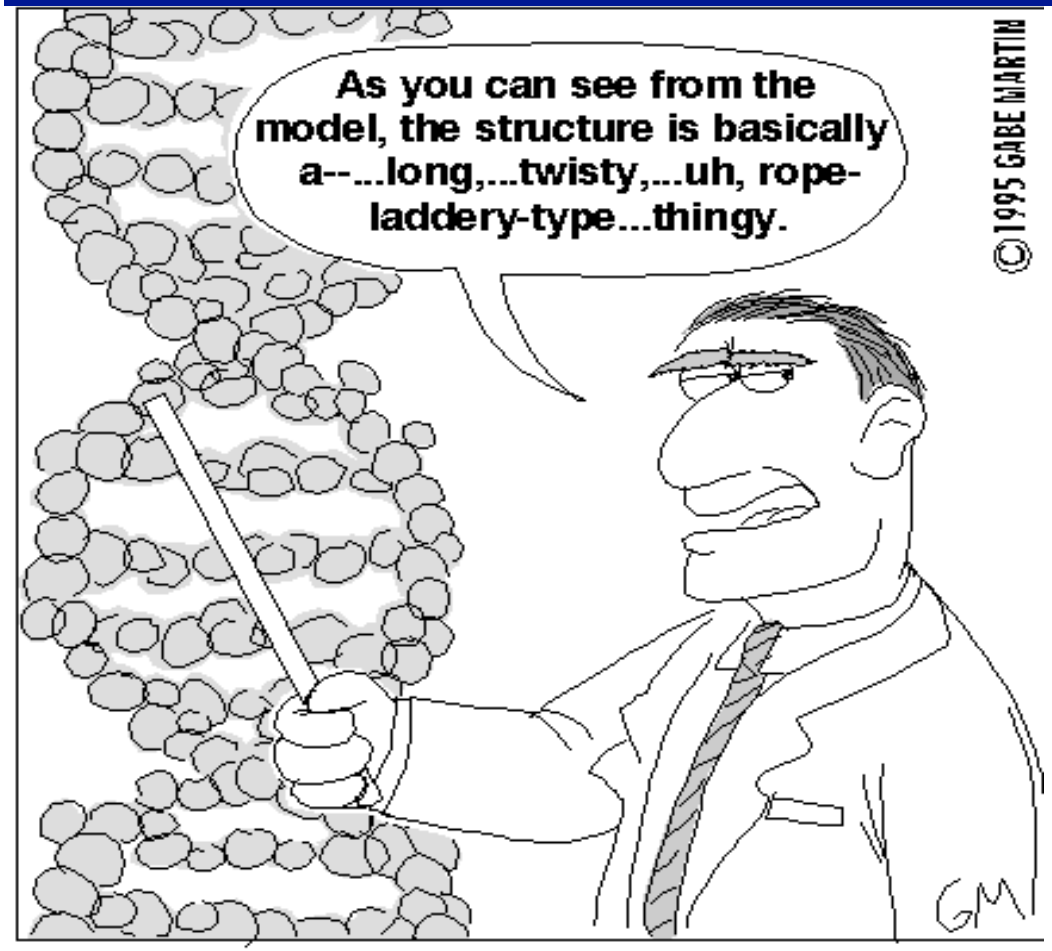
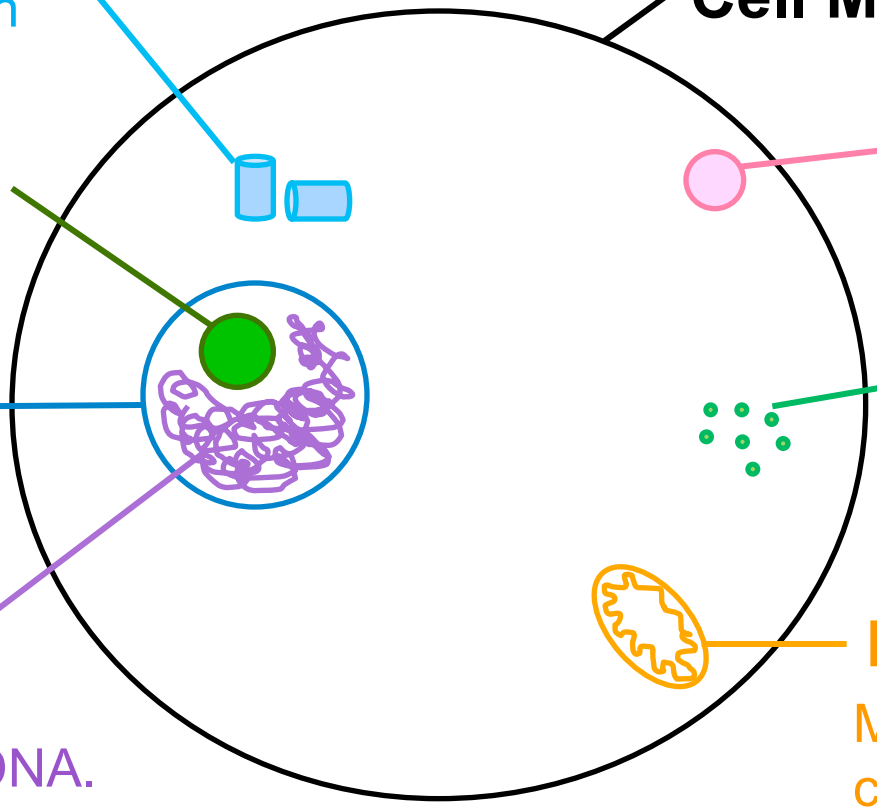
Biology 30 Unit 1

Introduction to Cell Division



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

Animal Cell



Centrioles
Cell division

Cell Membrane

Nucleolus
Makes RNA and ribosomes

Vesicle
Storage

Nucleus
Contains DNA

Ribosome
Protein synthesis

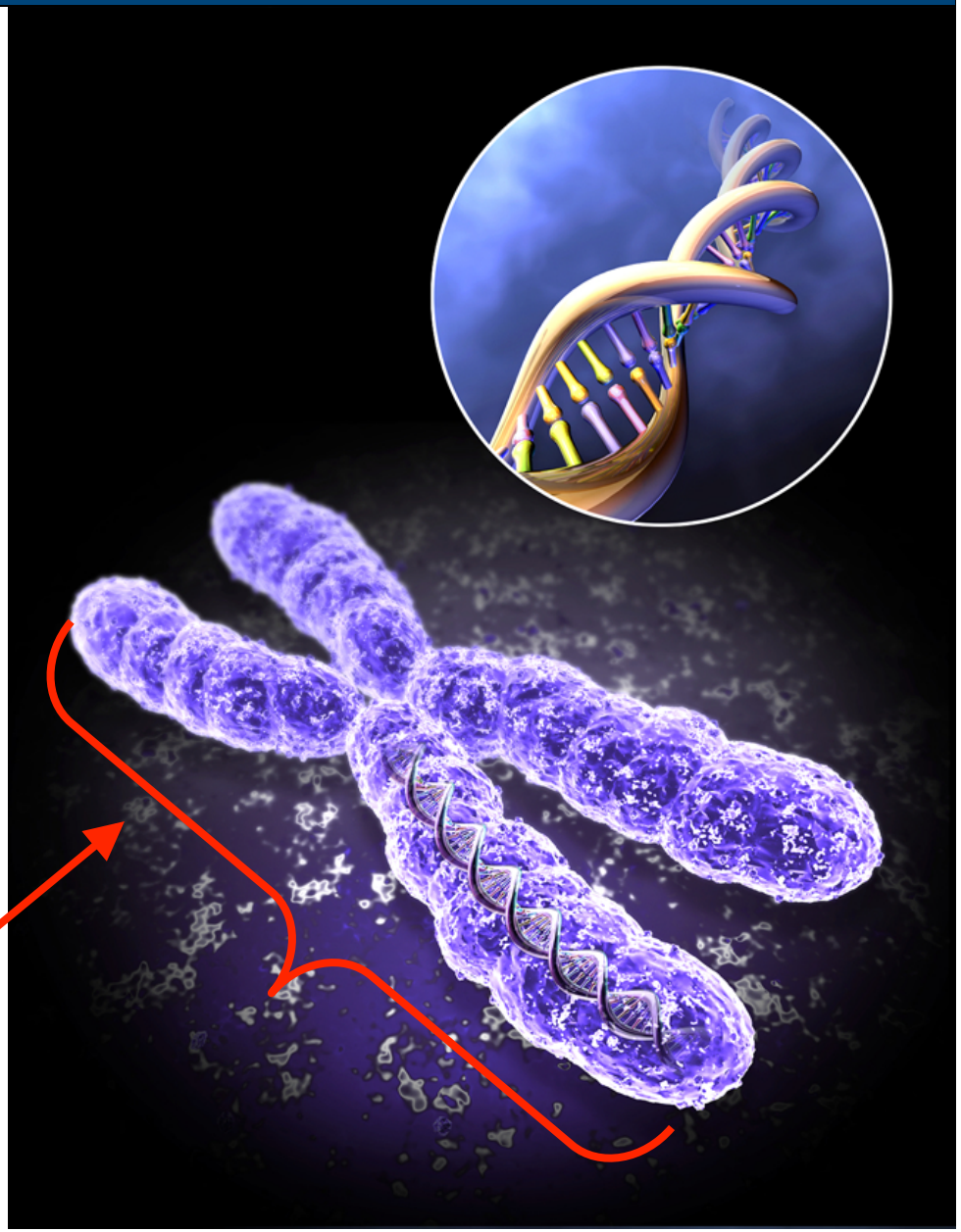
Chromatin
Uncoiled or uncondensed DNA. Present during interphase.

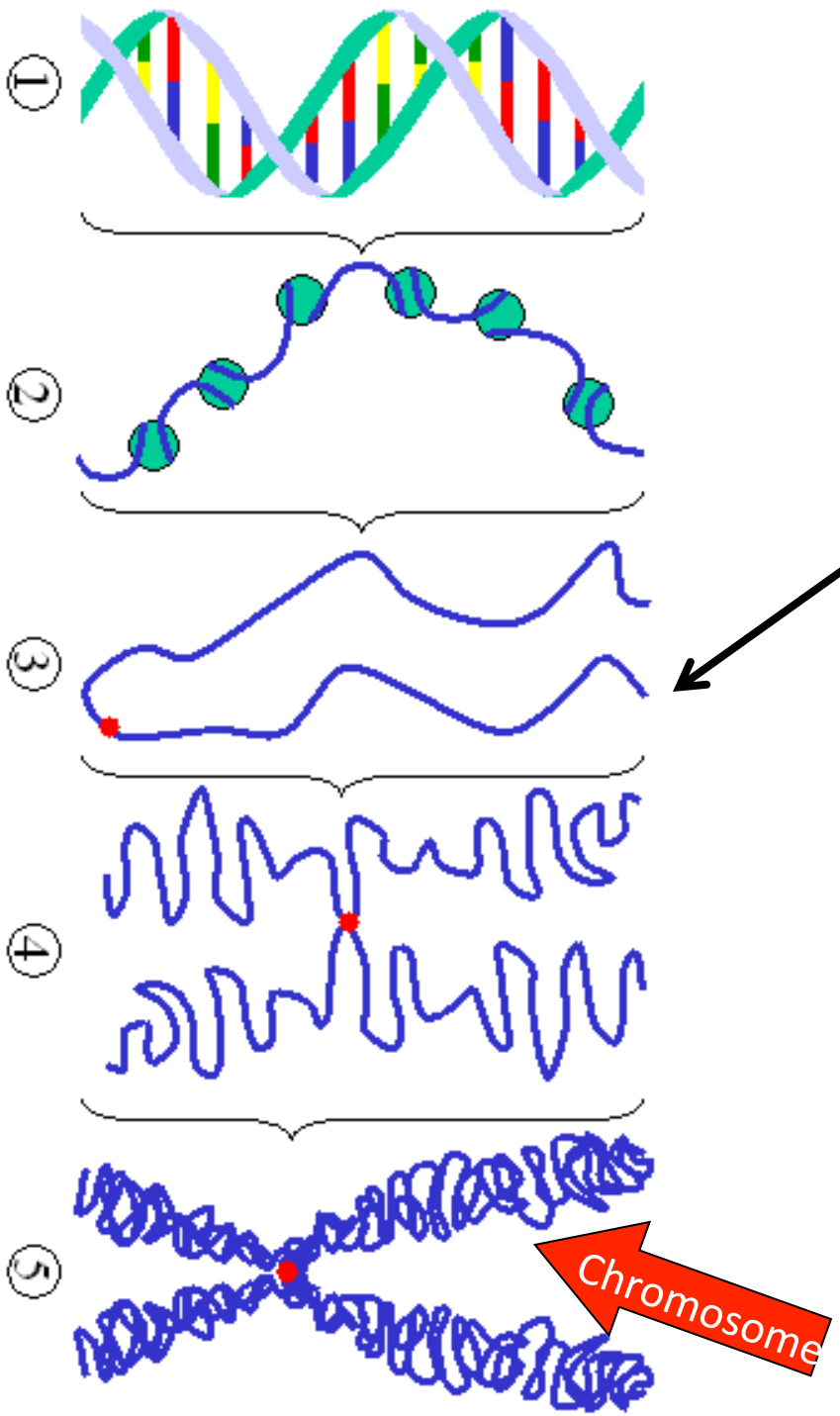
Mitochondrion
Makes energy through cellular respiration

