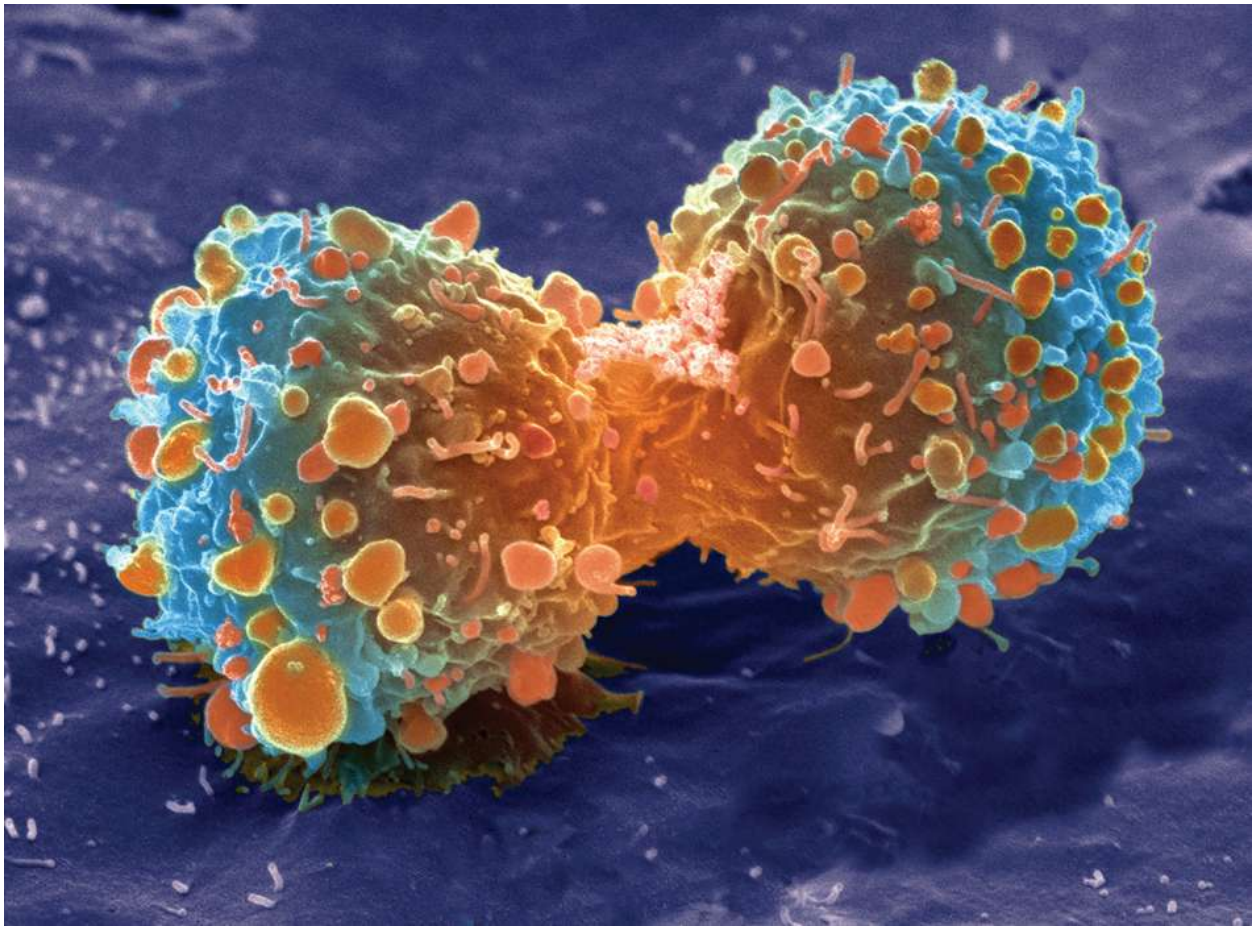
5.1 The Cell Cycle

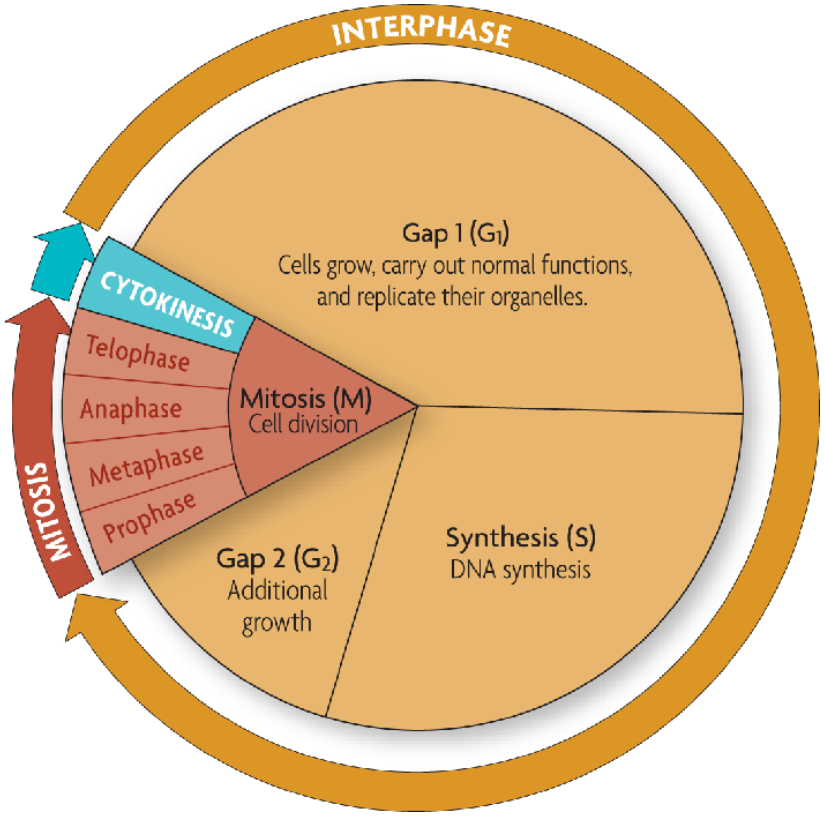
KEY CONCEPT

Cells have distinct phases of growth, reproduction, and normal functions.



The cell cycle has four main stages.

- The cell cycle is a regular pattern of growth, DNA replication, and cell division.



