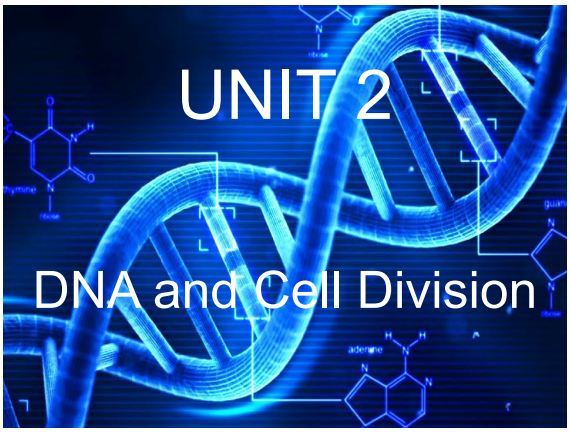


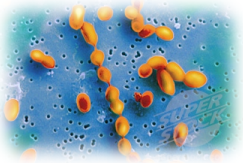
UNIT 4: DNA AND CELL DIVISION

Chapter 8: From DNA to Proteins

I. Identifying DNA as the Genetic Material (8.1)

A. Griffith finds a "**transforming principle**"

1. Griffith experimented with the **bacteria** that cause pneumonia.



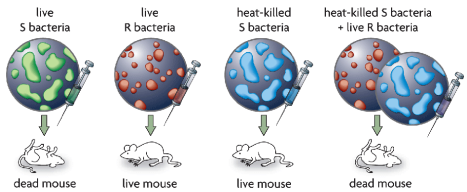
Pneumococcus ***bacteria***

2. He used **two forms** and injected them into mice

a. The S, or smooth form (**deadly**)

b. R form, or rough (**not deadly**).

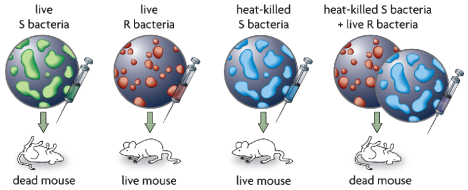
3. S form of bacteria **killed with heat** mice **unaffected**



4. Injected mice with **combination of heat-killed and live R bacteria**

a. **Mice died**

b. Griffith concluded that a **transforming material** passed from dead S bacteria to live R bacteria, making them deadly.



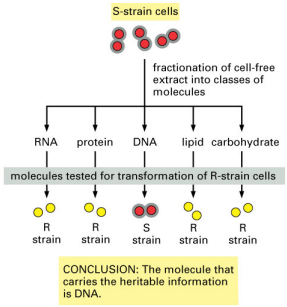
B. Avery identifies **DNA** as the **transforming principle**

1. Experimented with R bacteria and **extract** made from S bacteria

2. Allowed them to observe transformation of R bacteria

3. Developed process to **purify their extract**

a. Performed series of tests to find out if transforming principle was **DNA** or **protein**



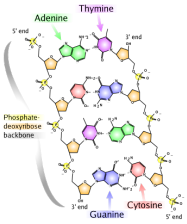
b. Performed **chemical tests** that showed no proteins were present.

c. Test revealed that **DNA was present**

4. Performed tests with **Enzymes**

a. Added enzymes to break down **proteins**- **transformation still occurred**.

b. Added enzymes to break down **RNA**- **transformation still occurred**.



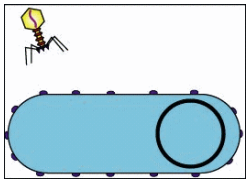
c. Added enzymes to break down **DNA**- **transformation failed to occur**.

d. **Concluded DNA was transforming factor**

C. Hershey and Chase confirm that DNA is the genetic material

1. Alfred Hershey and Martha Chase provided conclusive evidence that **DNA was the genetic material** in 1952

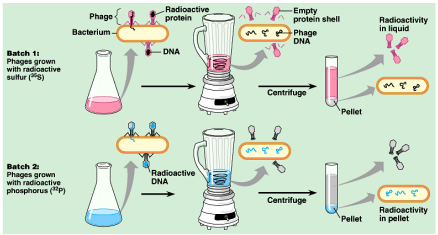
2. Studied **viruses** that infect bacteria (**bacteriophage**)



a. Bacteriophage is simple- **protein coat** surrounding **DNA core**

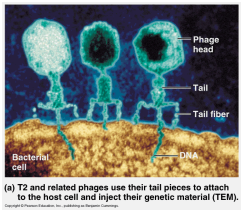
1). **Proteins** contain **sulfur** buy **very little phosphorus**

2). **DNA** contains **phosphorus** and **very little sulfur**



b. **Experiment No.1**- Bacteria infected with phages with **radioactive sulfur** atoms- **no radioactivity inside bacteria**

c. **Experiment No.2-** Bacteria infected with phages with **radioactive phosphorus** atoms- **radioactivity found inside bacteria**

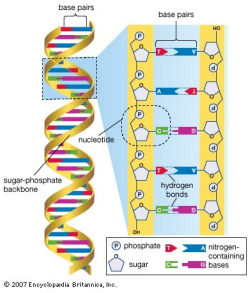


(a) T2 and related phages use their tail pieces to attach to the host cell and inject their genetic material (TEM).

d. Concluded phages **DNA** had entered bacteria but proteins had not. **Genetic material must be DNA**

II. Structure of DNA (8.2)

A. **DNA** is composed of **four types of nucleotides**



1. **DNA** is long **polymer composed** of **monomers** called **nucleotides.**

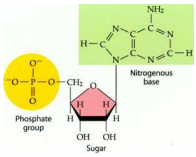
a. Each nucleotide has <u>three</u> parts

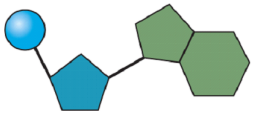
1). **Phosphate group**

2). Ring-shaped sugar called **deoxyribose**

3). **Nitrogen-containing base**

b. Scientists first believed that DNA was made of equal parts of four different nucleotides (same in all organisms





2. In 1950 Erwin Chargaff changed thinking by analyzing DNA of several different organisms

a. Found **same four bases** of DNA **in all organisms**

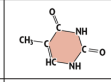
b. **Proportions** of 4 bases were **different** in organisms

Percentages of Bases in Four Organisms

Source of DNA	A	T	G	C
Streptococcus	29.8	31.6	20.5	18.0
Yeast	31.3	32.9	18.7	17.1
Herring	27.8	27.5	22.2	22.6
Human	30.9	29.4	19.9	19.8

c. Found amount of adenine equals thymine and amount of cytosine equals amount of guanine.