Glucose + oxygen → CO_2 + H_20 + **ATP**

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**

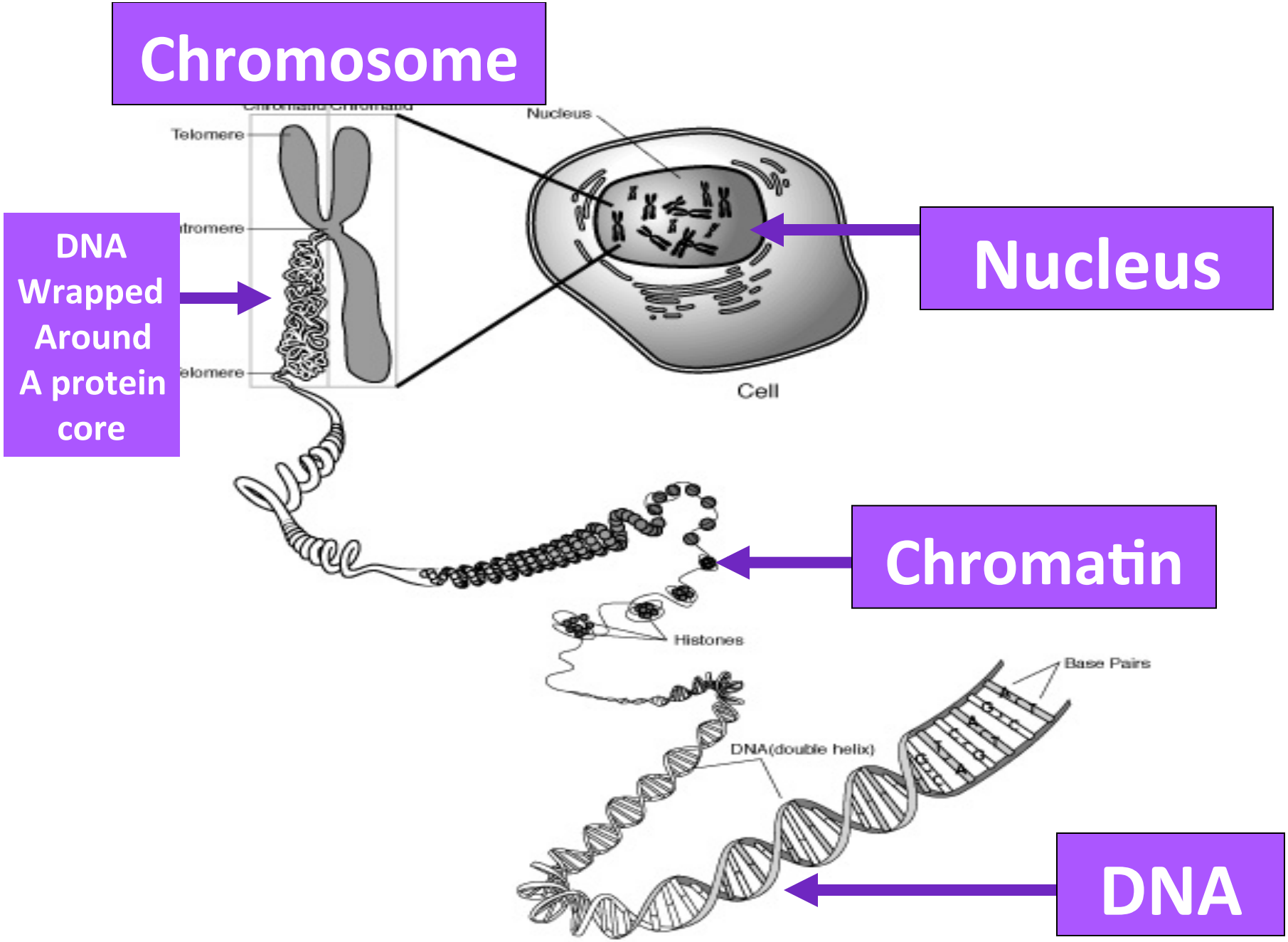


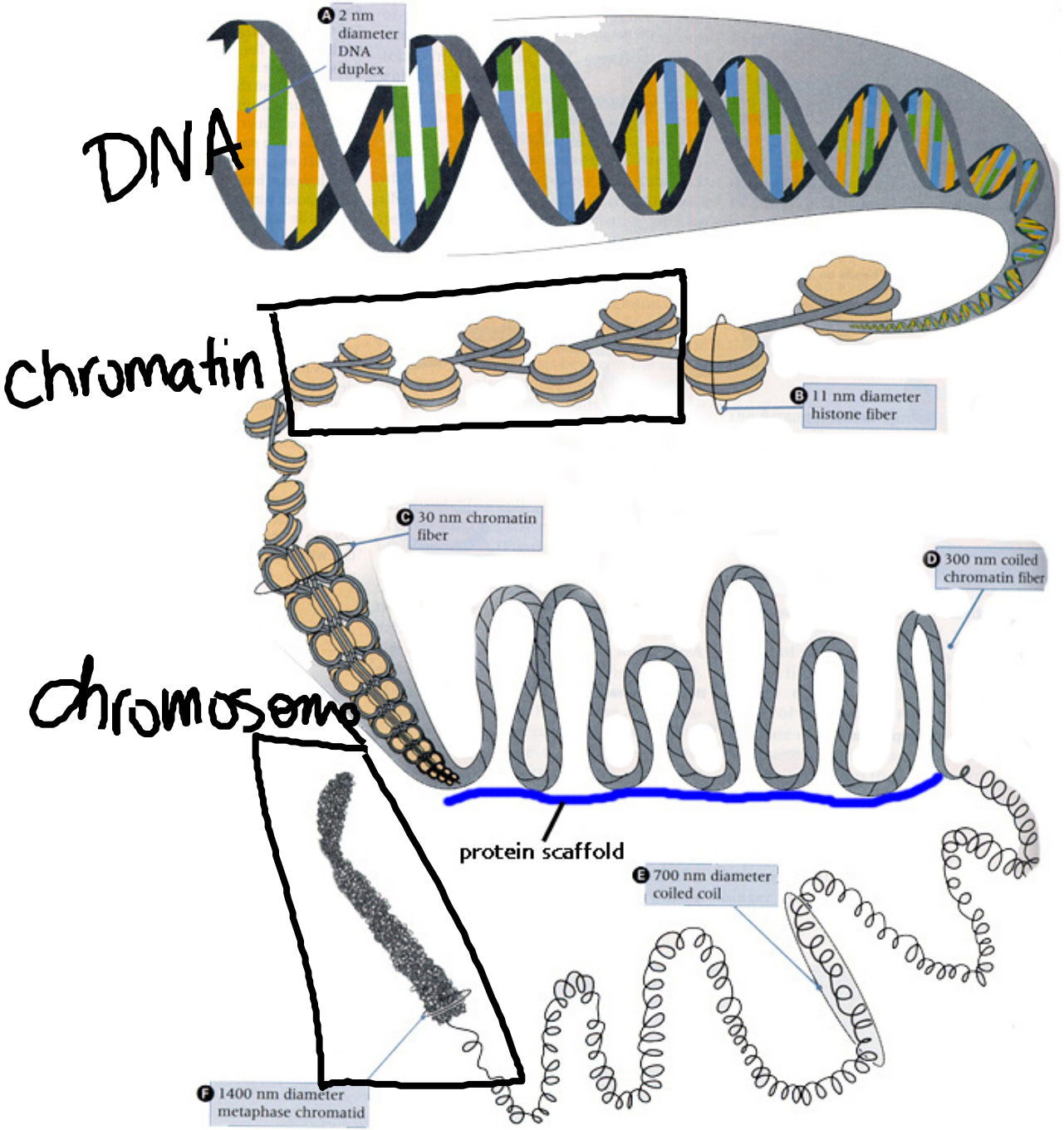


Chromosomes

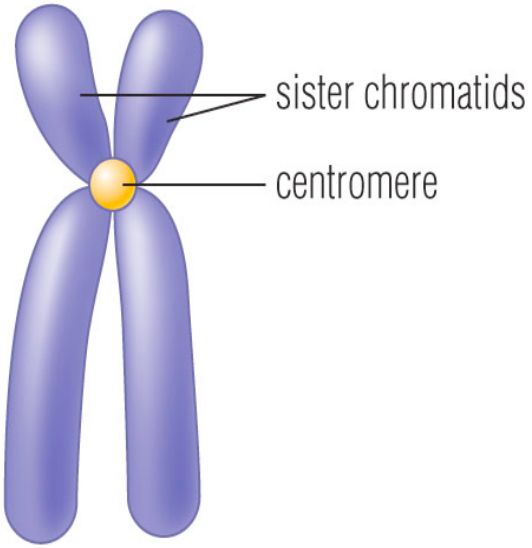
- long threads of **DNA** wrapped around a bead of protein (**a histone**) to form **chromatin** (threadlike)

- 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
Telomere
Nucleus
DNA Wrapped Around A protein core
Nucleus
Cell
Chromatin
Histones
Base Pairs
DNA(double helix)
DNA



Chromosomes depicted in this X-shaped form

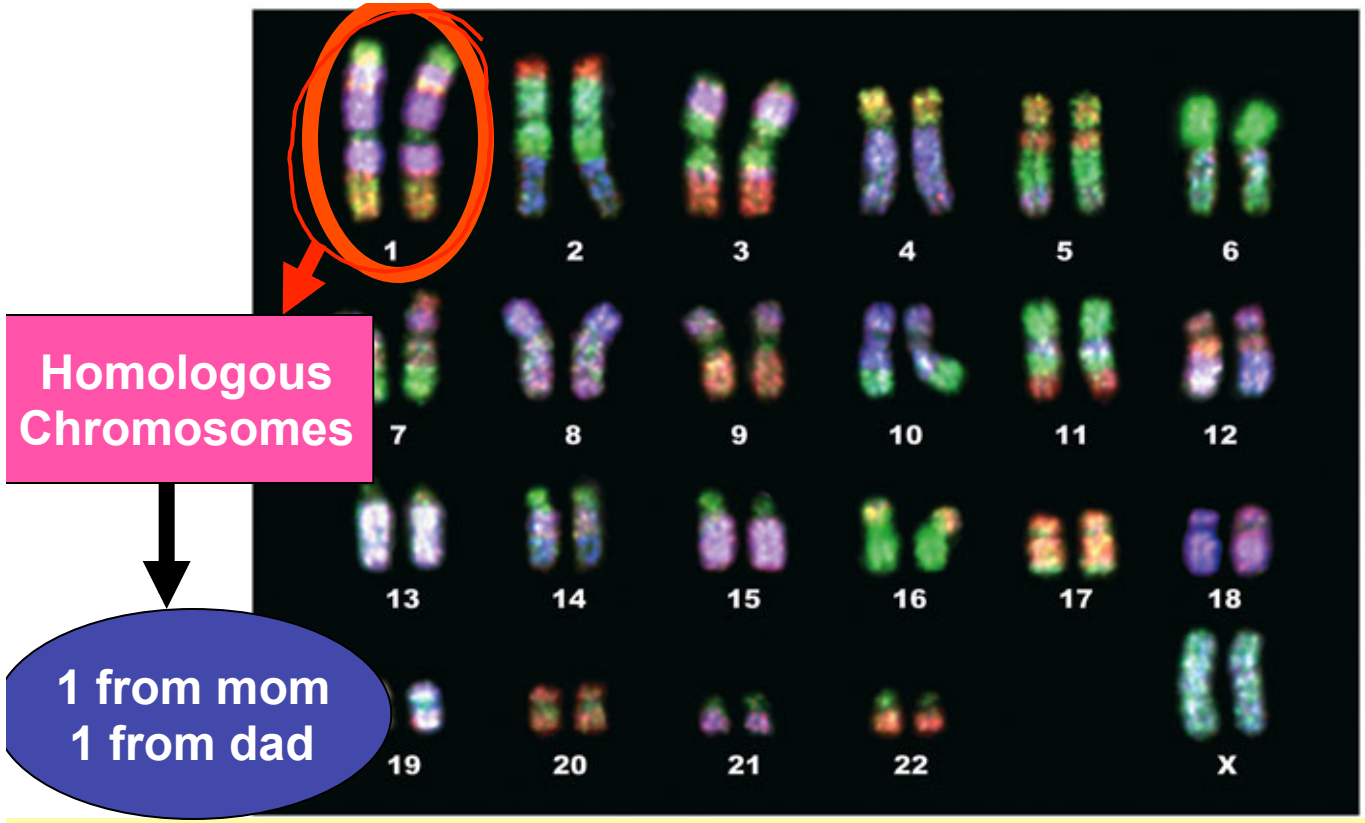


...have already been duplicated in preparation for mitosis (or meiosis).

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

DNA is found in chromatin/chromosomes
Chromosomes = DNA wrapped around a protein core

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

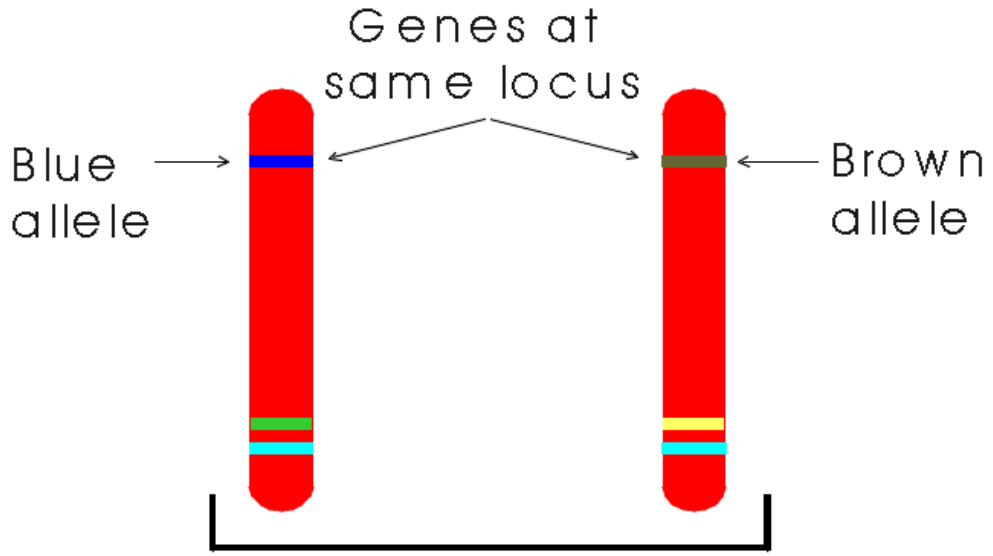


Humans have **46** chromosomes (**23 pairs**).
44 are autosomes.
Autosomes are chromosomes #1-22.
2 are sex chromosomes (# 23 pair)

Females = XX Males = XY

Homologous Chromosomes

<u>Homologous chromosomes</u> 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.

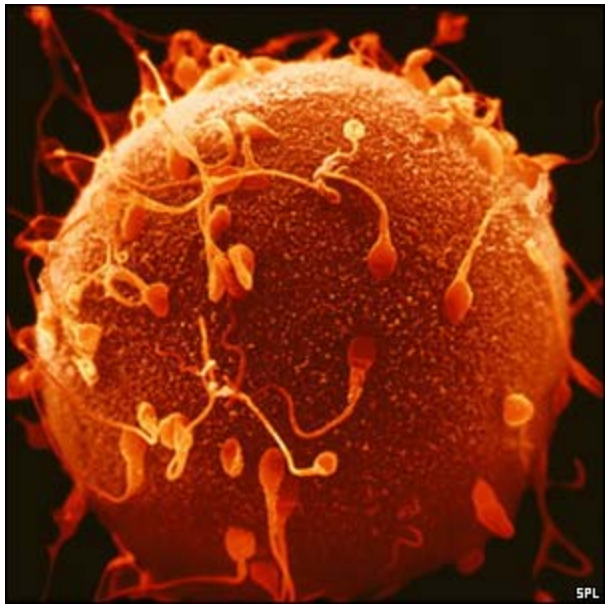
Diploid (2n)

- **Total number of chromosomes** in **every somatic (body) cell** of an organism
- Organisms obtain ½ their chromosomes from their mom and ½ from dad
- 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

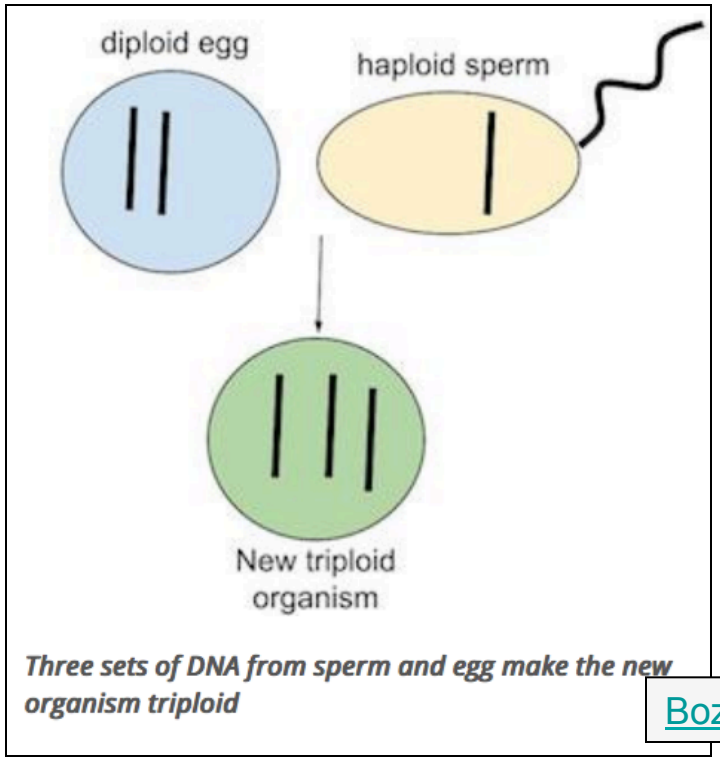
Diploid Numbers Are Unique

- **<u>All organisms have a unique diploid number</u>**
- 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	Haploid Number
Dog	78	39
Cat	38	
Shrimp		2
Scorpion	256	
Green Ash Tree		23
Human	46	