5.1 The Cell Cycle

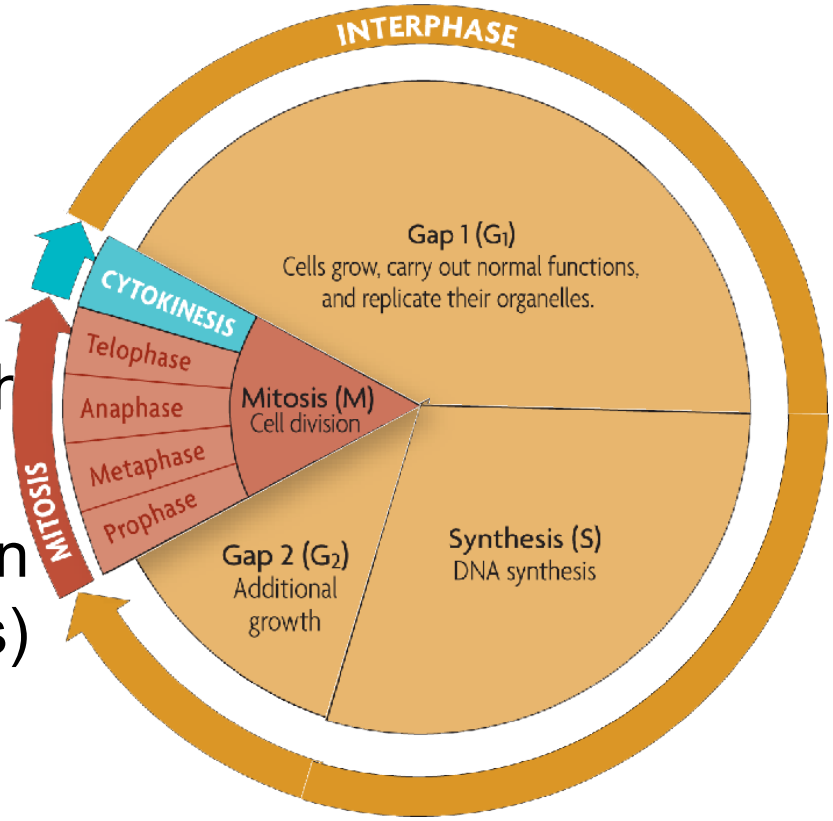
- The main stages of the cell cycle are gap 1, synthesis, gap 2, and mitosis.

  Gap 1 (G_1): cell growth and normal functions

  DNA synthesis (S): copies DNA

  Gap 2 (G_2): additional growth

  Mitosis (M): includes division of the cell nucleus (mitosis) and division of the cell cytoplasm (cytokinesis)



Mitosis occurs only if the cell is large enough and the DNA undamaged.

Cells divide at different rates.

- The rate of cell division varies with the need for those types of cells.

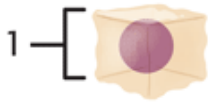
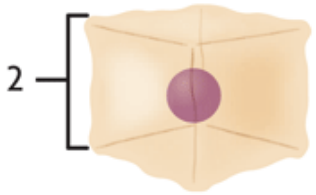
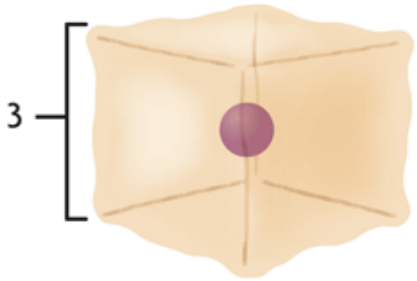
FIGURE 5.2 CELL DIVISION	
CELL TYPE	**APPROXIMATE LIFE SPAN**
Skin cell	2 weeks
Red blood cell	4 months
Liver cell	300–500 days
Intestine—internal lining	4–5 days
Intestine—muscle and other tissues	16 years

Some cells are unlikely to divide (G_0).

5.1 The Cell Cycle

Cell size is limited.

- Volume increases faster than surface area.

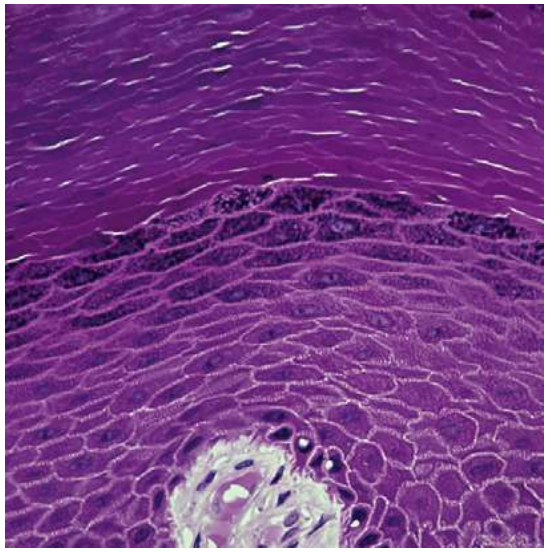
Relative size			
Surface area (length × width × number of sides)	6	24	54
Volume (length × width × height)	1	8	27
Ratio of surface area to volume	$\frac{6}{1}$ = 6:1	$\frac{24}{8}$ = 3:1	$\frac{54}{27}$ = 2:1

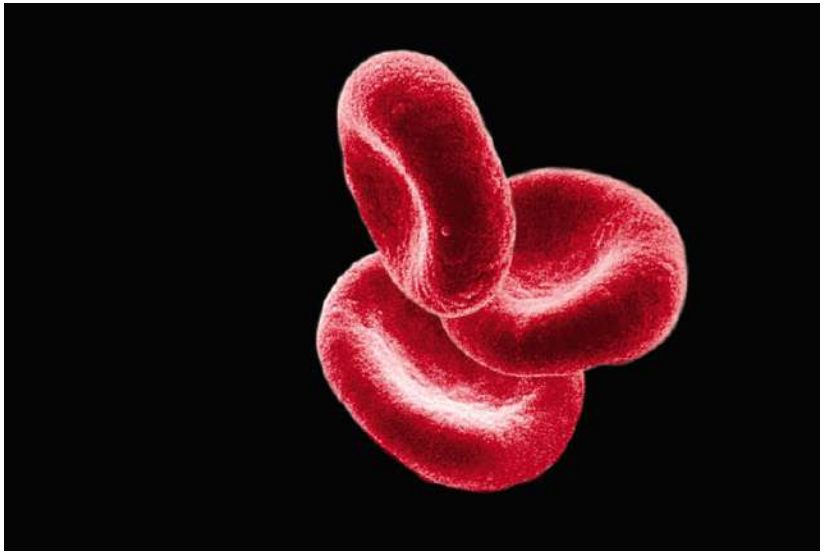
5.1 The Cell Cycle

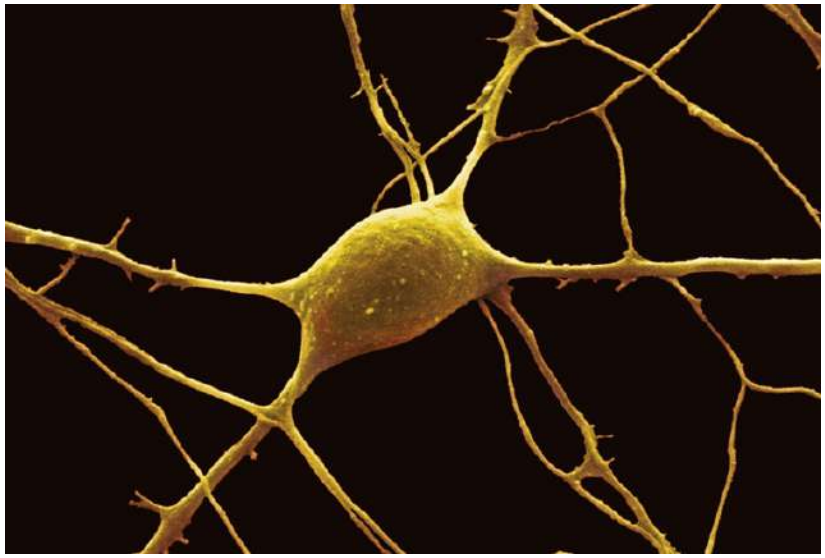
- Surface area must allow for adequate exchange of materials.