A = T and C = G (called **Chargaff's rules**)

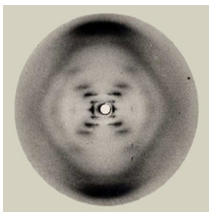
PYRIMIDINES = SINGLE RING			PURINES = DOUBLE RING		
Name of Base	Structural Formula	Model	Name of Base	Structural Formula	Model
thymine			adenine		
cytosine			guanine		

B. **Watson** and **Crick** developed accurate model of **DNA's three-dimensional structure**

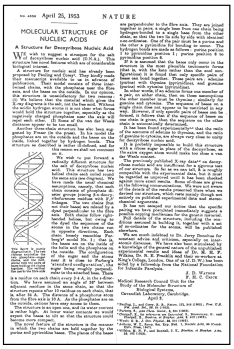
1. Used previous work of other scientists and hypothesized that DNA might also be a **helix**

a. Rosalind **Franklin** and Maurice **Wilkins** used **x-ray crystallography** and suggested DNA **helical shape**

b. Work of Hershey, Chase, Chargaff, and Linus Pauling



2. In **1953** Watson and Crick published their **DNA model** in a paper in the journal Nature



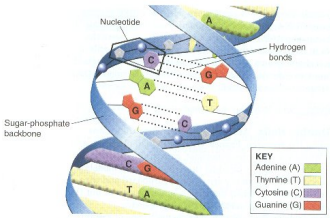
MOLECULAR STRUCTURE OF NUCLEIC ACIDS

a. **DNA was double helix**

b. Strands are **complementary** (they fit together and are the opposites of each other- **pairing of bases according to Chargaff's rules**

3. Nucleotides always pair in the same way

a. **Backbone formed by** covalent bonds that connect sugar of one nucleotide to phosphate of another

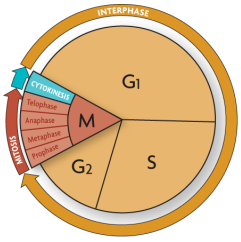


b. **Two sides** held together by **weak hydrogen bonds between bases**

c. **Base pairing rules- A with T** and **C with G**

III. DNA Replication (8.3)

A. Replication copies the genetic information



1. **Replication** creates **exact copies** of itself during the cell cycle

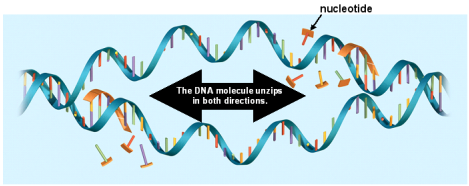
2. Replication assures every cell has complete set of identical genetic information

B. Proteins (**enzymes**) carry out the process of **replication**

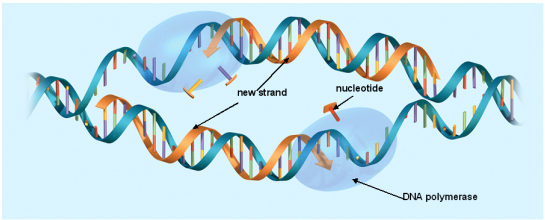
1. **Enzymes** begin to **unzip double helix** (DNA polymerases)

a. **Hydrogen bonds** are broken

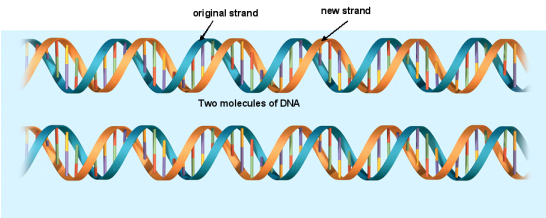
b. Molecule **separates** exposing bases



2. **Free-floating nucleotides** pair up one-by-one forming **complementary** strands to template



3. **Two identical molecules of DNA formed**

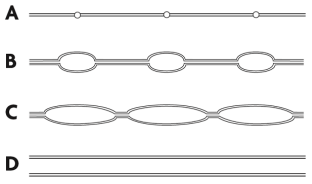


C. **Replication** is **fast** and **accurate**

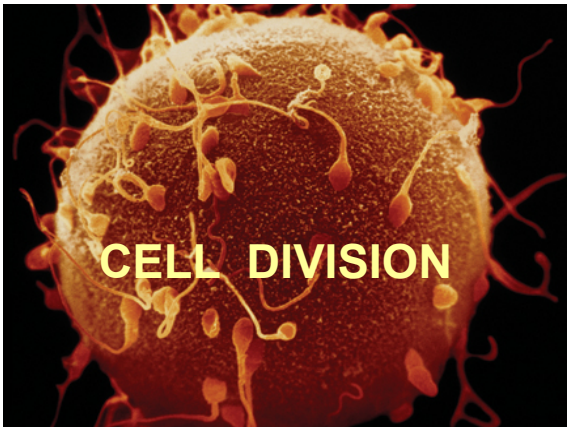
1. Process takes just a few hours

2. DNA replication **starts at many points** in eukaryotic chromosomes.

3. DNA polymerases can **find and correct errors**.



There are many origins of replication in eukaryotic chromosomes.



'Myths and Mutants'

Work with animals led to recognition of heritable traits in humans

Stories of heritable deformities in humans appear in myths and legends (e.g. cyclops, giants, etc.)