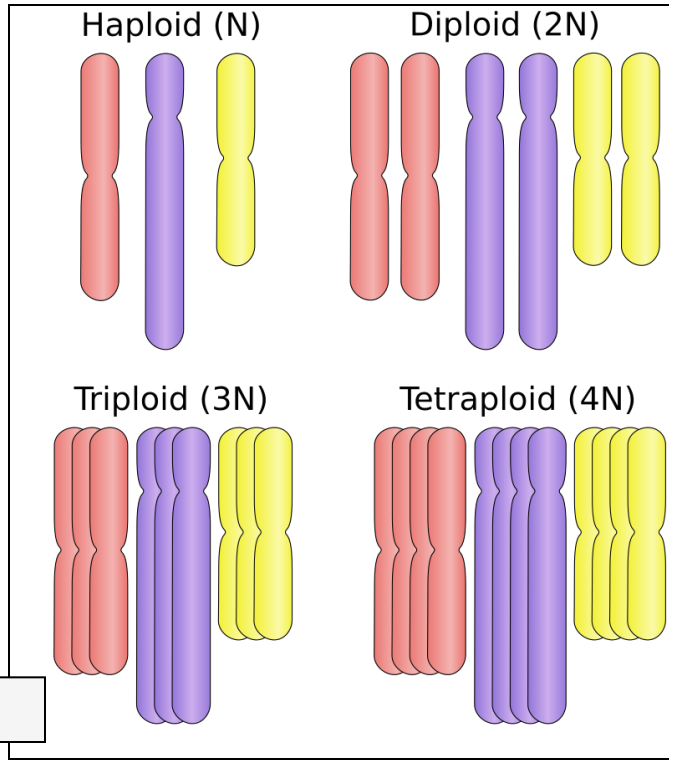
Polyploidy

- 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)



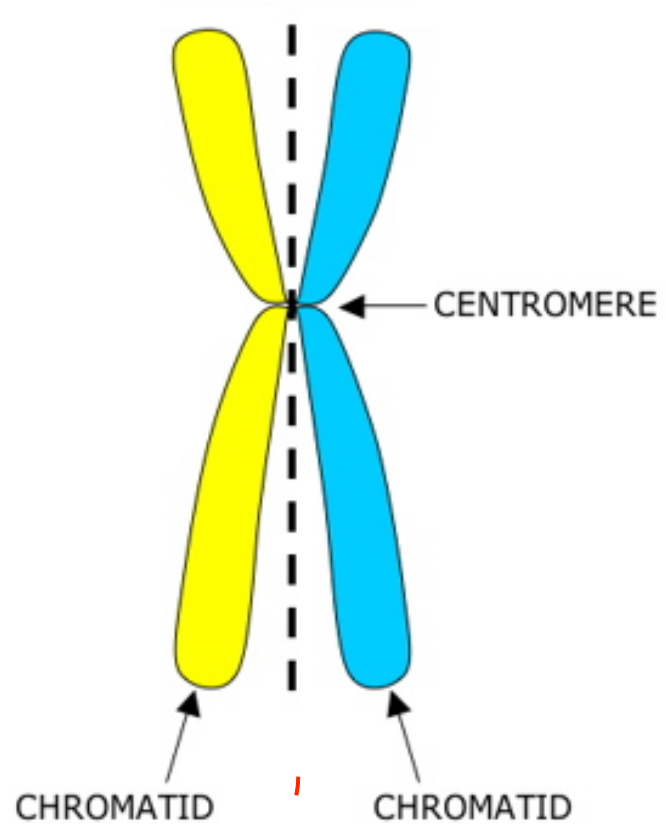
Three sets of DNA from sperm and egg make the new organism triploid

Bozeman Diploid vs. Haploid 8:30



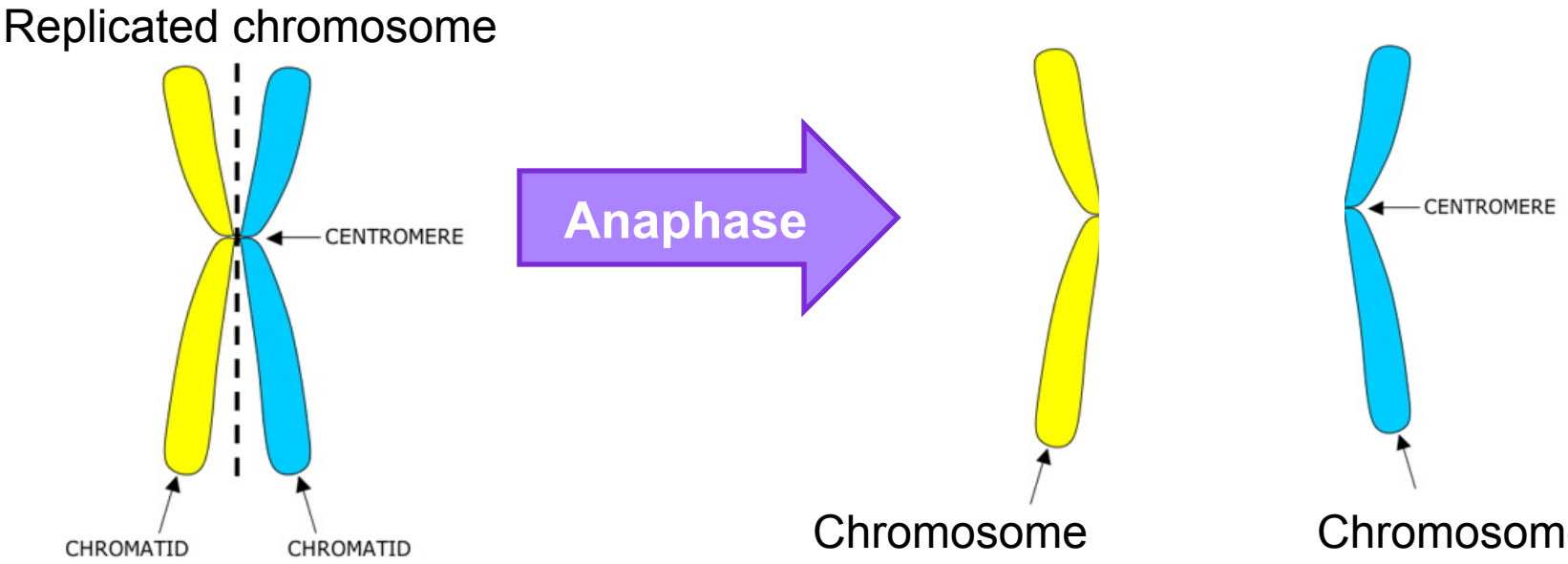
Chromosomes

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 ½ of a replicated chromosome. It's only called a chromatid while it is attached by the centromere to it's sister chromatid.

Chromatids → Chromosomes



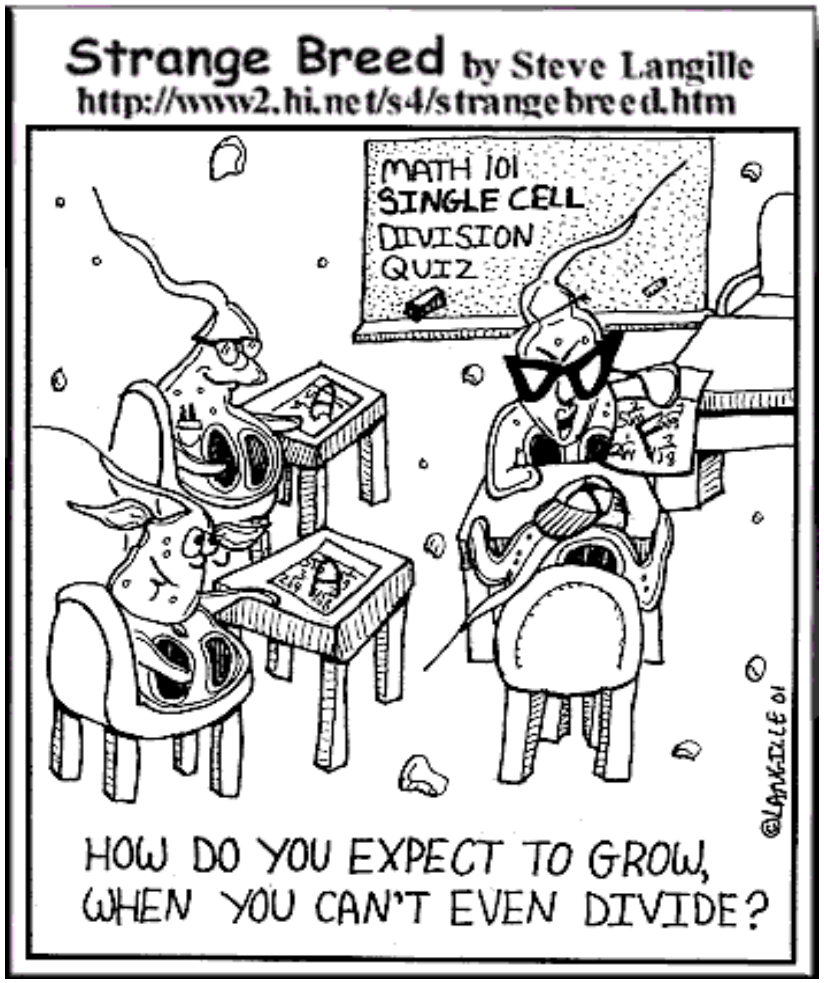
When replicated chromosomes or sister chromatids split apart in anaphase they are called chromosomes.

Cell Division

- Cells divide for two reasons:

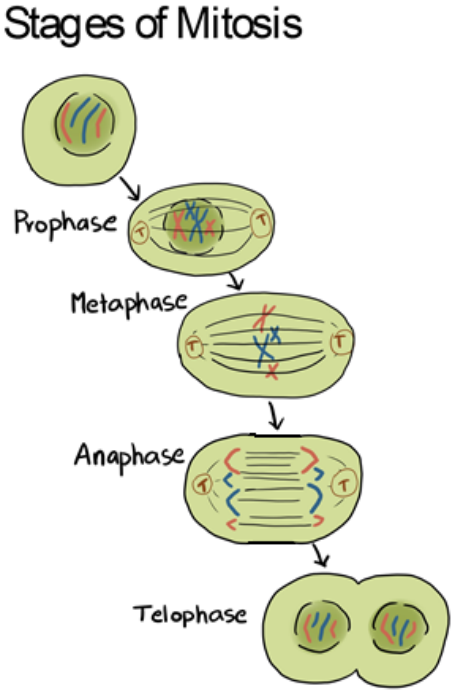
1. **Growth, maintenance & repair (MITOSIS)**
2. **Gamete formation (MEIOSIS)**

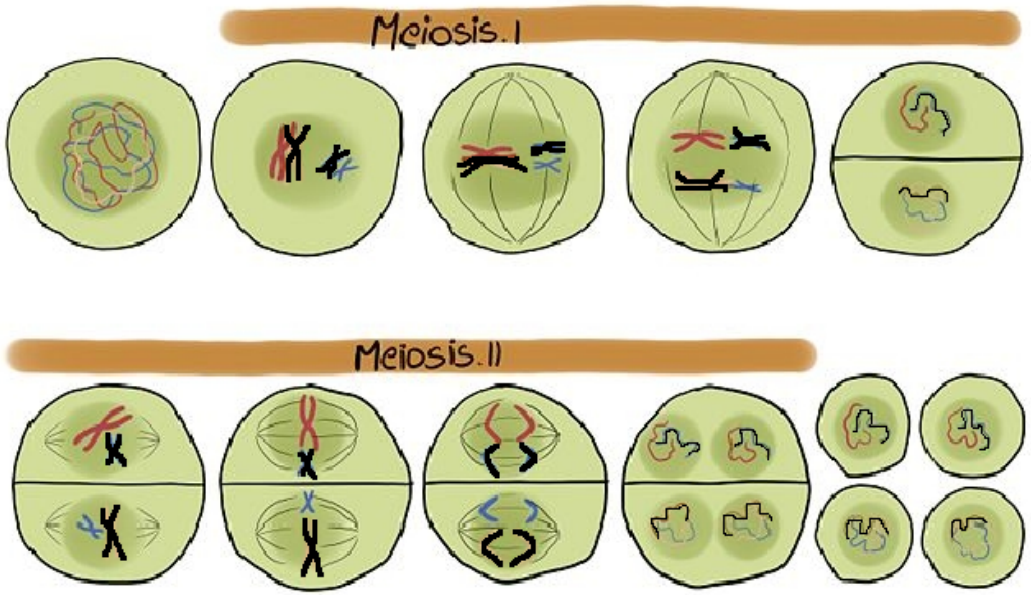
- During mitosis, a diploid cell splits into two diploid cells
- During meiosis, a diploid cell splits into four haploid cells



Mitosis Versus Meiosis

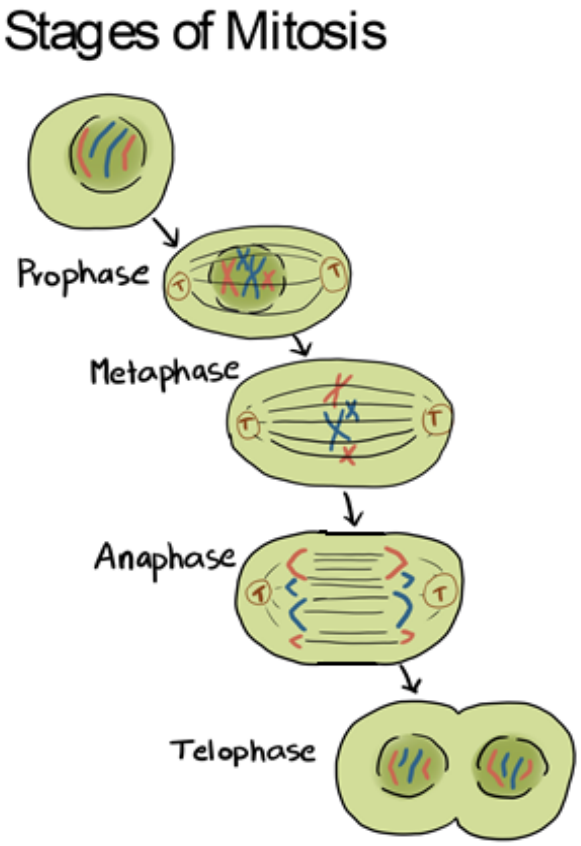
- There are two types of cell division: mitosis and meiosis. Most of the time when people refer to “cell division,” they mean mitosis, the process of making new body cells. Meiosis is the type of cell division that creates egg and sperm cells.