  Cell growth is coordinated with division.

  Cells that must be large have unique shapes.



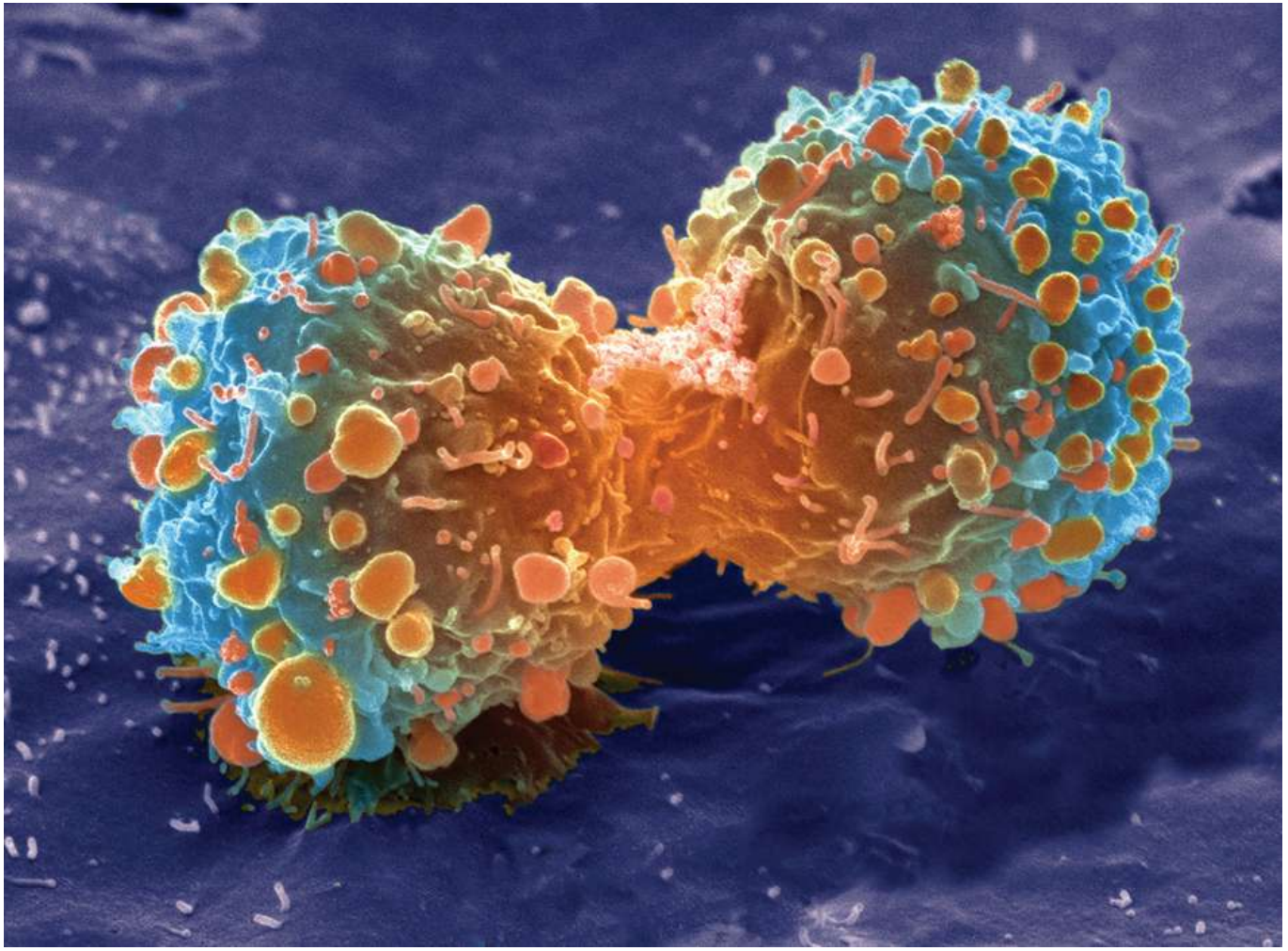




5.2 Mitosis & Cytokinesis

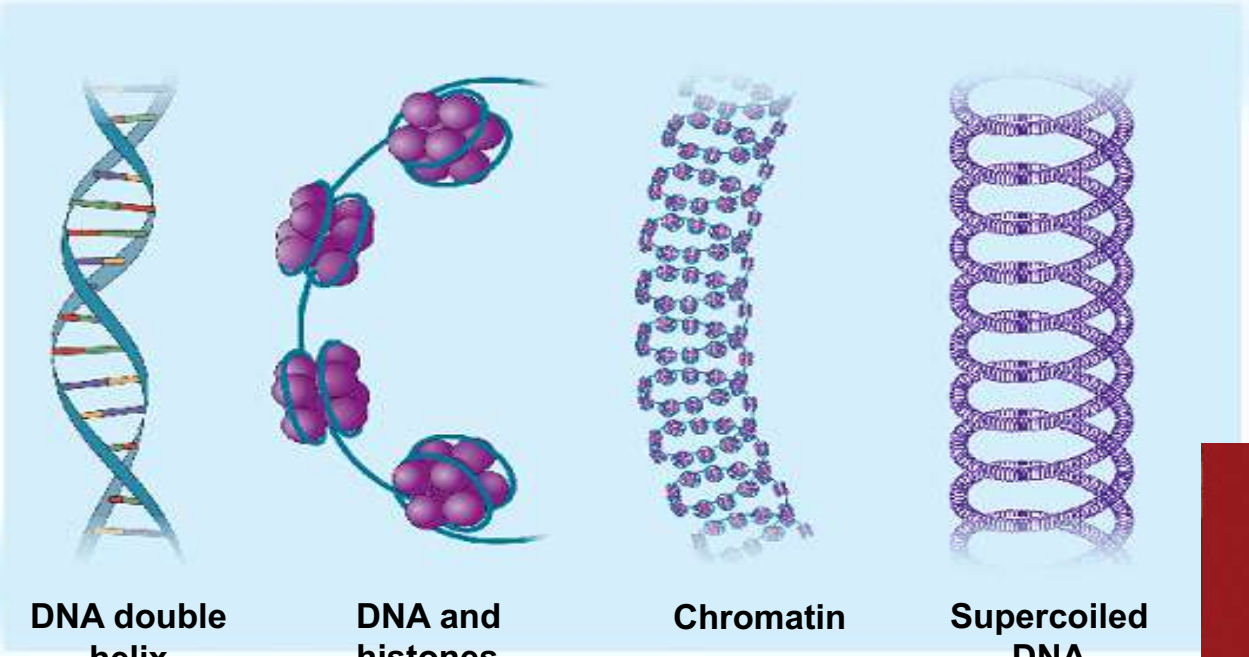
KEY CONCEPT

Cells divide during mitosis and cytokinesis.