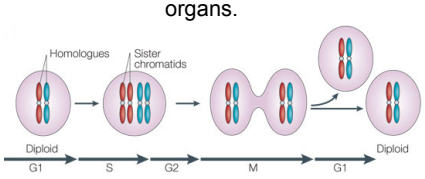
- 60 birth defects on Babylonian clay tablets (5000 years ago)
- Knowledge of traits played role in shaping social customs and mores (e.g. choosing a wife/husband)

IV. Chromosomes (6.1)

A. You have many types of specialized cells in your body

1. Cells can be divided into two types

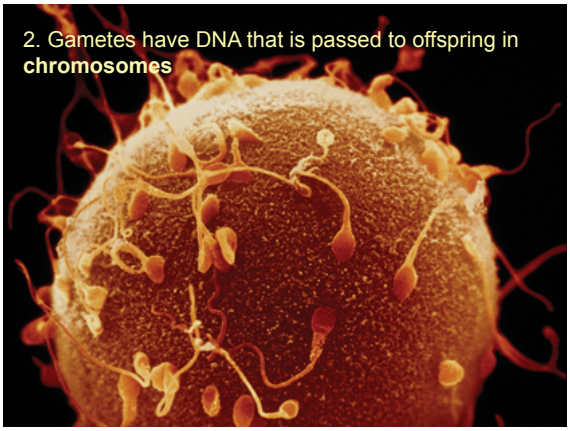
a. **Somatic Cells-** body cells. Make up most of your body tissues and organs.



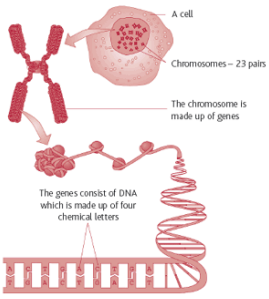
b. **Germ Cells**- cells in your reproductive organs, the ovaries and testes

1). Can develop into **gametes** (called **sex cells**)

2). Form **egg** and **sperm** cells



B. Each species has characteristic number of chromosomes per cell.



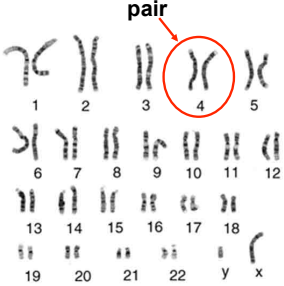
1. Chromosome number does <u>not</u> seem to be linked to complexity of organism.

2. Organisms differ from each other because of way genes are **expressed**, <u>not</u> because they have **different genes**.

V. You cells have autosomes and sex chromosomes

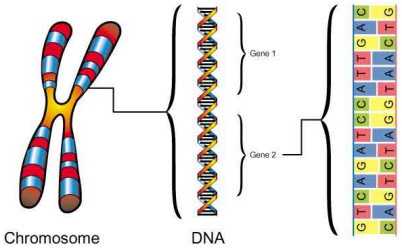
A. Your body has **23 pairs of chromosomes**

1. Each pair referred to as **homologous pair**



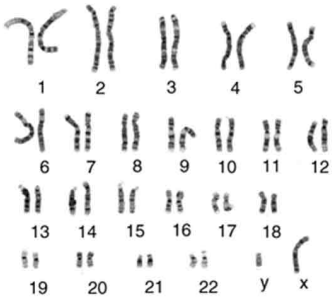
2. **Homologous chromosomes** are two chromosomes- one from <u>father</u> and one from <u>mother</u>

3. Chromosomes contain **genes** (22,000) that code for a specific <u>functional</u> products; such as a pigments for eye color, or enzymes. Many code for <u>structural</u> proteins.



Genes

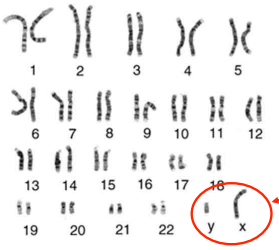
B. **Autosomes**- chromosome pairs 1-22 are called autosomes (are **homologous**)



C. **Sex chromosomes**- <u>pair</u> of chromosomes

1. Directly control development of **sexual characteristics**

2. Very different in humans (<u>not</u> homologous)



a. **X chromosome- female**

b. **Y-chromosome- male**

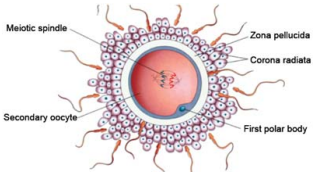
Sex chromosomes

D. Body cells are diploid; gametes are haploid

1. sexual reproduction involves fusion of two gametes

a. results in **genetic mixture** of <u>both parents</u>

b. Fusion of egg and sperm called **fertilization**

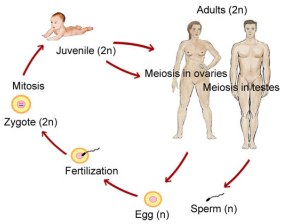


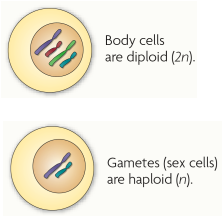
c. **Egg** and **sperm** only have **half usual number of chromosomes**

2. Diploid and Haploid cells

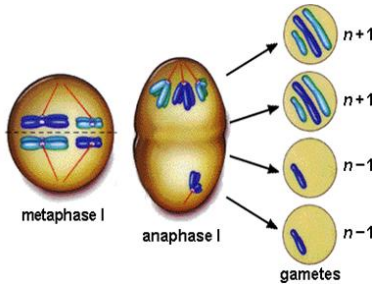
a. **Body cells** are **diploid** (two copies of each chromosome)

b. **Gametes** are **haploid** (have one copy of each chromosome)



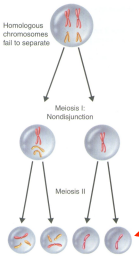


3. Maintaining the correct number of chromosomes is important to survival of organisms



3. Maintaining the correct number of chromosomes is important to survival of organisms

4. **Germ cells (sex cells)** undergo process of meiosis to form **gametes**



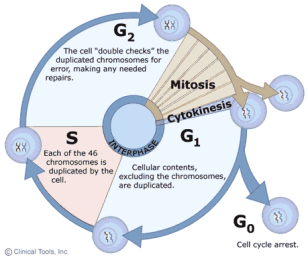
a. diploid cell divides into **haploid cell**

b. Sometimes called **reduction division**

Haploid cells

VI. The Cell Cycle has four main stages (5.1)

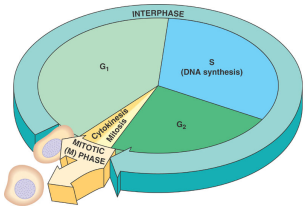
A. The **cell cycle** is a regular pattern of **growth**, **DNA replication**, and **cell division** in **eukaryotic cells**