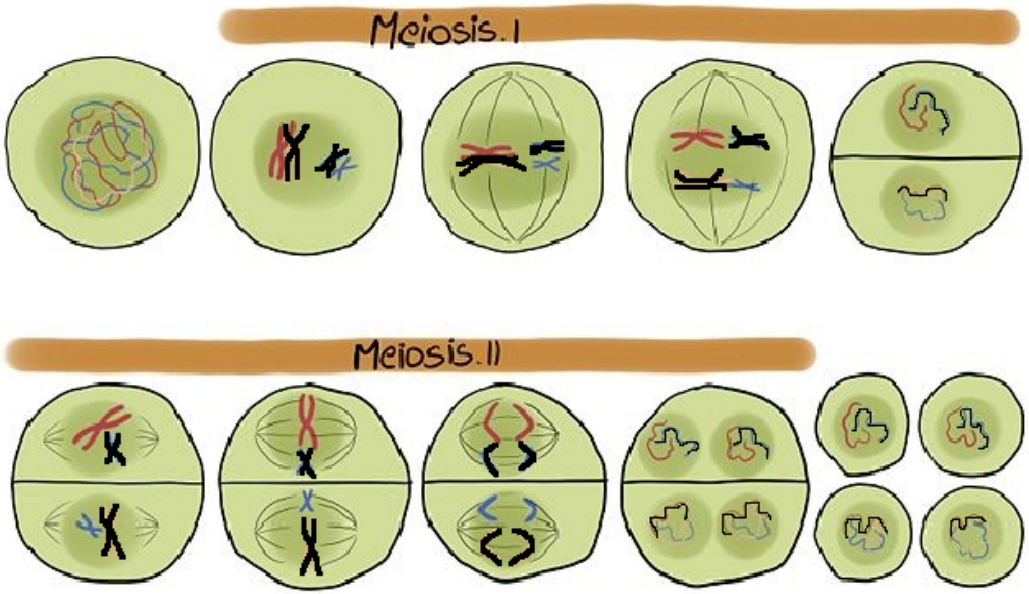
Mitosis Versus Meiosis

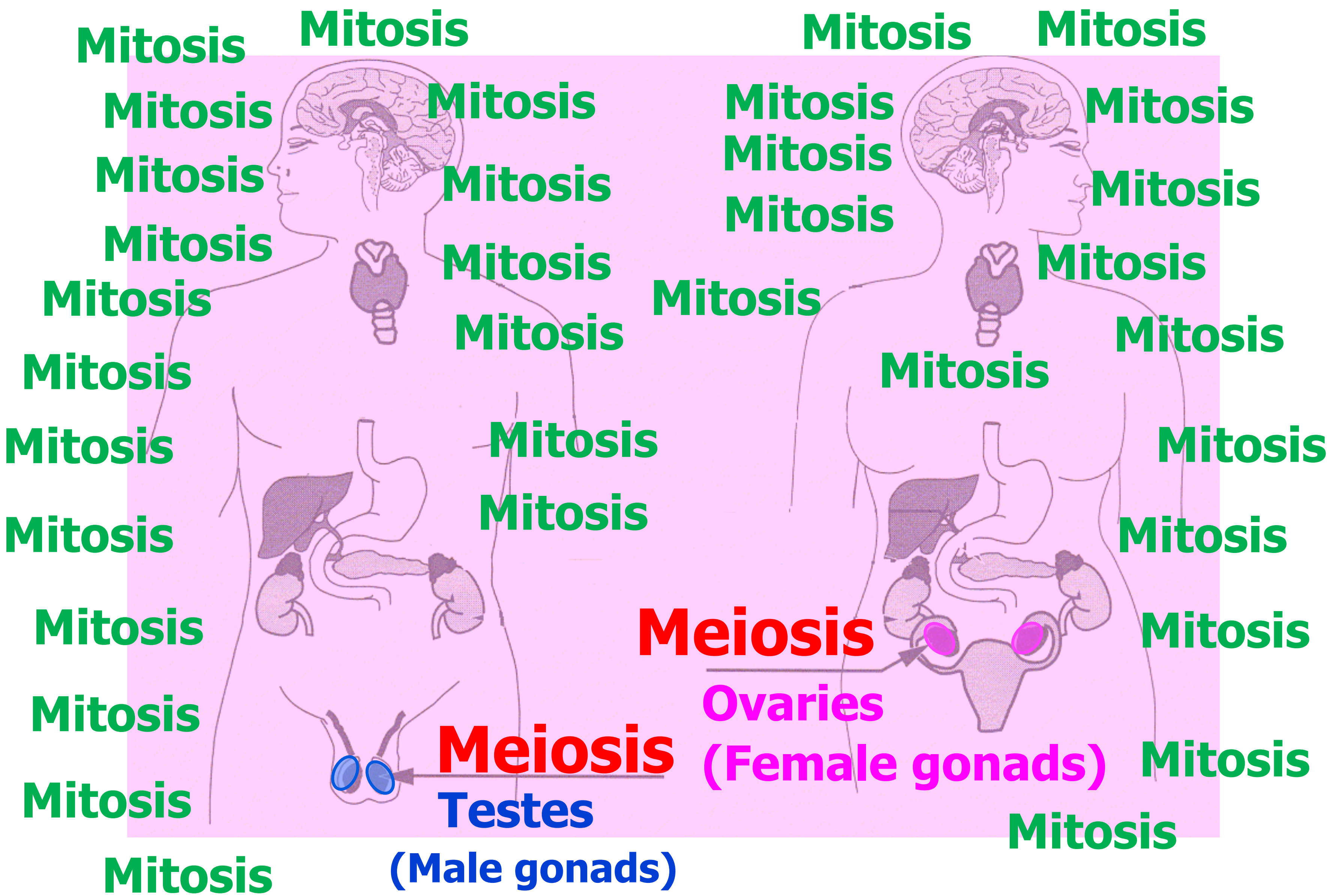
- Mitosis is a fundamental process for life. During mitosis, a cell duplicates all of its contents, including its chromosomes, and splits to form two identical daughter cells. Because this process is so critical, the steps of mitosis are carefully controlled by a number of genes. When mitosis is not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



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
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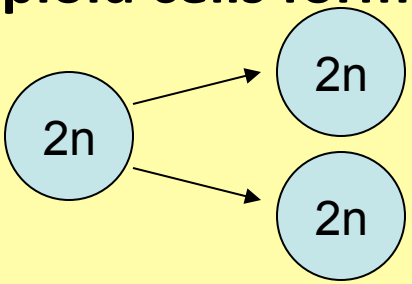
Mitosis
Mitosis
Mitosis
Mitosis
Meiosis
Ovaries
(Female gonads)
Meiosis
Testes
(Male gonads)

Two Types of Cell Division

MITOSIS (IPMAT)

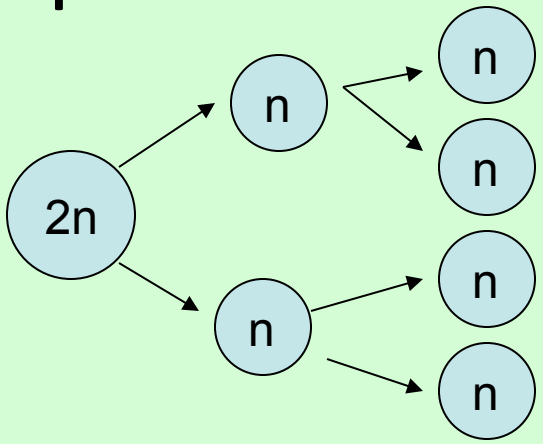
- For growth, maintenance & repair
- 2n cell → 2n cells (46 chromosomes → 46 chromosomes) Diploid
- 2 diploid cells form



- Occurs in somatic cells in the human body!

MEIOSIS (IPMATPMAT)

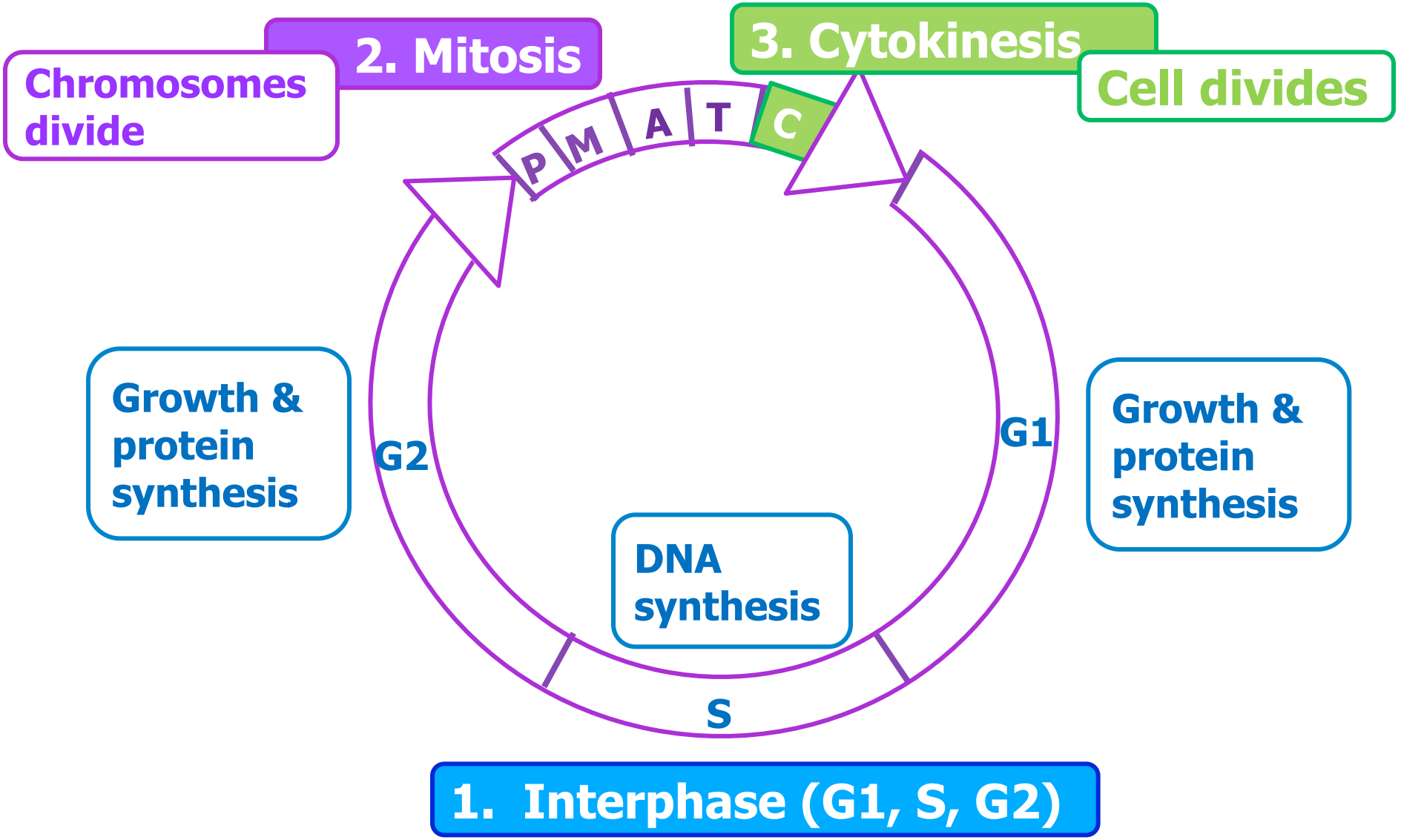
- For gamete formation
  - sperm & egg
- 2n cell → n cells haploid. (46 chromosomes → 23 chromosomes)
- 4 haploid cells form



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

CELL CYCLE

– 3 phases: Interphase, Mitosis, and Cytokinesis



Cell Cycle Animation

Interphase: Stage prior to Mitosis

Chromosomes not visible.

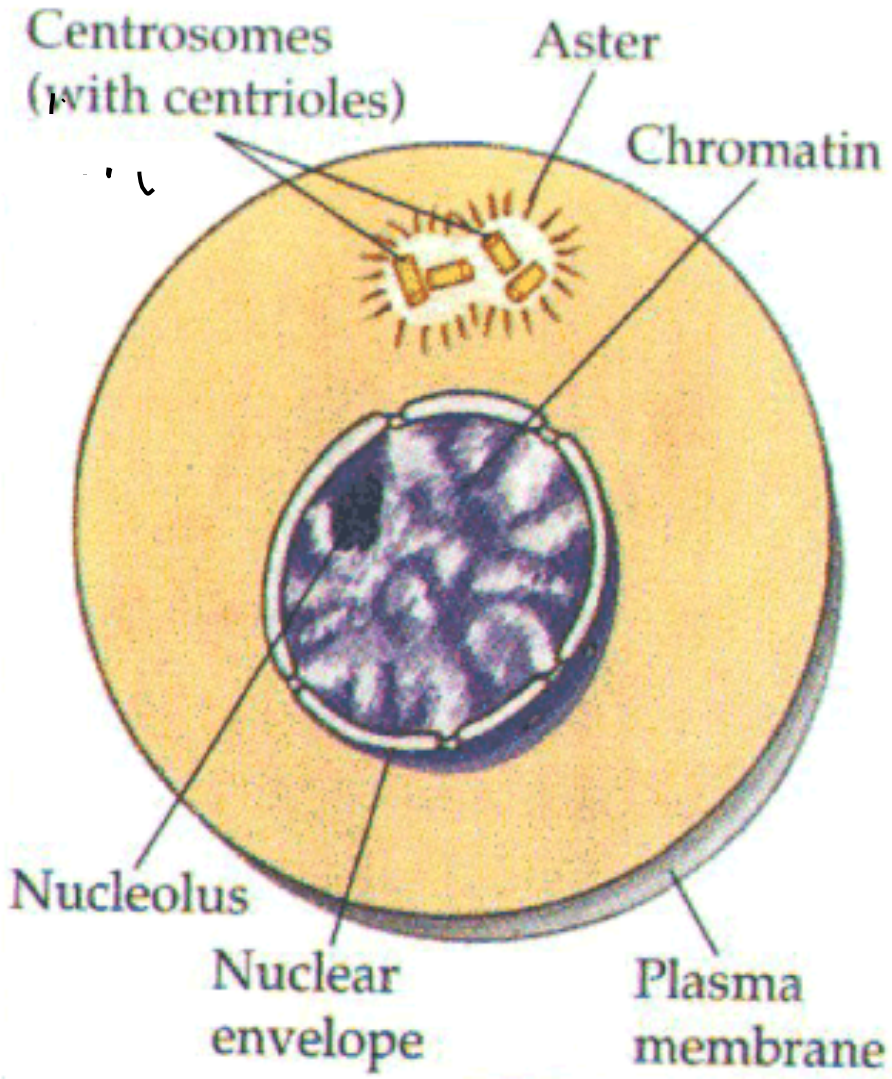
–DNA is in form of chromatin.