Chromosomes condense at the start of mitosis.

- DNA wraps around proteins (histones) that condense it.

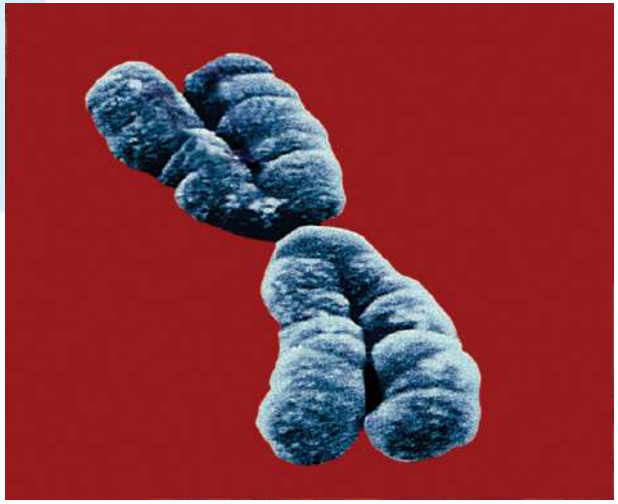


DNA double helix

DNA and histones

Chromatin

Supercoiled DNA



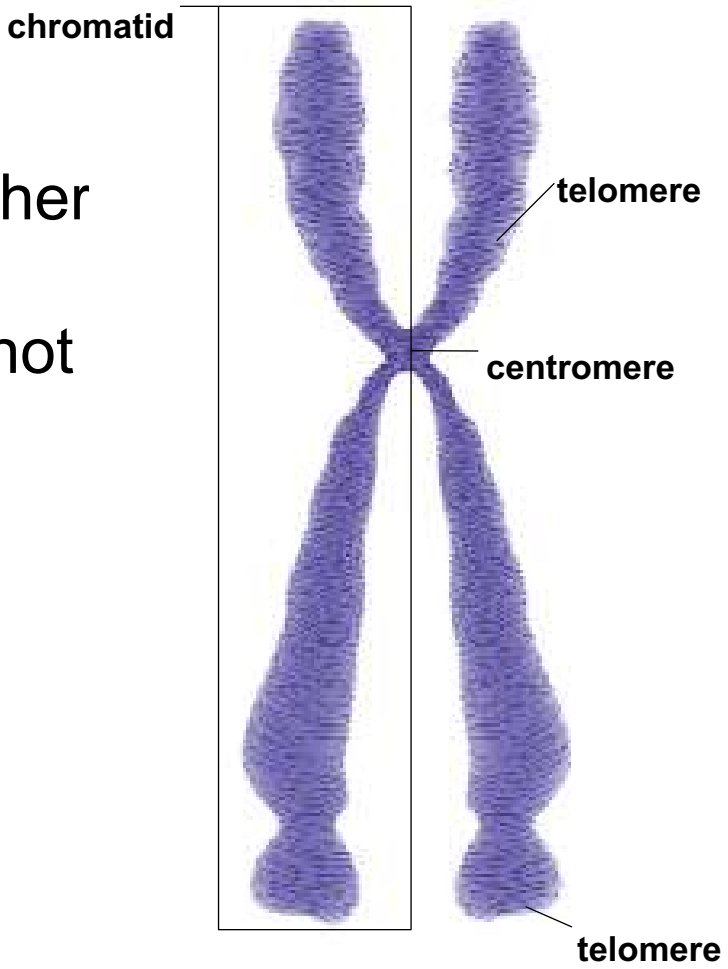
5.2 Mitosis & Cytokinesis

- DNA plus proteins is called chromatin.

One half of a duplicated chromosome is a chromatid.

Sister chromatids are held together at the centromere.

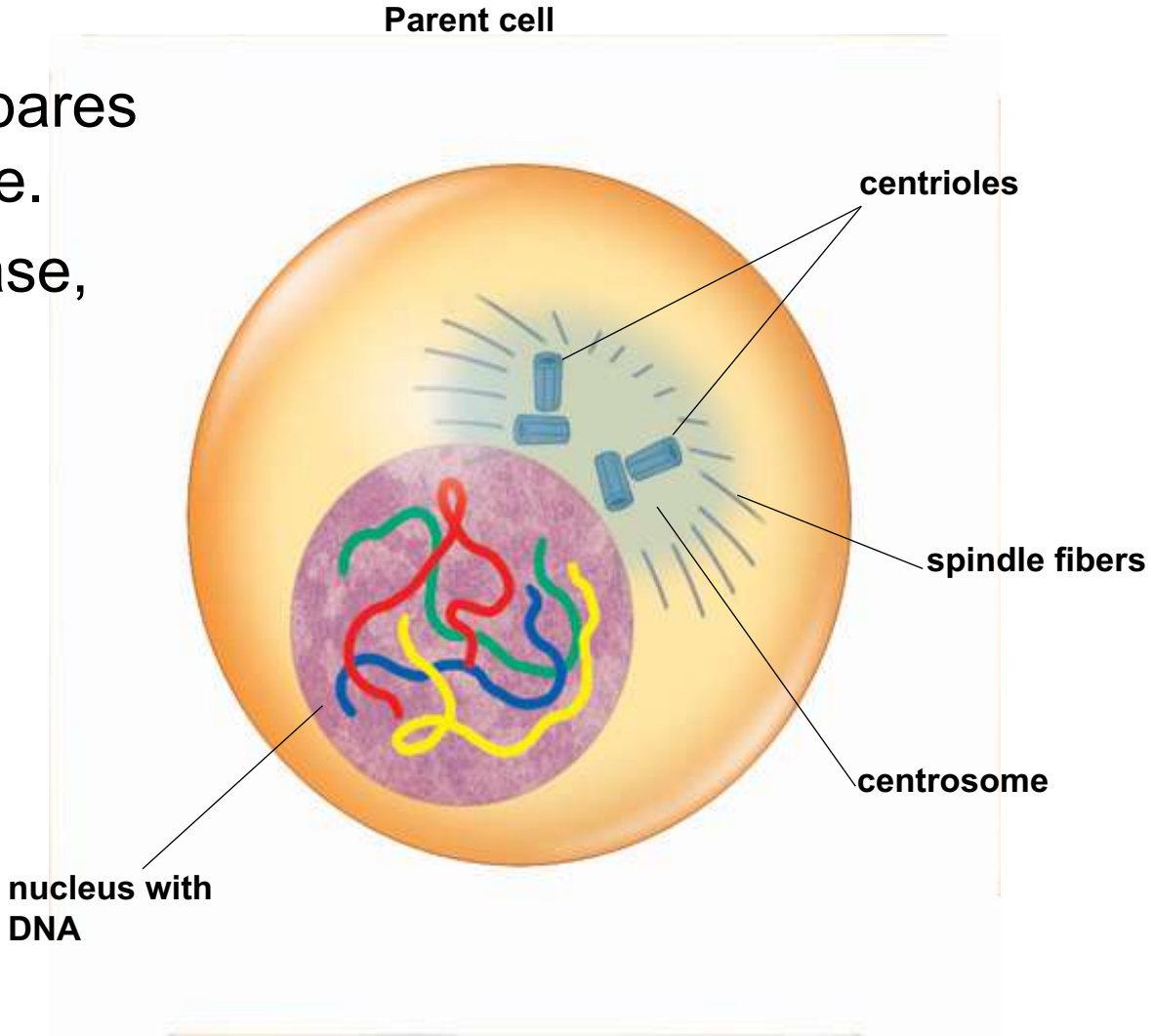
Telomeres protect DNA and do not include genes.