1. **Originally** divided into two stages (observations were limited by microscopes at the time)

a. **Interphase-** cell appeared to be at rest

b. **Mitosis-** cell dividing

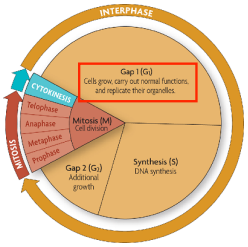


2. Improved techniques and tools later allowed scientist to identify **4 distinct stages**

a. **Gap 1 (G_1)** - cell carries out normal functions

1). **Cell** <u>increases</u> in **size**

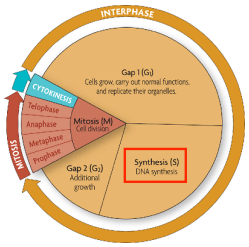
2). **Organelles** <u>increase</u> in **numbers**



b. **Synthesis (S)** - Cell makes copy of its nuclear DNA.

1). ***Synthesis*** means "the combining of parts to make a whole.

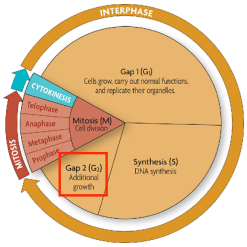
2). By end of S stage, cell nucleus contains **two** complete **sets of DNA**



c. **Gap 2 (G_2)** - Cells continue to carry out normal functions

1).Additional **growth** occurs

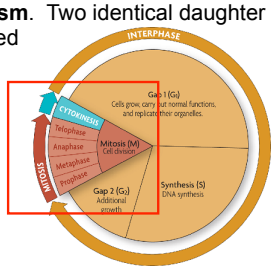
2). **Critical checkpoint** (before cell goes through mitosis cell must be adequate size, undamaged DNA)

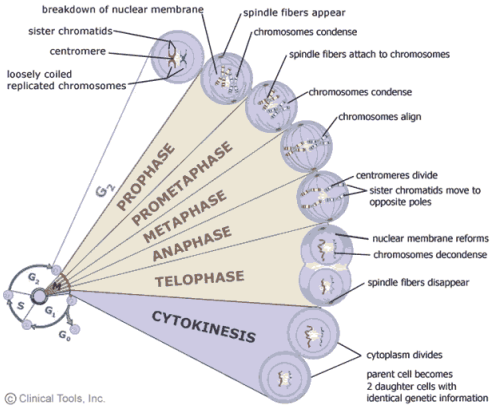


d. **Mitosis (M)** - Includes two processes

1). **Mitosis** - **Division** of cell **nucleus** and its **contents**

2). **Cytokinesis** - Process that **divides** the **cell cytoplasm**. Two identical daughter cells produced





B. Cells divide at different rates

1. **Rates** of cell division **vary widely**

a. **Prokaryotic** cells typically divide much **faster** than **eukaryotic** cells

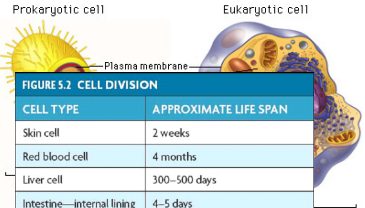
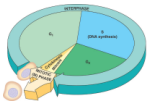


FIGURE 5.2 CELL DIVISION

CELL TYPE	APPROXIMATE LIFE SPAN
Skin cell	2 weeks
Red blood cell	4 months
Liver cell	300–500 days
Intestine—internal lining	4–5 days
Intestine—muscle and other tissues	16 years

2. In **human cells**, **S**, **G_2**, and **M** stages together usually take about **12 hours**



a. Length of **G_1** stage **differs** most for different cell types

b. Rate of cell division greater in embryos and children

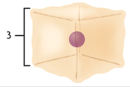
FIGURE 5.2 CELL DIVISION	
CELL TYPE	**APPROXIMATE LIFE SPAN**
Skin cell	2 weeks
Red blood cell	4 months
Liver cell	300–500 days
Intestine—internal lining	4–5 days
Intestine—muscle and other tissues	16 years

C. Cell size is limited

1. Cells have **upper** and **lower** size limits

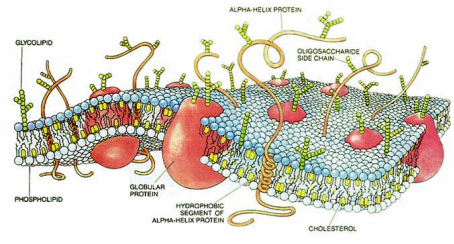
a. Must be **big** enough to "hold" everything

b. Upper limit due to ratio of cell **surface area** to **volume**

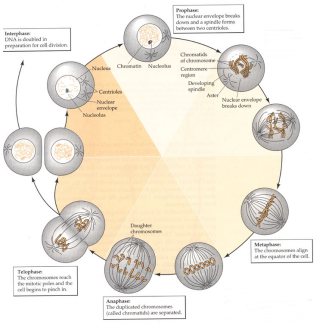
Relative size	1 	2 	3 
Surface area (length × width × number of sides)	6	24	54
Volume (length × width × height)	1	8	27
Ratio of surface area to volume	$\frac{6}{1}$ = 6:1	$\frac{24}{8}$ = 3:1	$\frac{54}{27}$ = 2:1

1).Oxygen, nutrients, and wastes move across the **cell membrane** (surface of cell)

2). As cell grows, its surface area (cell membrane) does not grow as fast as volume- too **small** for adequate <u>exchange</u> of materials



2. To maintain suitable cell size, **growth** and **cell division** must be **coordinated**.



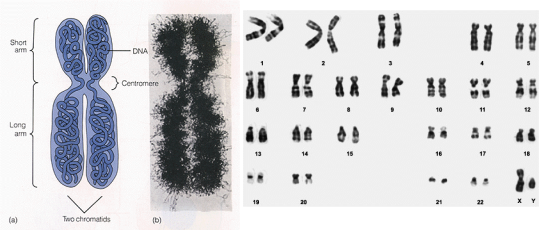
VII. **Mitosis** and **Cytokinesis** (5.2)