Main Events:

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

Its the longest phase

http://www.youtube.com/watch?v=-G-3BDlnK58&safe=active&safety_mode=true



Preview of Mitosis

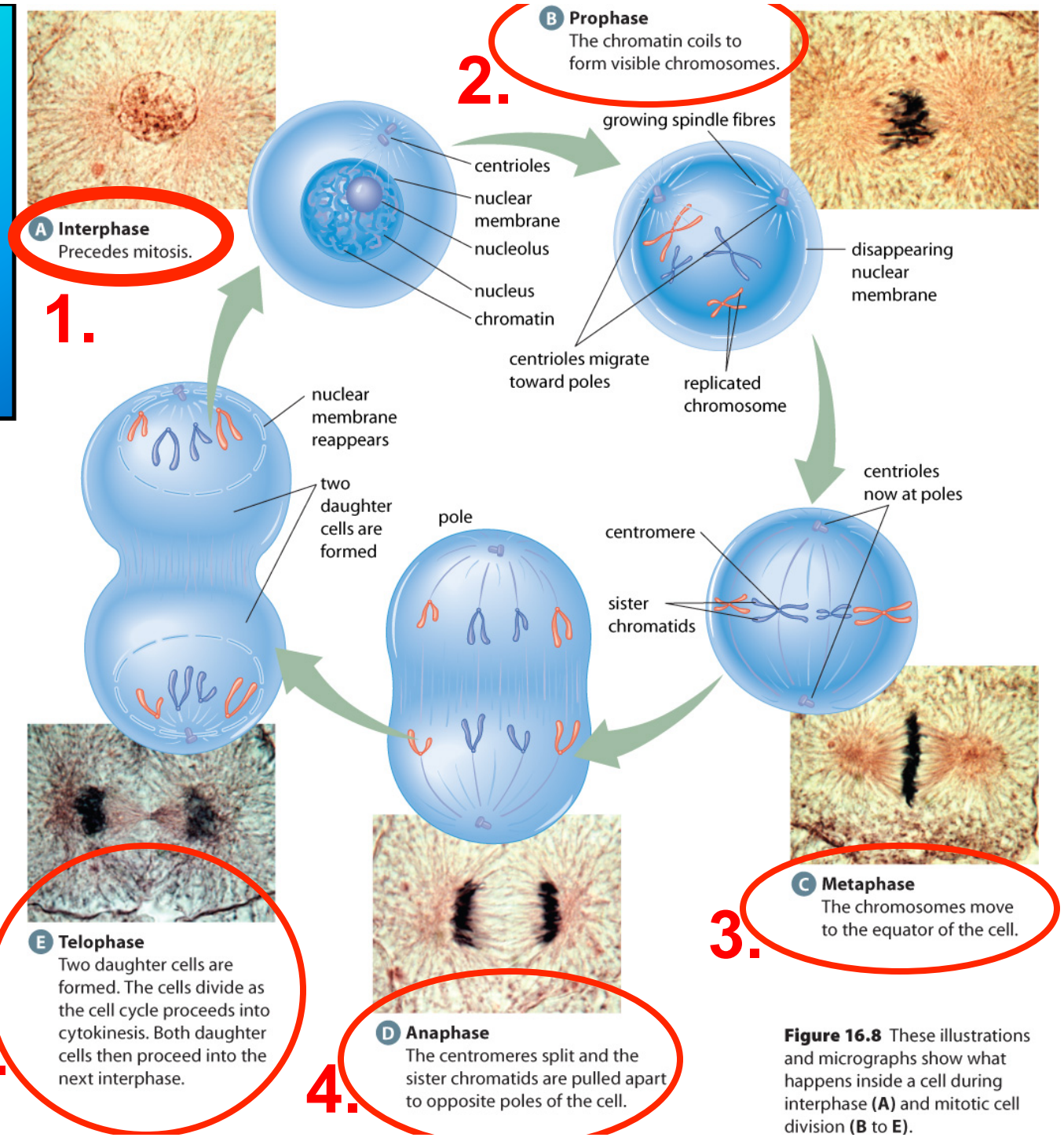


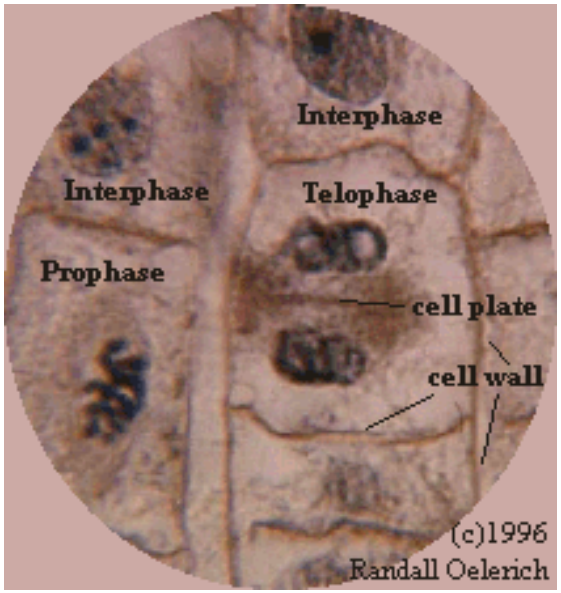
Figure 16.8 These illustrations and micrographs show what happens inside a cell during interphase **(A)** and mitotic cell division **(B** to **E)**.

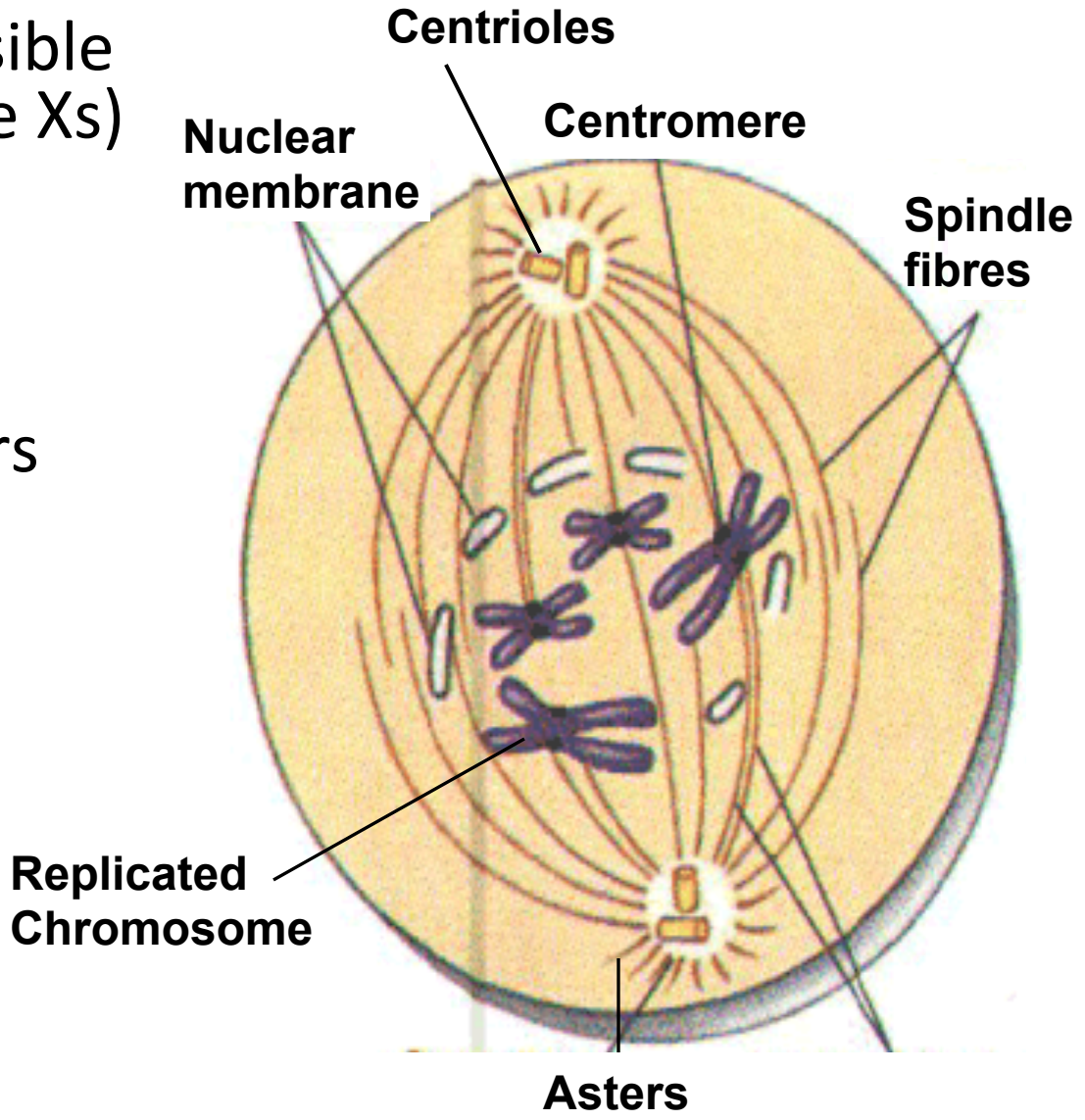
Mitosis Animation (McGraw-Hill)

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

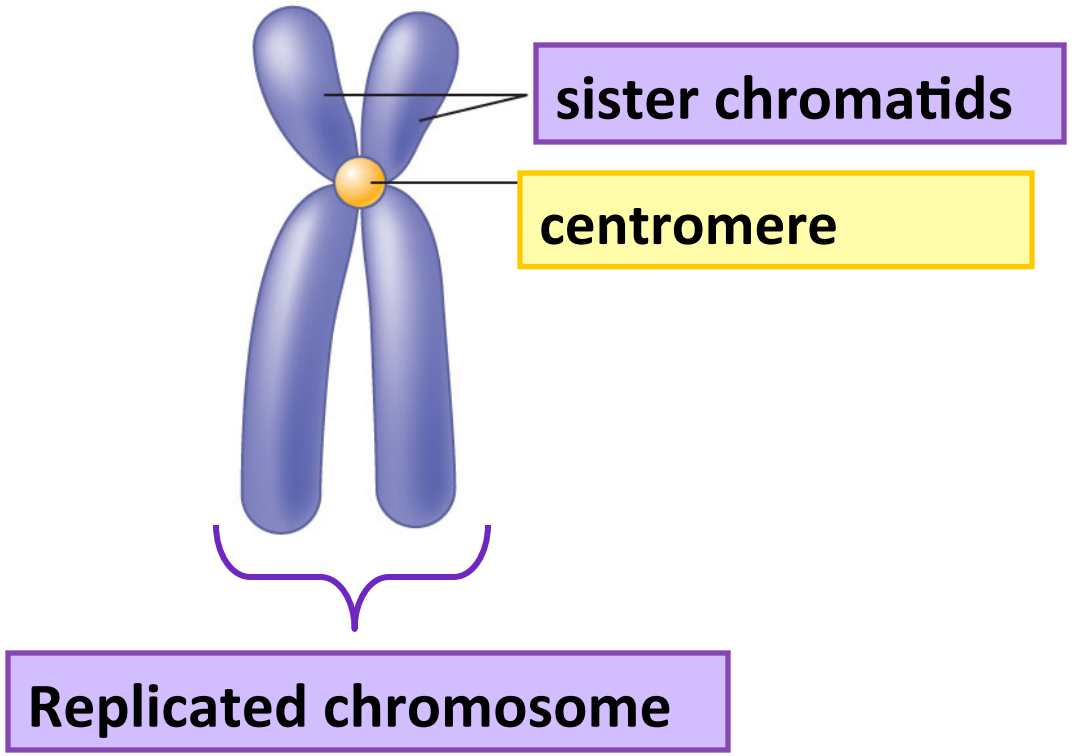
Prophase (PREPARE)

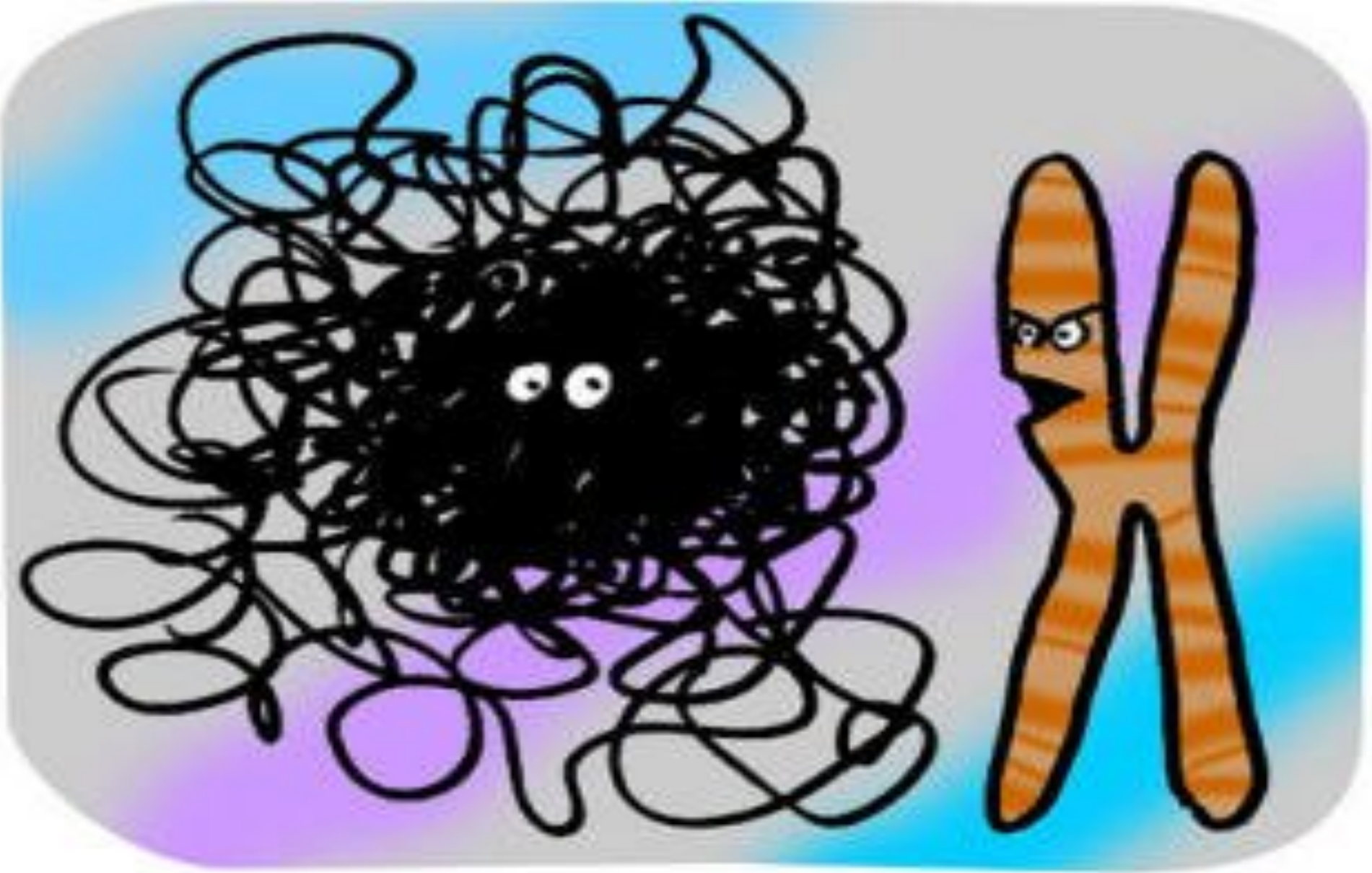
- Chromatin becomes visible chromosomes (look like Xs)
- nuclear membrane disappears
- Centrioles separate
- Spindle fibers and asters form





Chromosomes during Prophase and Metaphase

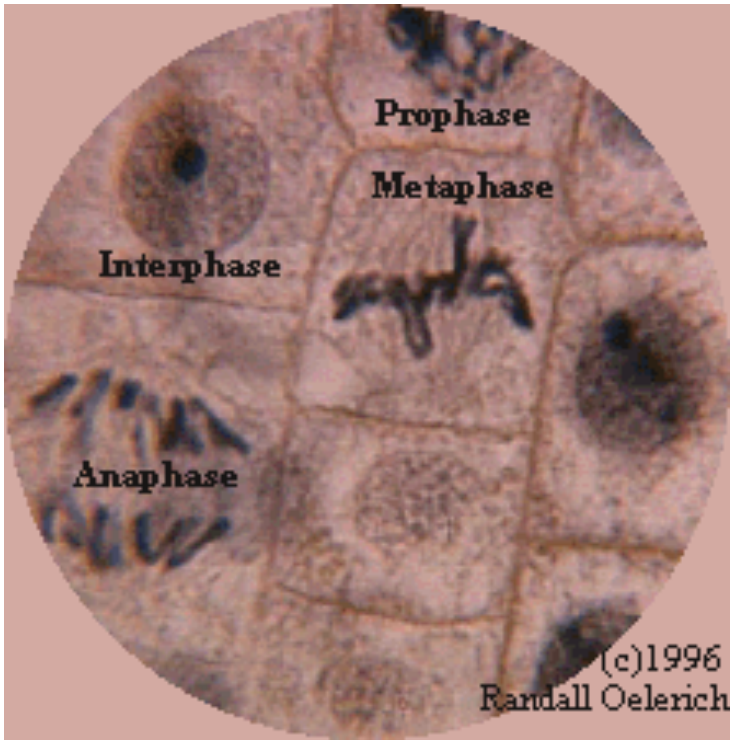


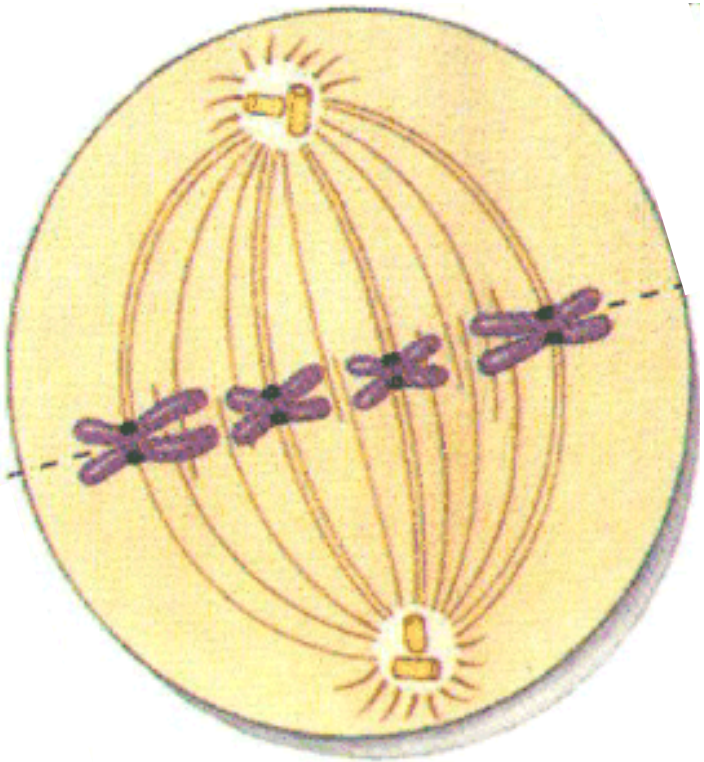


Dude, mitosis starts in five minutes...
I can't believe you're not condensed yet.