Condensed, duplicated chromosome

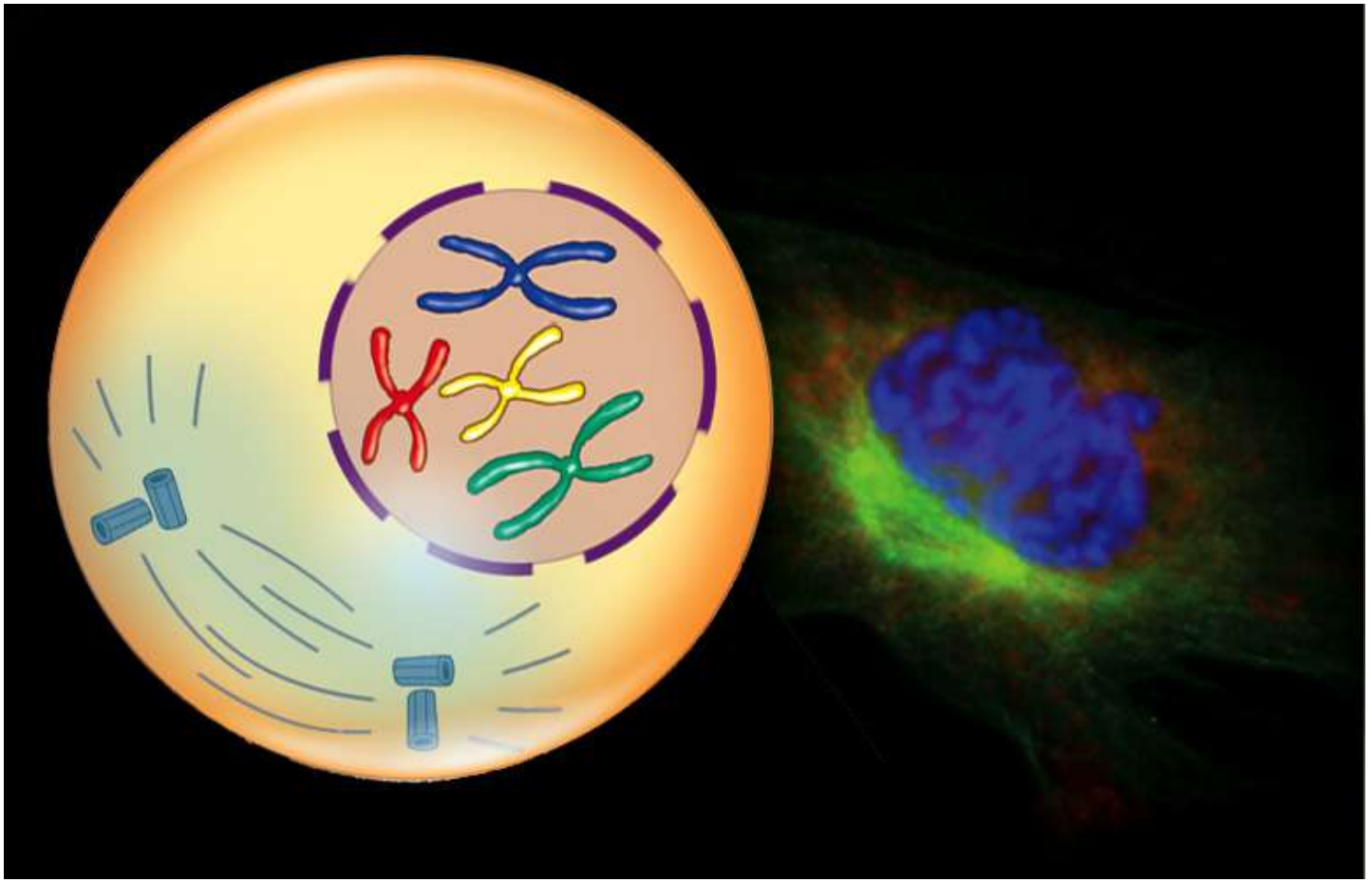
Mitosis and cytokinesis produce two genetically identical daughter cells.

- Interphase prepares the cell to divide.
- During interphase, the DNA is duplicated.