A. Chromosomes condense at start of mitosis

1. **Chromosome** - one long continuous thread of **DNA**

a. Consists of numerous **genes**

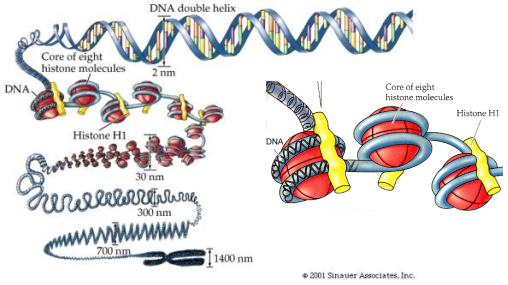
b. You have **46 chromosomes**



c. Must be **condensed** to fit into cell nucleus

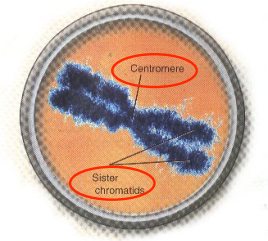
1). **DNA** <u>wraps around</u> proteins called **histones**

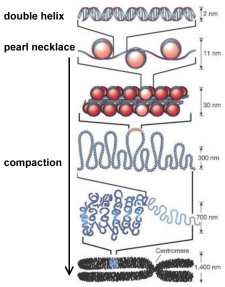
2). When loosely condensed called **chromatin**

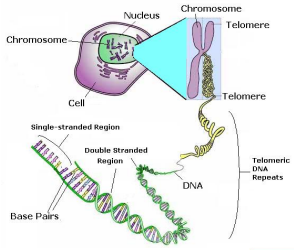


d. Chromosome looks like "**X**" (each half is identical DNA- called a **chromatid**)

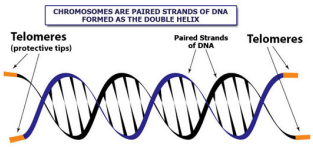
e. **Sister chromatids** held together by **centromere**





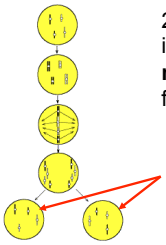


f. **Telomeres** - found at ends of DNA molecules and prevent DNA from coming apart



B. **Mitosis** and **cytokinesis** produce **two genetically identical daughter cells**

1. **Interphase** - important role in preparing cell to divide (2 sets of DNA and are large enough)

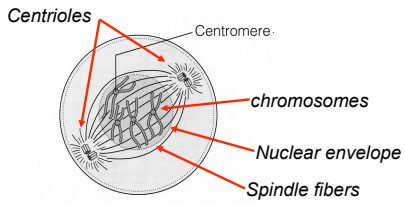


2. **Mitosis** - divides cell's **nucleus** into **two genetically identical nuclei**, each with its own single, full set of **DNA**

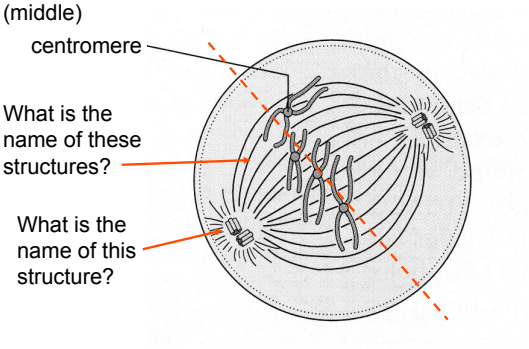
Two genetically identical nuclei

3. Four main phases of Mitosis

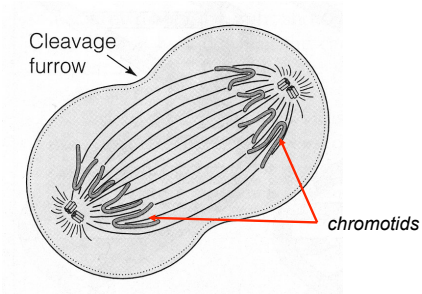
a. ***Prophase*** - **DNA condenses** into tightly coiled **chromosomes**. **Nuclear envelope** breaks down. **Centrioles** move to poles and **spindle fibers** form



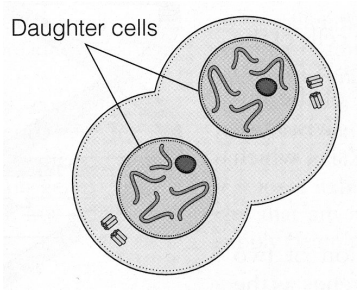
b. ***Metaphase*** - **Spindle fibers** attach to each **chromosome**. Chromosomes align along cell equator (middle)



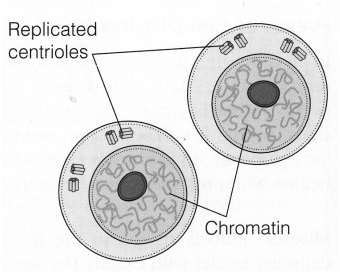
c. ***Anaphase*** - **Chromatids** separate to opposite sides of cell

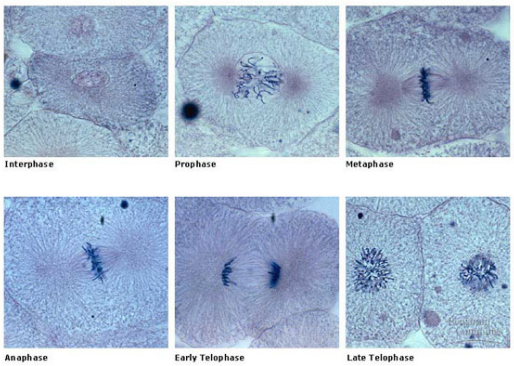


d. ***Telophase*** - **Nuclear membrane** starts to form. **Chromosomes** begin to uncoil and **spindle fibers** fall apart



4. **Cytokinesis** - division of cytoplasm. Different in animal and plant cells.