Metaphase (MIDDLE)

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

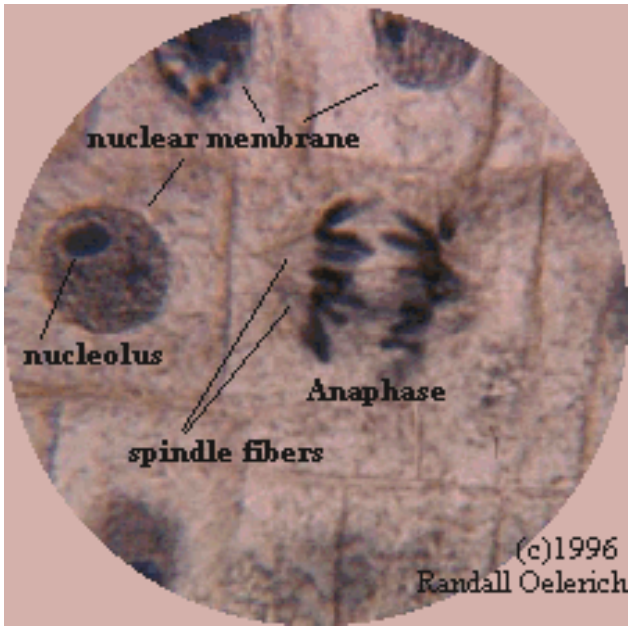


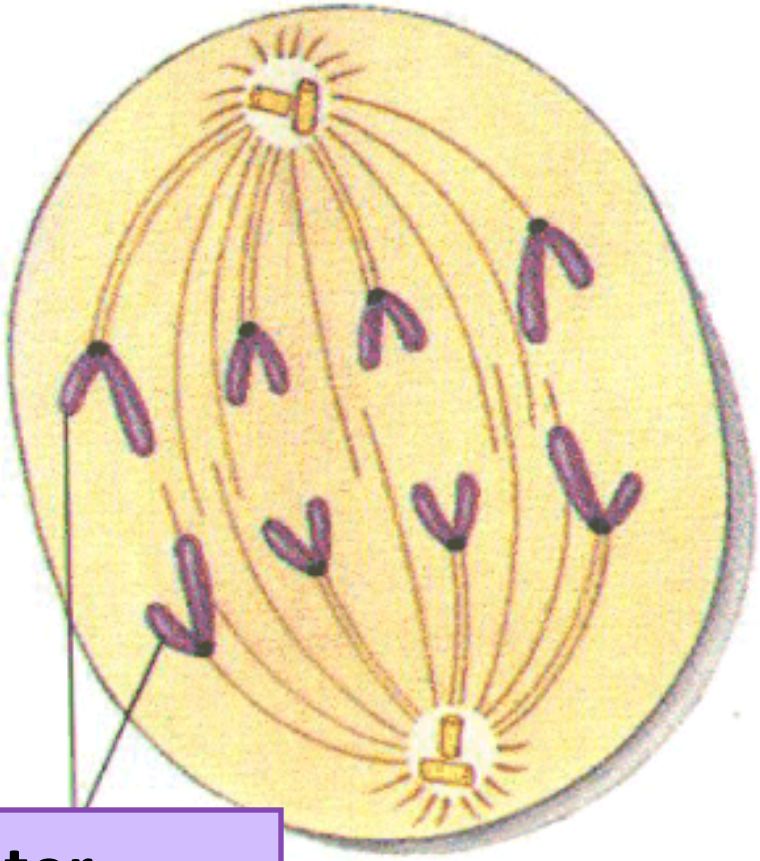


Metaphase plate

Anaphase (APART)

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

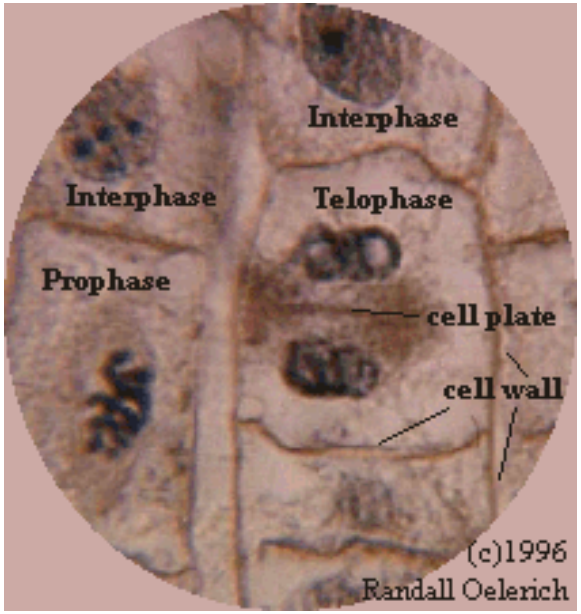


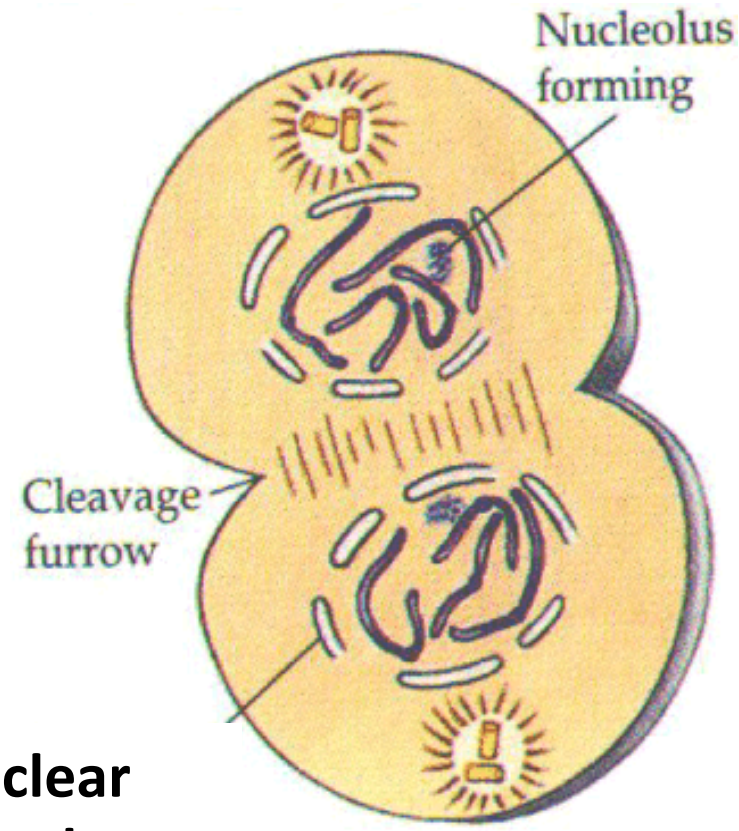


Daughter chromosomes

Telophase (TEAR into two)

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





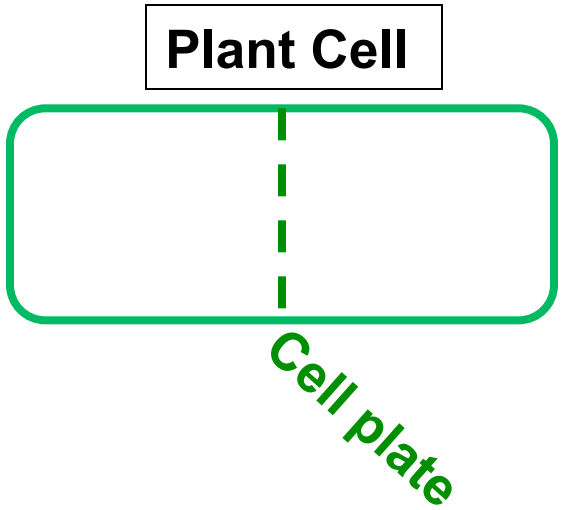
Nuclear membrane forming

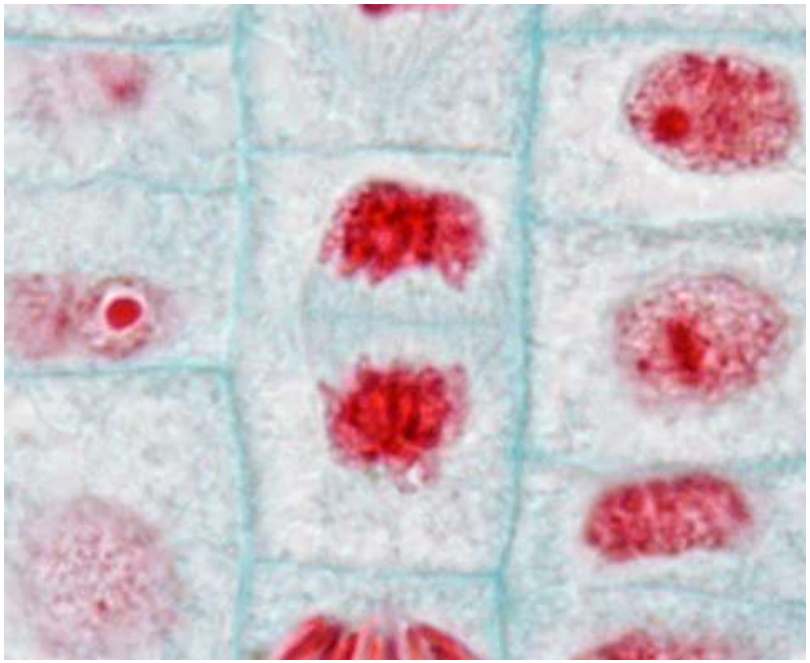
I Propose Men Are Toads

I	Prepare	Middle	Apart	Tear in two
n	r	e	n	e
t	o	t	a	l
e	p	a	p	o
r	h	p	h	p
p	a	h	a	h
h	s	a	s	a
a	e	s	e	s
s		e		e
e				

Cytokinesis (cytoplasm divides)

- **Cytoplasm pinches in or invaginates in animal 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

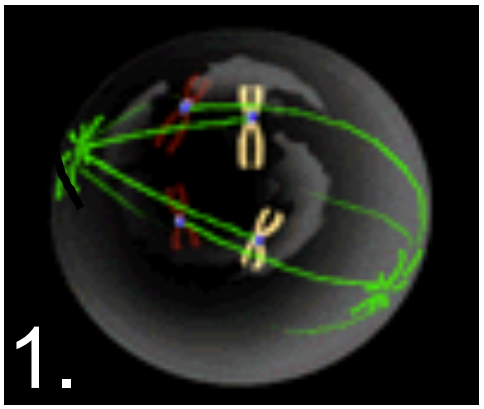
http://www.youtube.com/watch?v=cvlpmmvB_m4&safety_mode=true&safe=active&persist_safety_mode=1

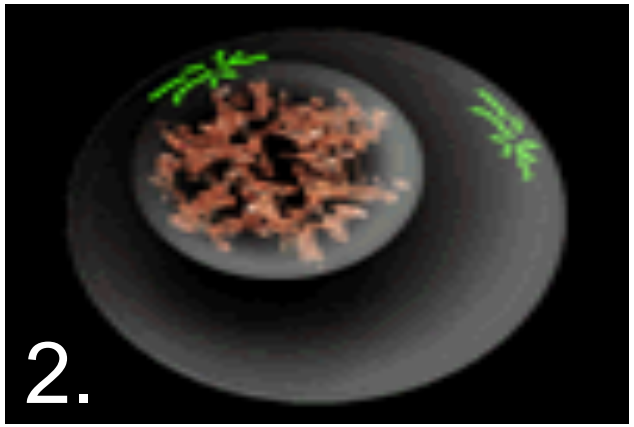
Bozeman Mitosis (13:35)

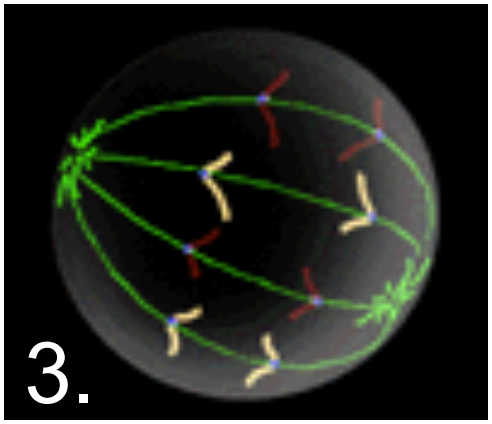
http://www.youtube.com/watch?v=1cVZBV9tD-A&safety_mode=true&safe=active&persist_safety_mode=1

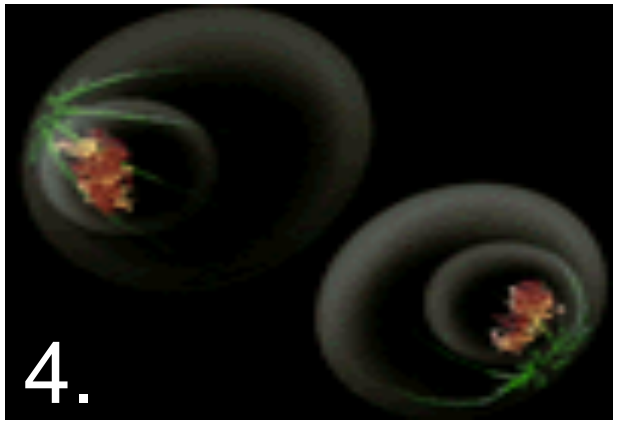
Stage	Number of Cells	Time
Interphase	9	50%
Prophase	2	11%
Metaphase	3	17%
Anaphase	2	11%
Telophase	2	11%

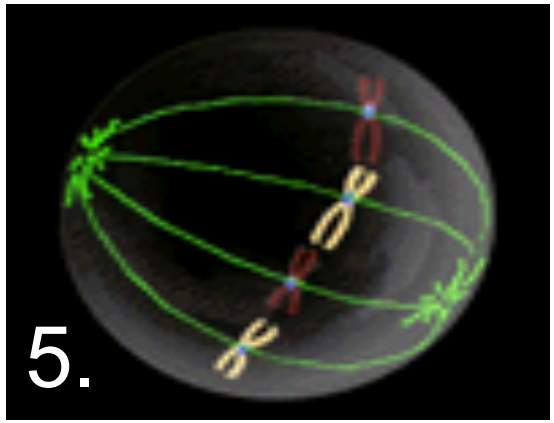
Identify the stages!