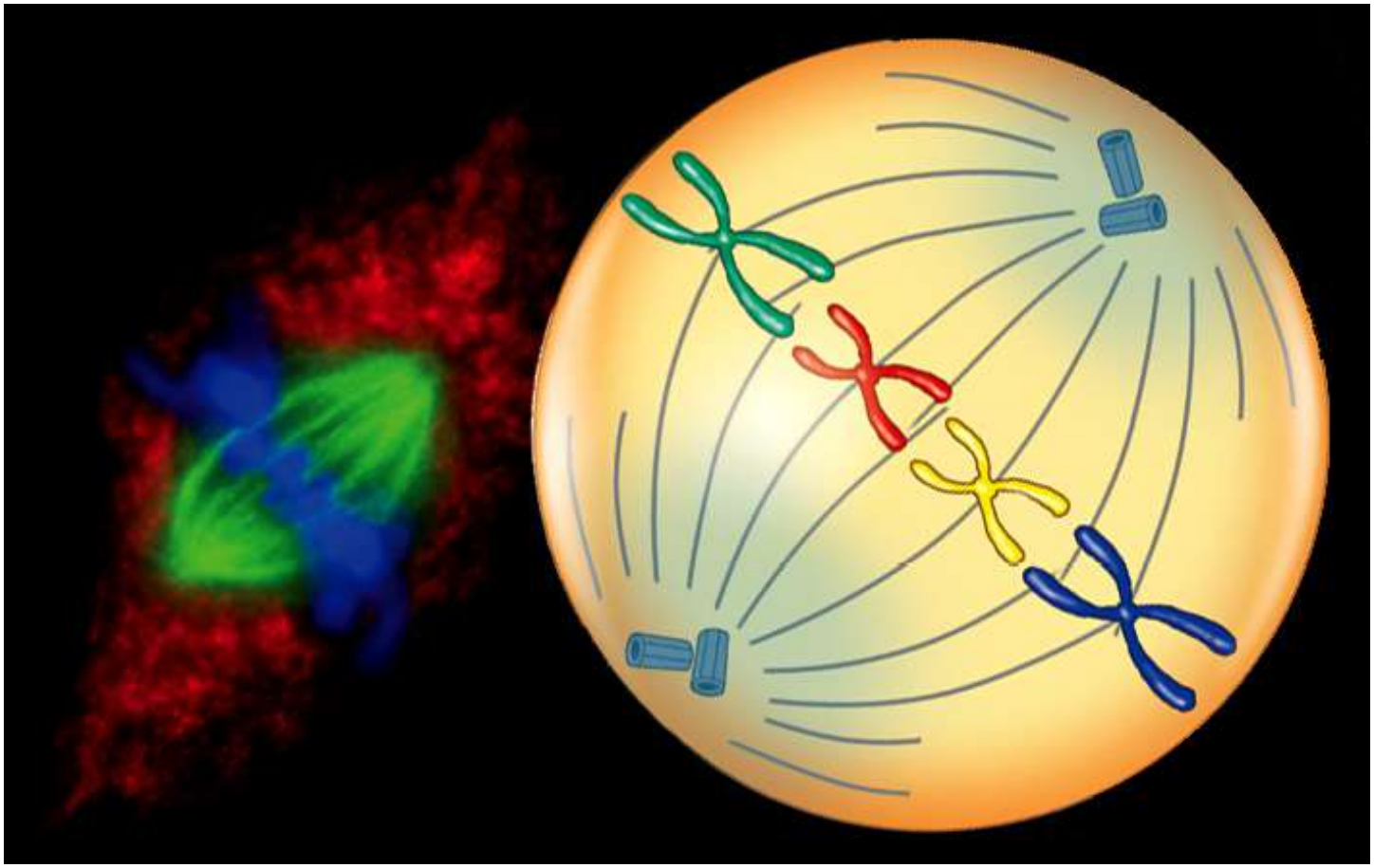
5.2 Mitosis & Cytokinesis

- Mitosis divides the cell's nucleus in four phases.
  During prophase, chromosomes condense and spindle fibers form.



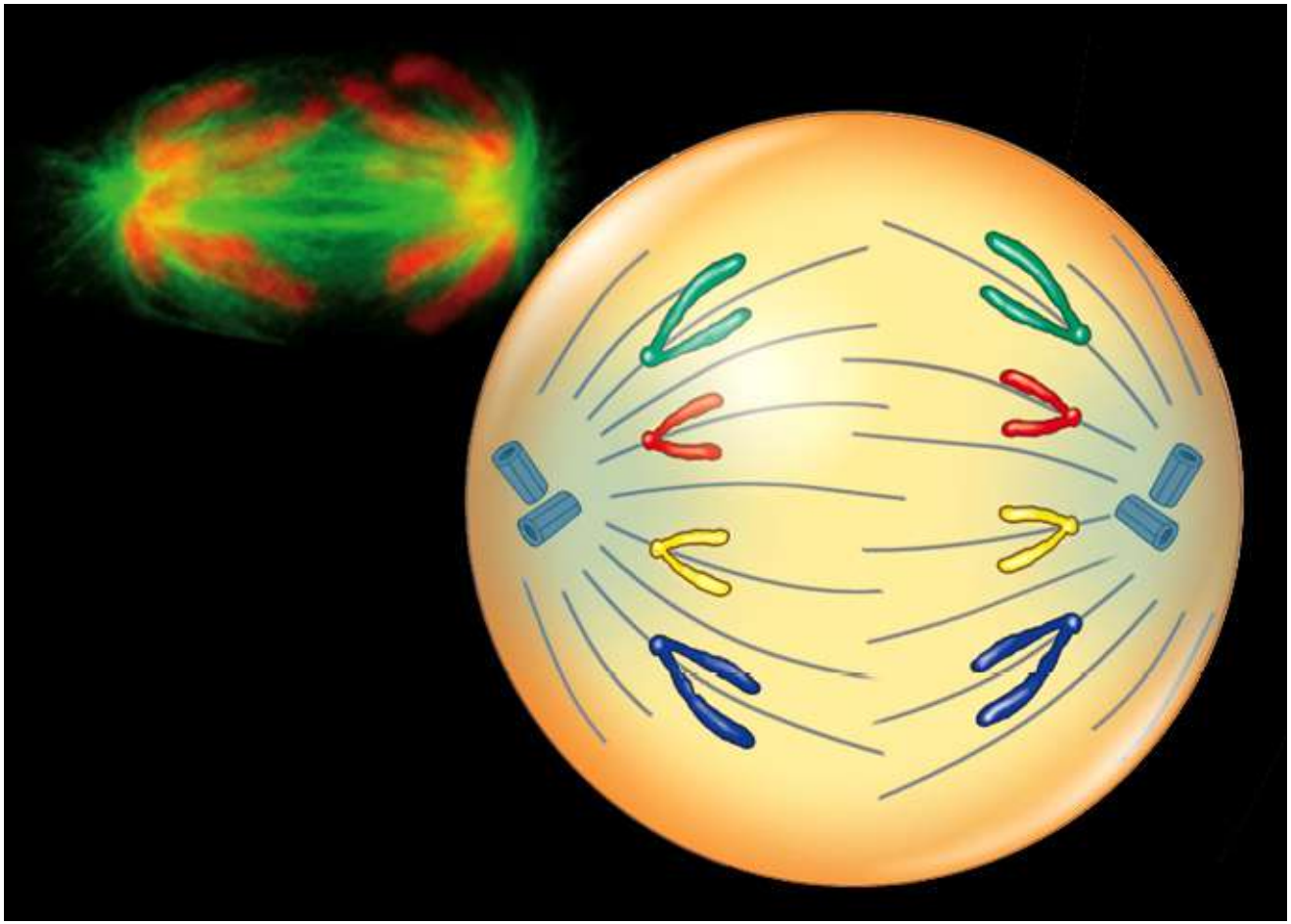
5.2 Mitosis & Cytokinesis

- Mitosis divides the cell's nucleus in four phases.
  During metaphase, chromosomes line up in the middle of the cell.