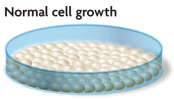




VIII. Regulation of Cell Cycle (5.3)

A. **Internal** and **external** factors regulate cell division

1. **External factors**



a. Include **physical** and **chemical** factors

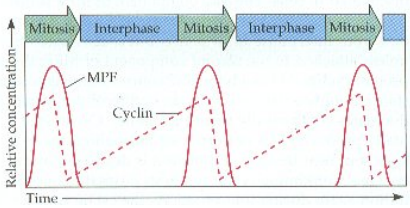
b. Once a cell touches another cell it stops dividing

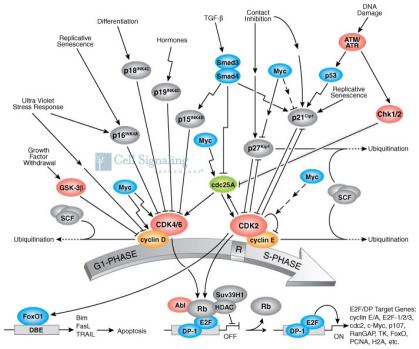
c. Many cells release chemical signals (**growth factors**) that trigger cell growth.

2. **Internal factors**

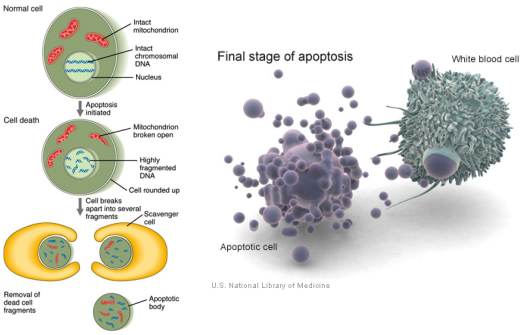
a. **External** factors <u>trigger</u> **internal** factors that affect cell cycle

b. Two of the most important internal factors are **kinases** and **cyclins**





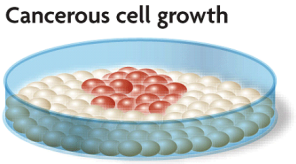
3. **Apoptosis** - programmed **cell death** (signals <u>activate</u> genes producing **self-destructive enzymes**



B. **Cell division** is <u>uncontrolled</u> in **cancer**.

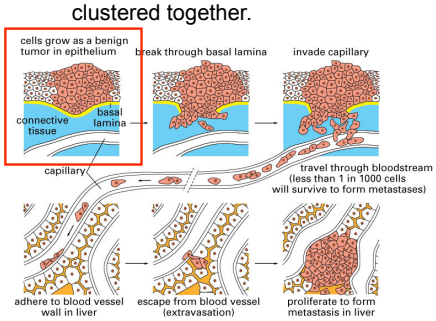
1. **Cancer** - common name for <u>class or diseases</u> characterized by **uncontrolled cell division**

a. Form from disorganized clumps called **tumors**

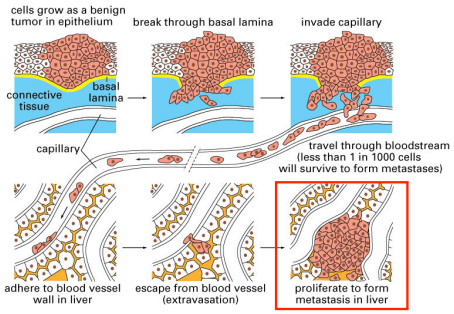


b. Two types of tumors

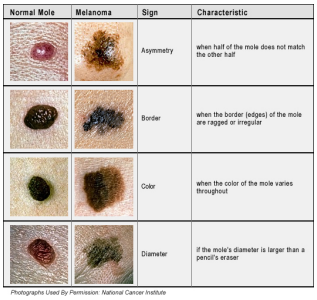
1). **Benign** - cancer cells typically remain clustered together.

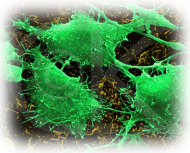


2). **Malignant** - Some cell break away (or **metastasize**) from the tumor and spread through body



2. **Cancer cells** come from normal cells that have suffered damage to genes that make proteins involved in cell division

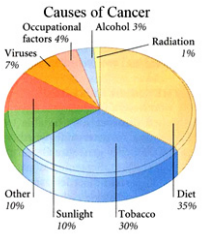


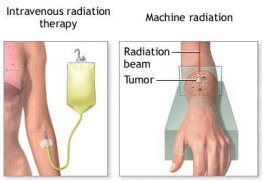


Brain cancer cells

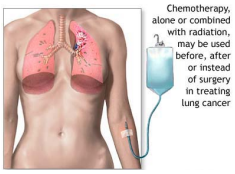
a. damage from **radiation**, **inherited**, **chemicals**, **ultraviolet radiation**

b. **Carcinogens -** Substances know to <u>cause</u> **cancer**





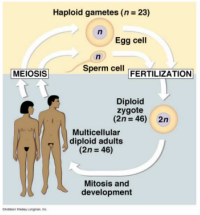
c. **Cancer** can be <u>treated</u> with both **radiation** and **chemotherapy**.(these typically kill both cancerous and healthy cells)



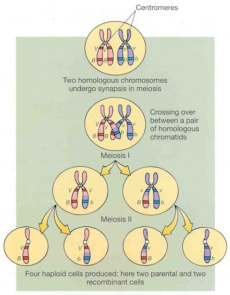
IX. Asexual Reproduction (5.4)

A. **Binary fission** is similar in function to mitosis

1. **Reproduction** occurs in two ways (**sexual** and **asexual** reproduction)

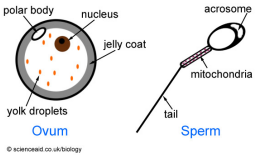


a. **Sexual reproduction** - joining of two specialized cells (**gametes** - egg and sperm), one from each parent

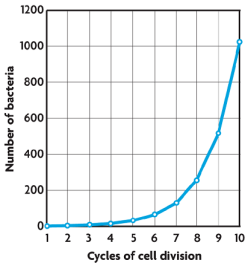


1). Offspring are **genetically unique**

2). <u>Mixture</u> of **genes** from both parents



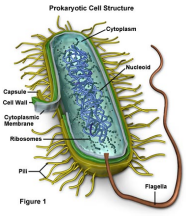
b. **Asexual reproduction** - creation of offspring from a single parent. **Offspring genetically identical**