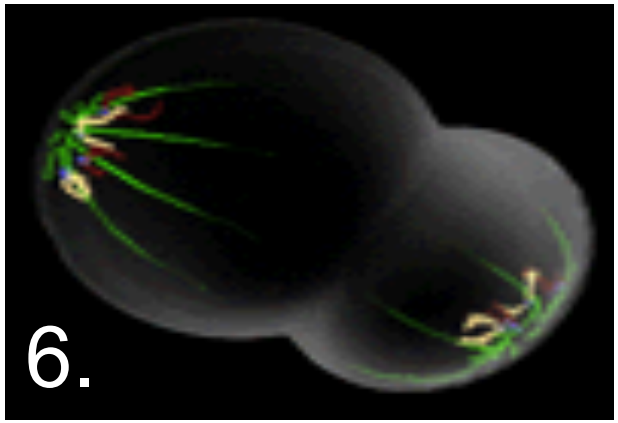












1. Prophase
2. Interphase
3. Anaphase
4. Cytokinesis
5. Metaphase
6. Telophase

Cell division in pig kidney epithilial 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

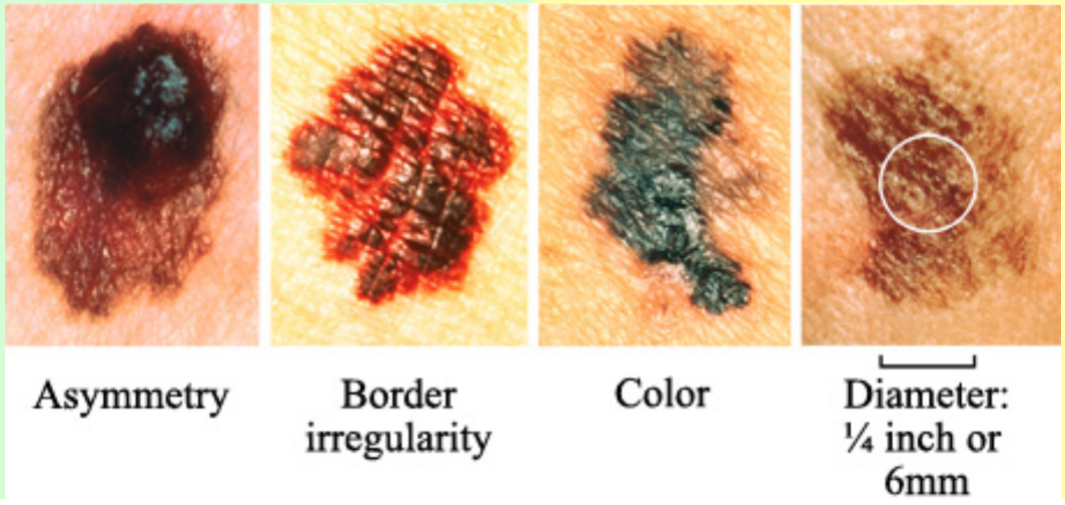
What is the phase?

9. Protein synthesis	Interphase (G1 & G2)
10. Cell divides into two	Cytokinesis
11. Chromosomes divide	Anaphase
12. DNA replicates	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

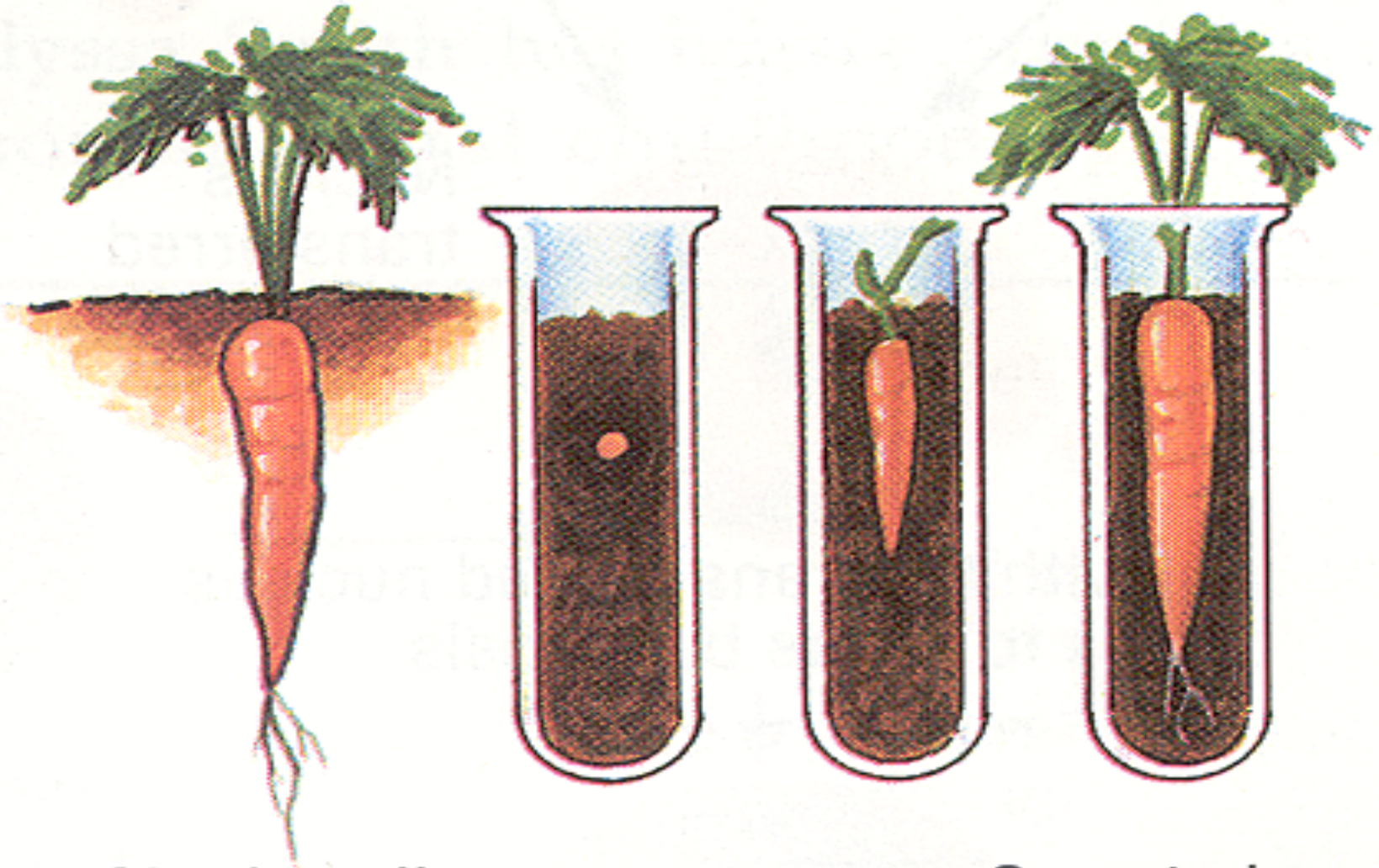
- **Keep reproducing** – don't know when to stop – <u>Abnormal Mitosis</u>
- **Don't die** if moved to another part of the body (metastasis)
- Don't stick together and don't **specialize** (they stay



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**



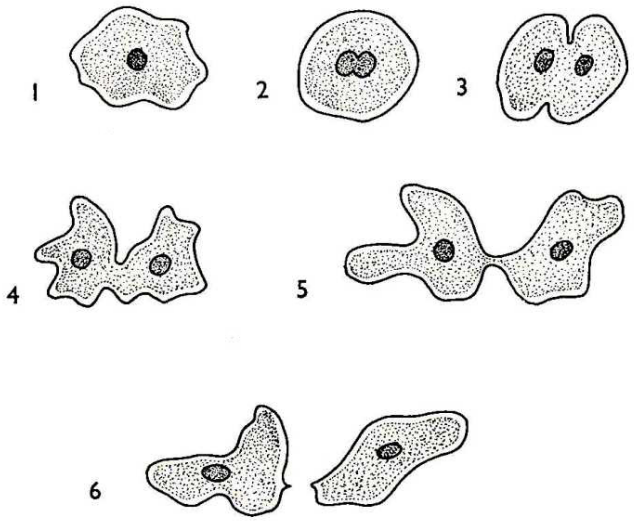
Single cell extracted from carrot

Carrot cloned

Simple cloning

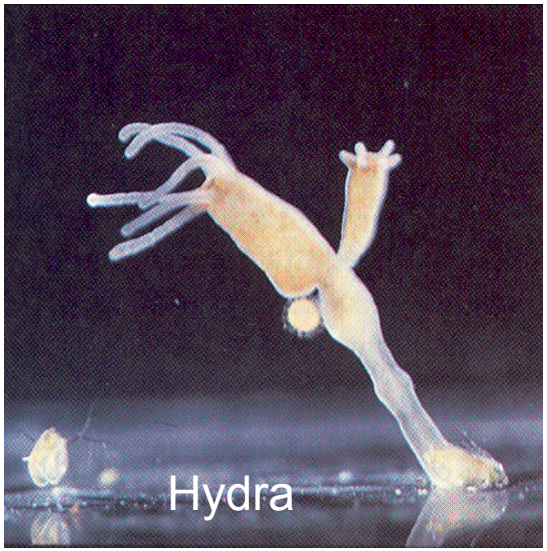
Asexual Reproduction

- 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


Hydra

Find some mor es that reproduce

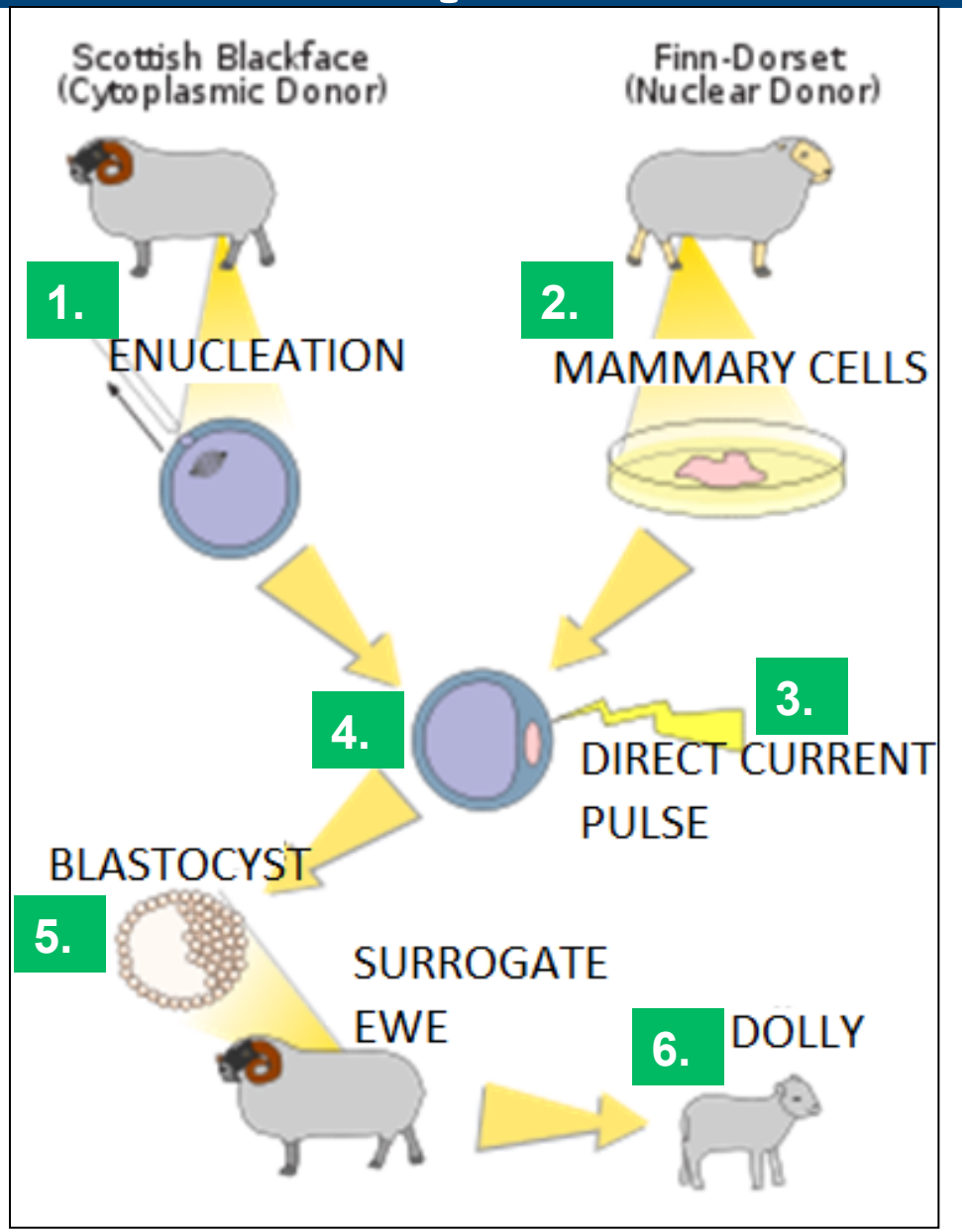

Hammerhead Shark


Komodo Dragon

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
5. Blastula stage implanted into surrogate
6. Genetically identical sheep are developed

Clone your own mouse!

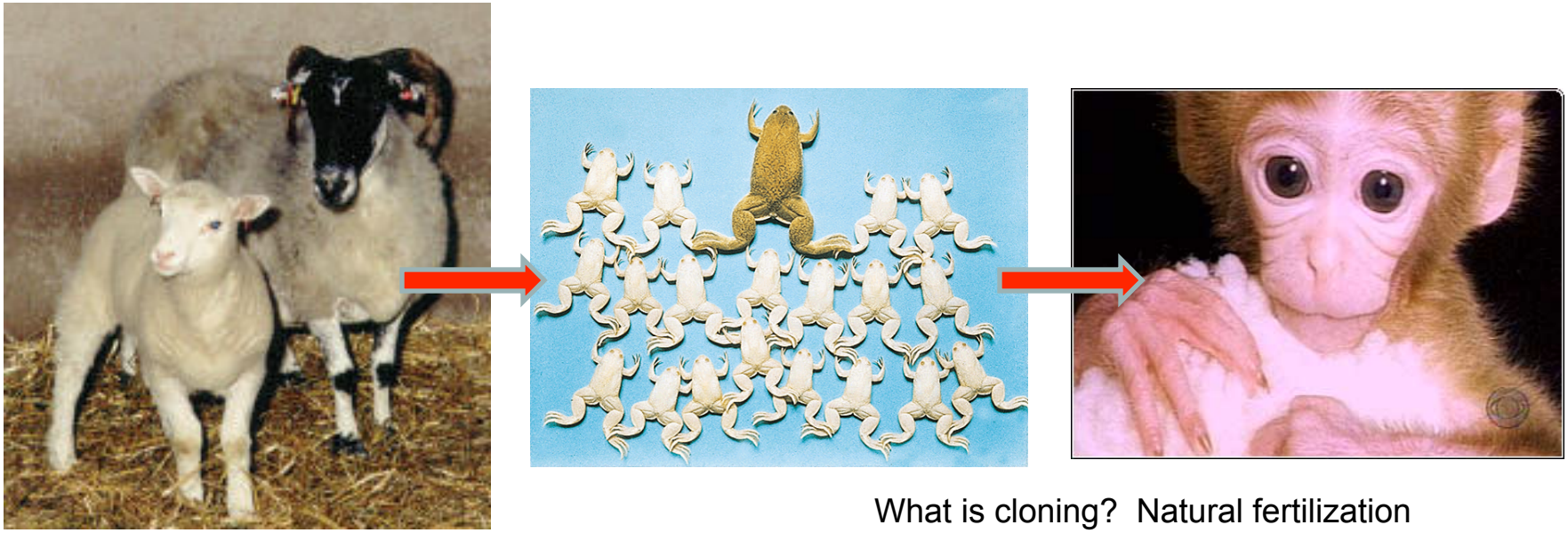


Cloning of Dolly and other mammals?