5.2 Mitosis & Cytokinesis

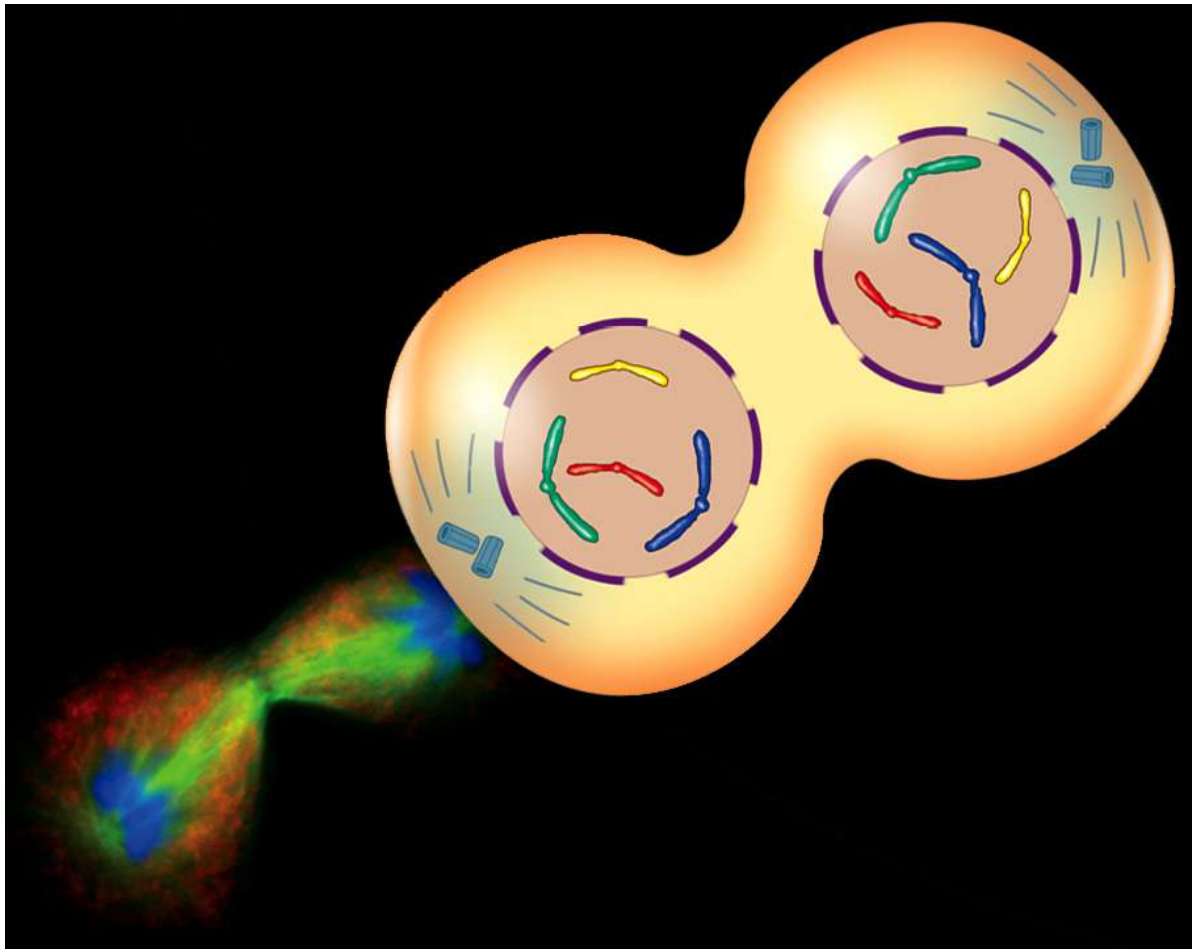
- Mitosis divides the cell's nucleus in four phases.
  During anaphase, sister chromatids separate to opposite sides of the cell.



5.2 Mitosis & Cytokinesis

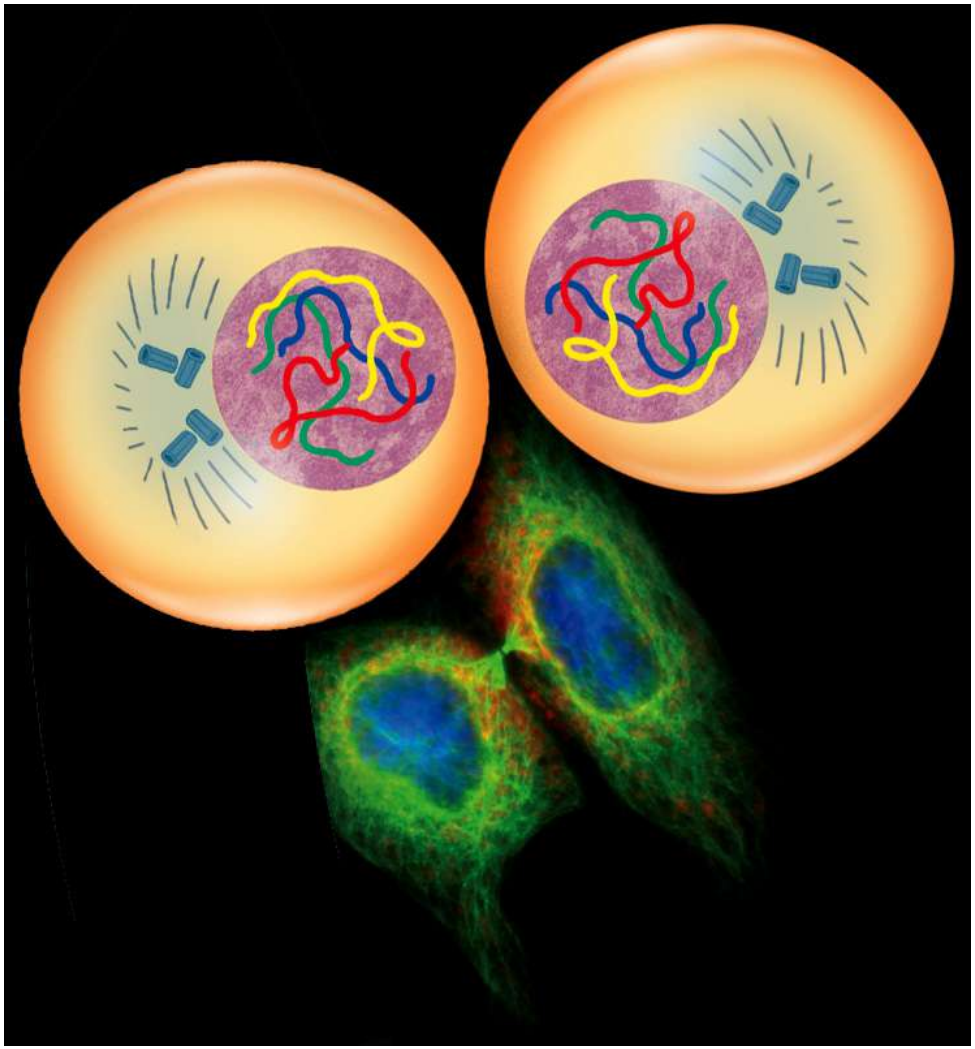
Mitosis divides the cell's nucleus in four phases.