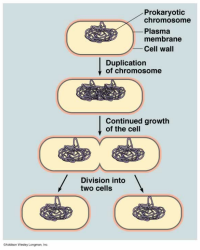


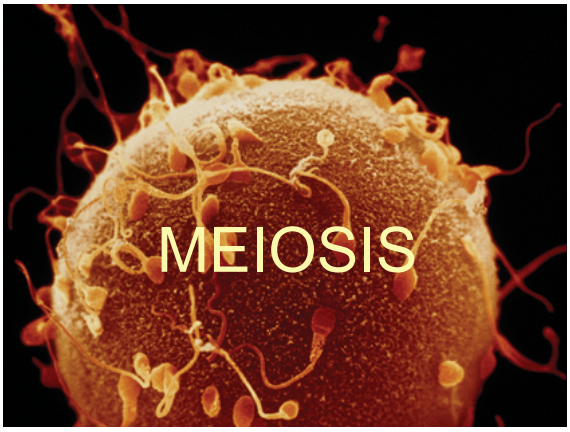
2. **Binary fission** - asexual reproduction of single-celled organism

a. Occurs in **prokaryotes**

b. **binary fission** and **mitosis** have similar results

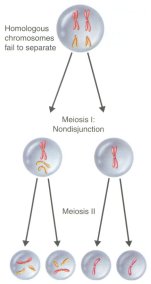






X. Process of Meiosis (6.2)

A. Cells go through **two rounds of division** in meiosis



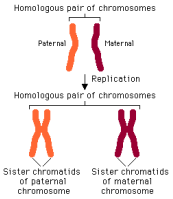
1. **Meiosis produces four haploid cells** from one diploid cell

2. Process involves two rounds of cell division- **Meiosis I** and **Meiosis II**.

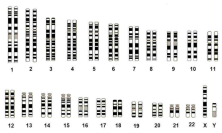
B. Homologous Chromosomes and sister Chromatids

1. Need to distinguish between the two to understand meiosis

2. **Homologous chromosomes**- two separate chromosomes- one from mother, one from father.

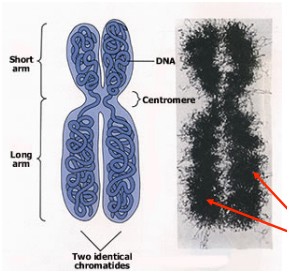


a. very similar to each other- **same length** and **carry same genes**

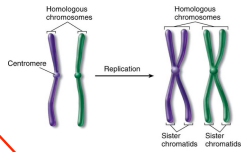


b. Each half of duplicated chromosome is called a **chromatid**. (together called **sister chromatids**)

1). Homologous chromosomes divided in meiosis I



2). **Sister chromatids** not divided until meiosis II

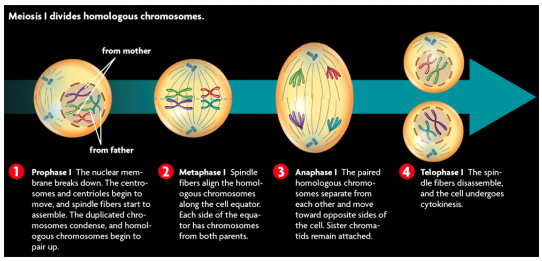


Sister chromatids

C. **Meiosis I** (first of two phases)

1. Occurs <u>after</u> **DNA** has been **replicated**

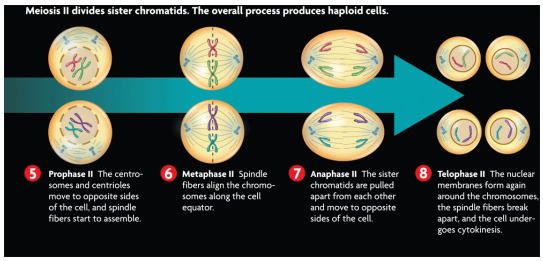
2. Divides homologous chromosomes in **four phases**



D. **Meiosis II** (second of two phases)

1. Divides sister chromatids in **four phases**

2. DNA is <u>not</u> replicated between meiosis I and meiosis II

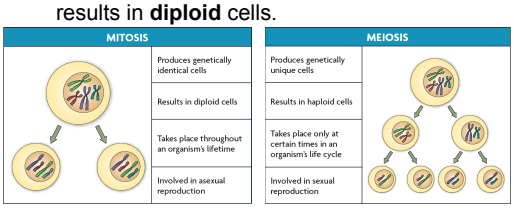


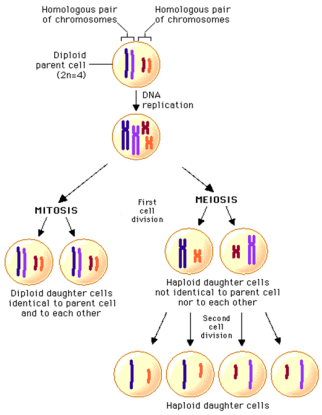
E. Meiosis differs from mitosis in significant ways.

1. **Meiosis** has **two cell divisions** while **mitosis has one**.

2. In mitosis, homologous chromosomes never pair up

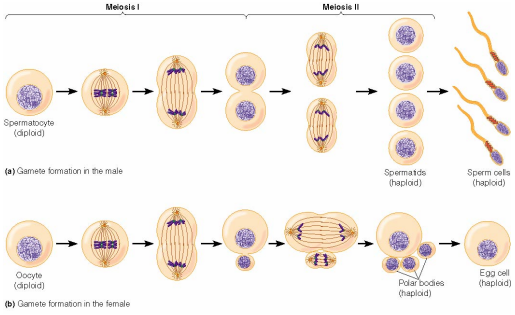
3. **Meiosis** results in **haploid** cells; **mitosis** results in **diploid** cells.