Can you clone yourself using a hair cell?

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

  (totipotent = unspecialized or undifferentiated)
- **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

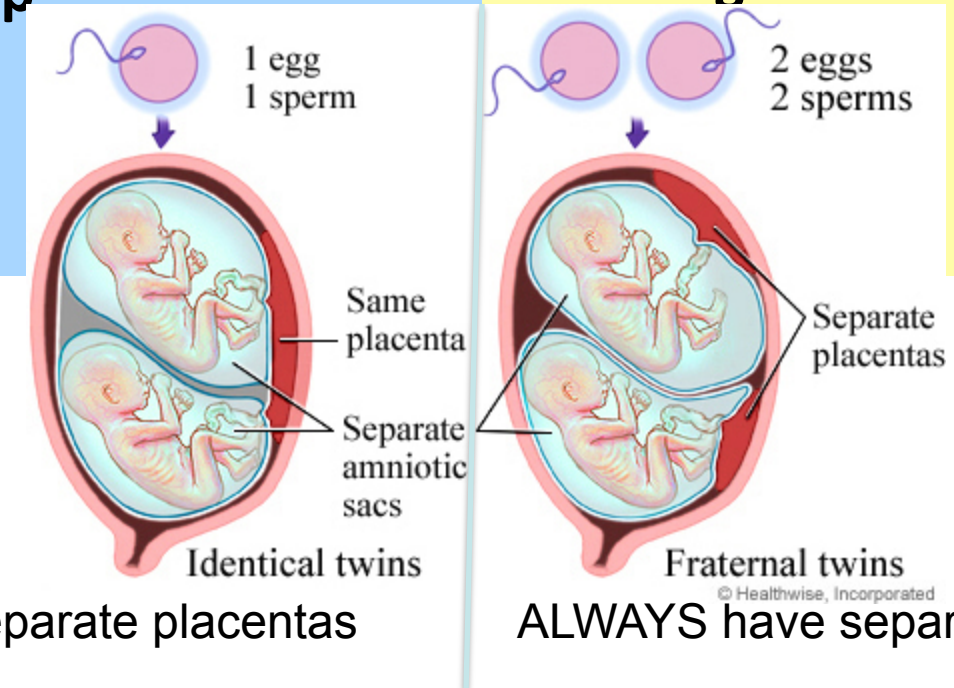
Twins

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



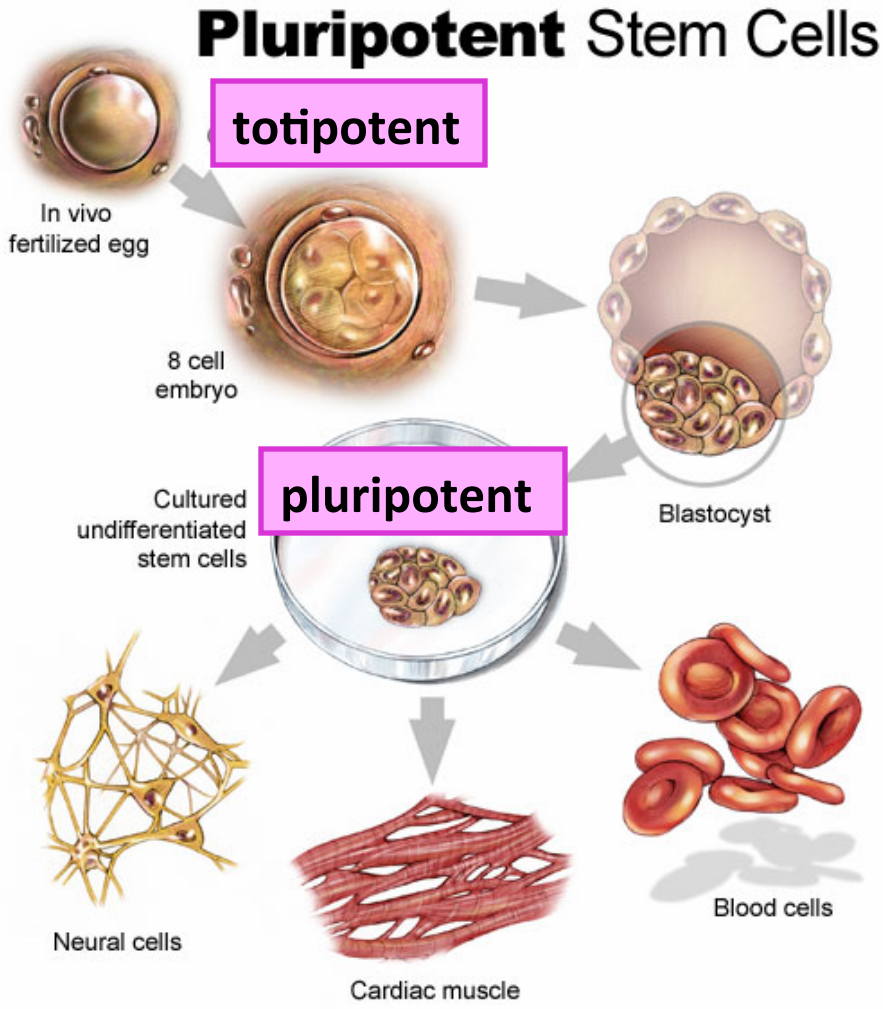
Around 30% have separate placentas

ALWAYS have separate placentas

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

Stem Cells in Our Bodies

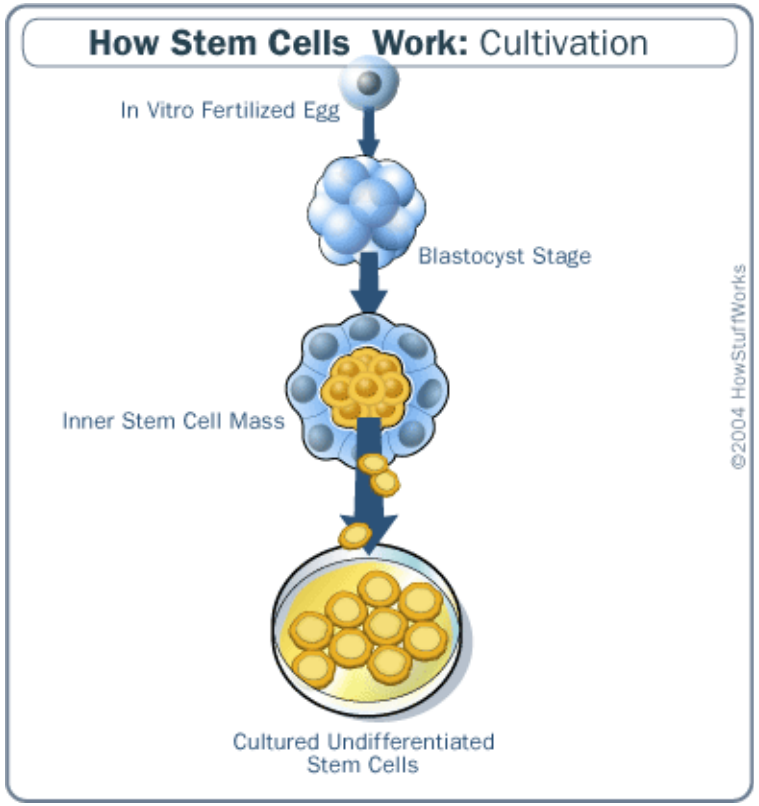


Stem Cells

Stem cells can be derived from:

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

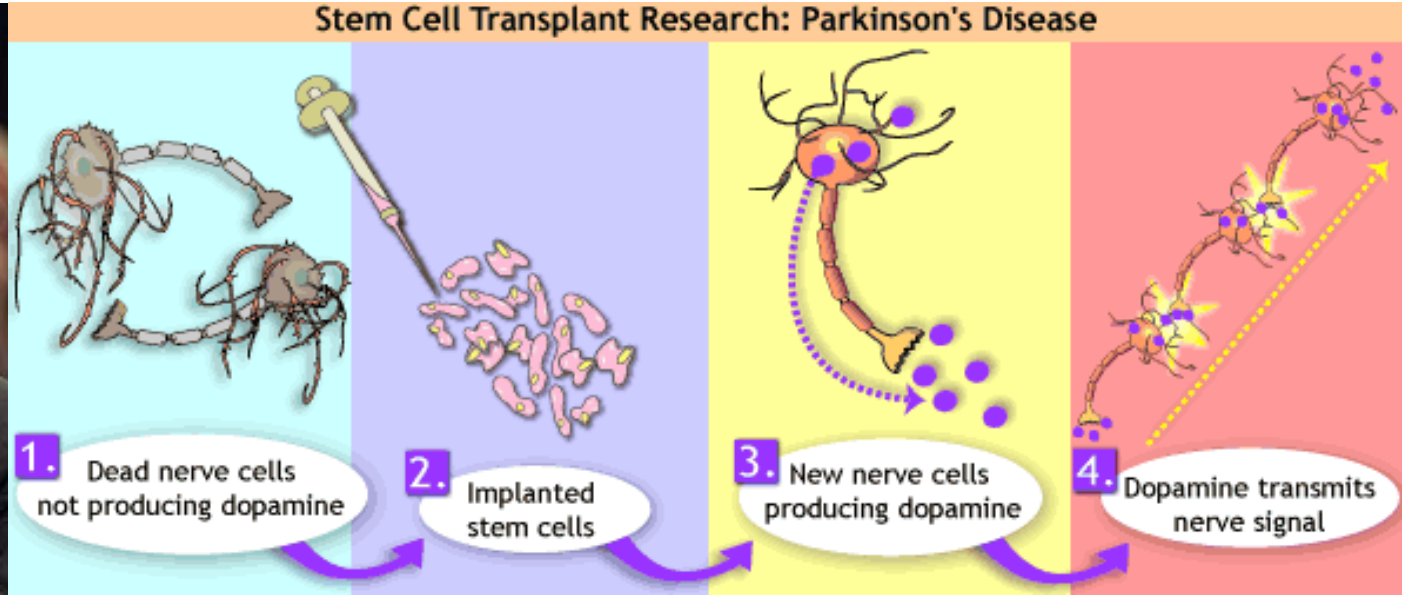
Where do Stem Cell come from?



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

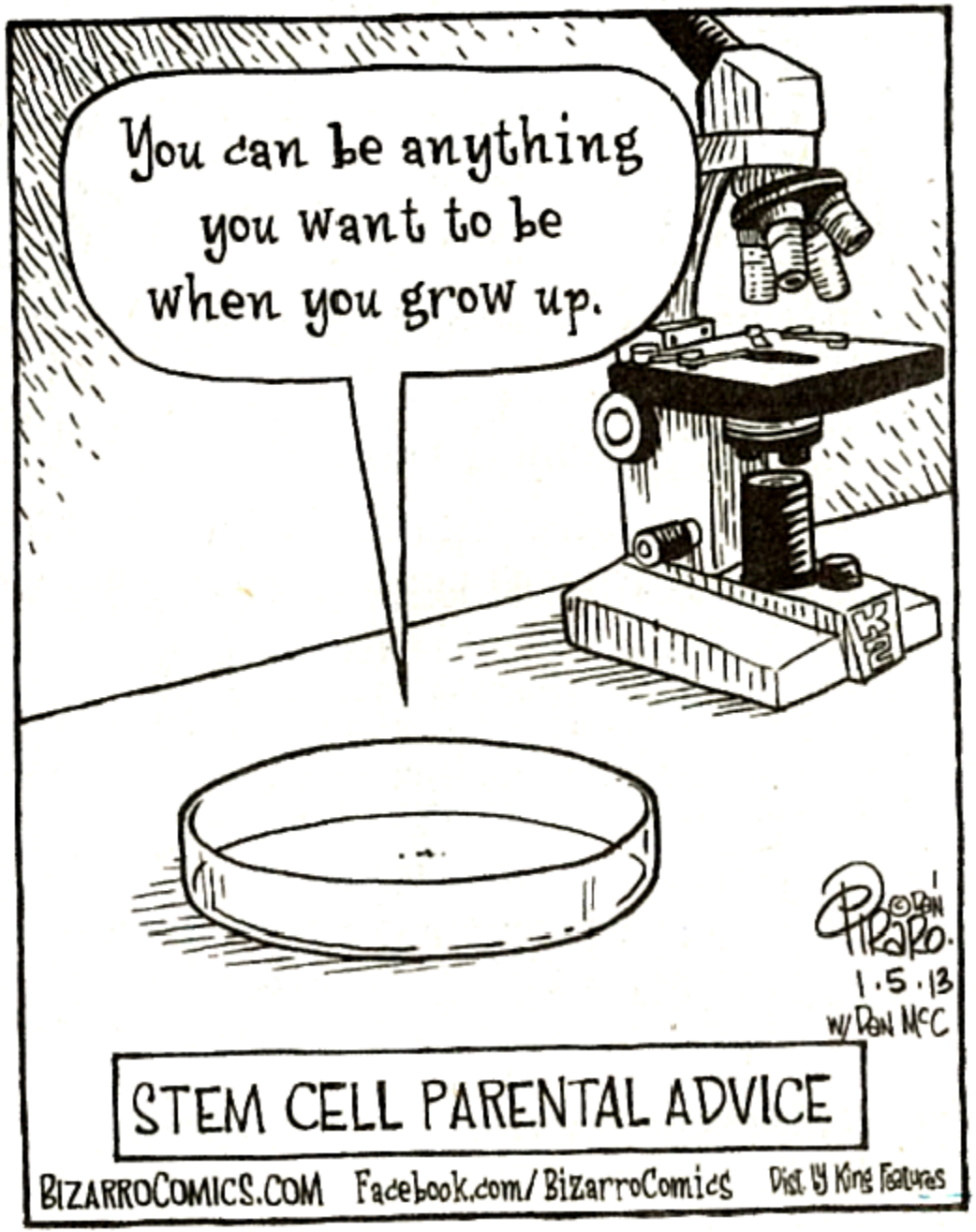


What are some issues in stem cell research?

- 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**




GARY MACKSTEIN
©2001 MILWAUKEE JOURNAL SENTINEL
Copley News Service
LIFE BEGINS AT THE PETRI DISH!
CLONING FOR RESEARCH!
EVEN THE HUMAN EMBRYOS ARE DIVIDED...
SCIENTIFIC RESEARCH


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