F. Haploid cells develop into mature gametes

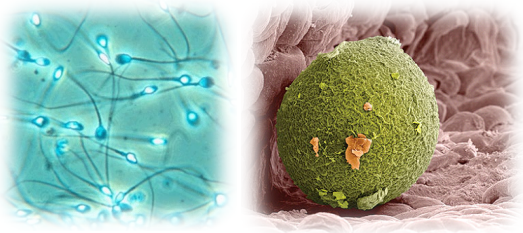
1. **gametogenesis**- production of mature gametes



2. Differs between the sexes

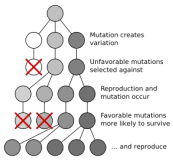
a. **Males** produce 4 equal sperm cells

b. **Females** produce one large egg and smaller polar bodies that are eventually broken down



B. **Advantages** and **Disadvantages** of **Asexual reproduction**

1.In <u>environments that don't change</u>, **asexual** may be better. If they are well suited to environment may be more efficient

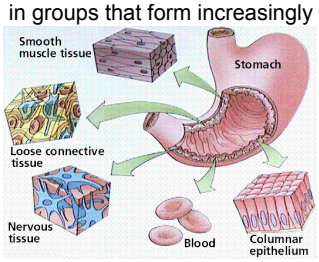


2. In <u>changing environments</u> **sexual** reproduction produces genetic diversity which raises chances for survival

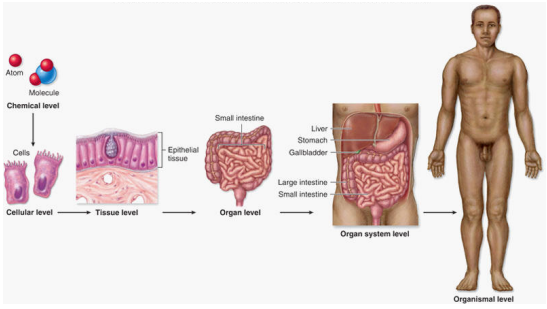
XI. Multicellular Life (5.5)

A. **Multicellular** organisms depend on interactions among different cell types.

1. Cells communicate and work together in groups that form increasingly large,

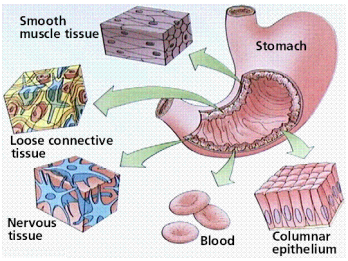


a. **CELLS → TISSUES → ORGANS → ORGAN SYTEMS**

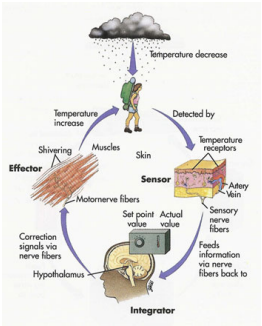


b. **Tissue** - **group** or **cells** that **work together** to perform a **particular function**

c. **Organ** - **group** of **tissues** that **work together** to perform **specific function** or related functions

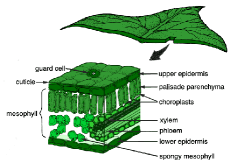


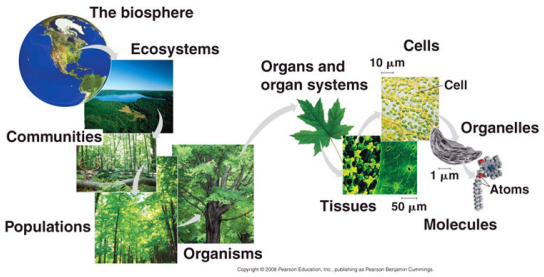
d. **Organ system** - **organs** that carry out **similar functions**



1). Organ systems work together to maintain **homeostasis**

2). Occurs in plants and animals



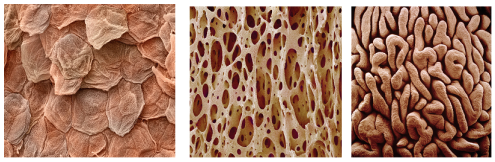


B. Specialized cells perform specific functions

1. **Cell differentiation** - process by which unspecialized cells develop into their mature **forms** and **functions**

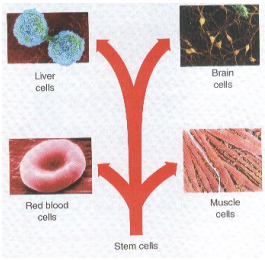
a. Every cell in body has full set of **DNA**

b. Cells only use certain **genes** and become **specific** (ie. bone cells, muscle cells, nerve cells, etc.)



C. Stem cells can develop into different cell types

1. **Stem cells** - unique type of body cell



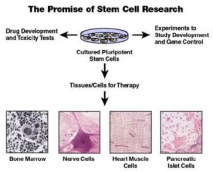
a. Can divide and renew themselves for long periods of time

b. Remain undifferentiated in form

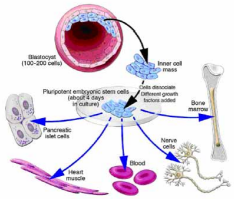
c. Develop into a variety of specialized cell types

2. Stem cells can be **catorgorized** by their ability or potential to develop into differentiated cell types and different tissues.

Class	totipotent	pluripotent	multipotent
Type of cell	fertilized egg 	embryonic stem cell 	adult stem cell (example from blood) 
Can give rise to	all cells	almost any cell	closely related cells
Example	new organism	neurons, skin, muscle, kidney, cartilage, bone, liver, pancreas	red blood cells, platelets, white blood cells

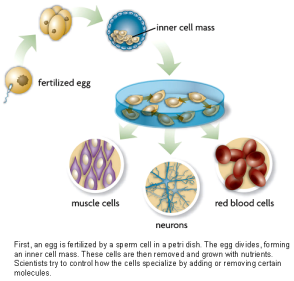


3. **Adult Stem Cells** - partially undifferentiated cells located among the specialized cells or many organs and tissues



4. **Embryonic Stem Cells** - come from donated embryos grown in a clinic

5. Research and Treatment Hope



First, an egg is fertilized by a sperm cell in a petri dish. The egg divides, forming an inner cell mass. These cells are then removed and grown with nutrients. Scientists try to control how the cells specialize by adding or removing certain molecules.

a. Stem cells have long been used to treat **leukemia** and **lymphoma**

b. Might be used to repair damaged **organs**

c. Used to cure **diseases** (i.e. diabetes)