During telophase, the new nuclei form and chromosomes begin to uncoil.



5.2 Mitosis & Cytokinesis

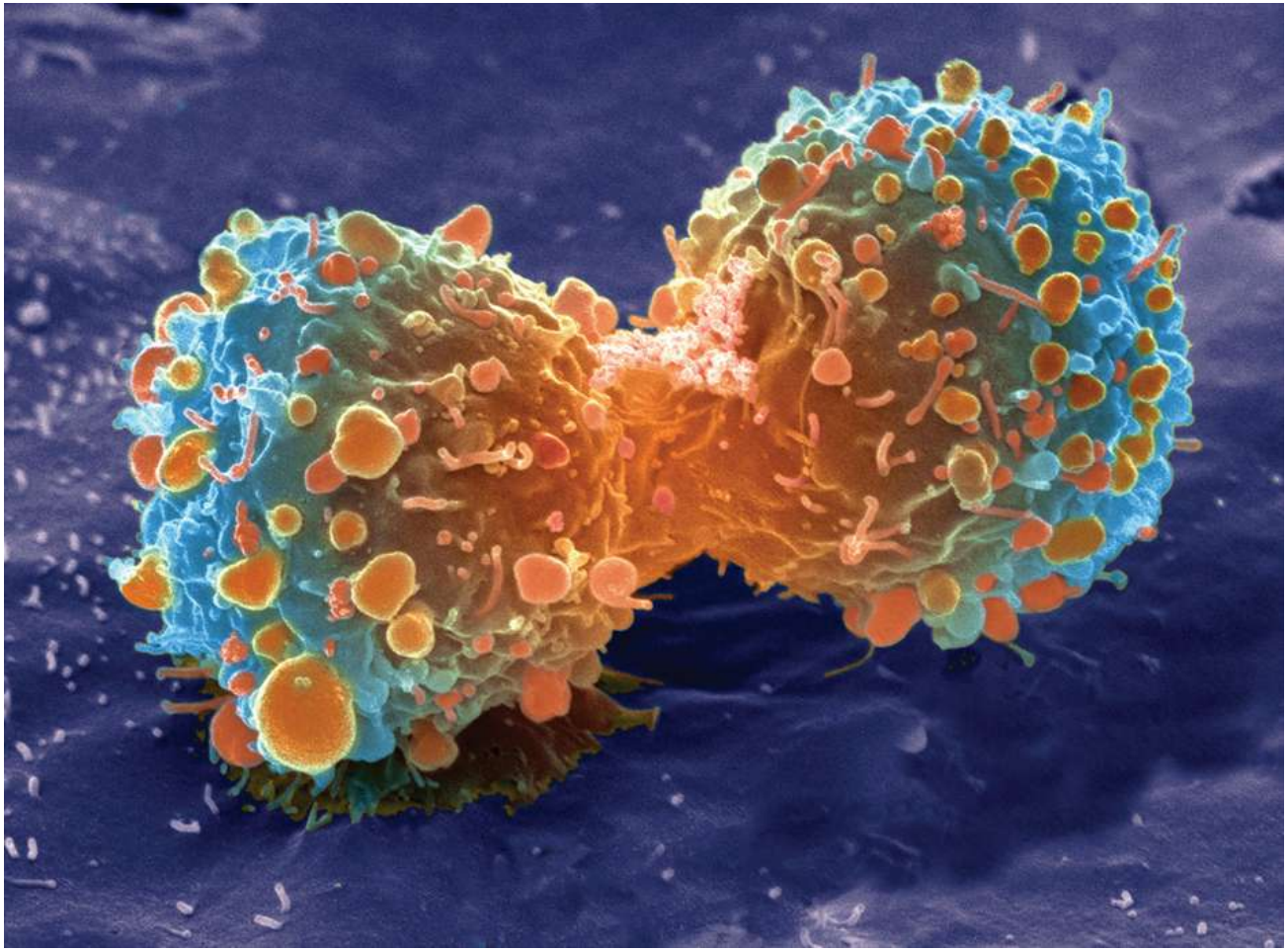
- Cytokinesis differs in animal and plant cells.
  - In animal cells, the membrane pinches closed.
  - In plant cells, a cell plate forms.



5.3 Regulation of the Cell Cycle

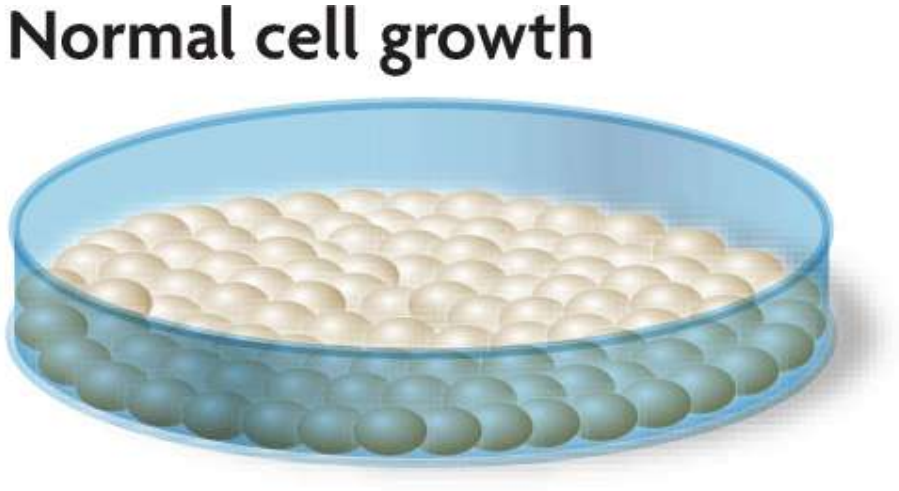
KEY CONCEPT

Cell cycle regulation is necessary for healthy growth.



Internal and external factors regulate cell division.

- External factors include physical and chemical signals.
- Growth factors are proteins that stimulate cell division.
  - Most mammal cells form a single layer in a culture dish and stop dividing once they touch other cells.



5.3 Regulation of the Cell Cycle

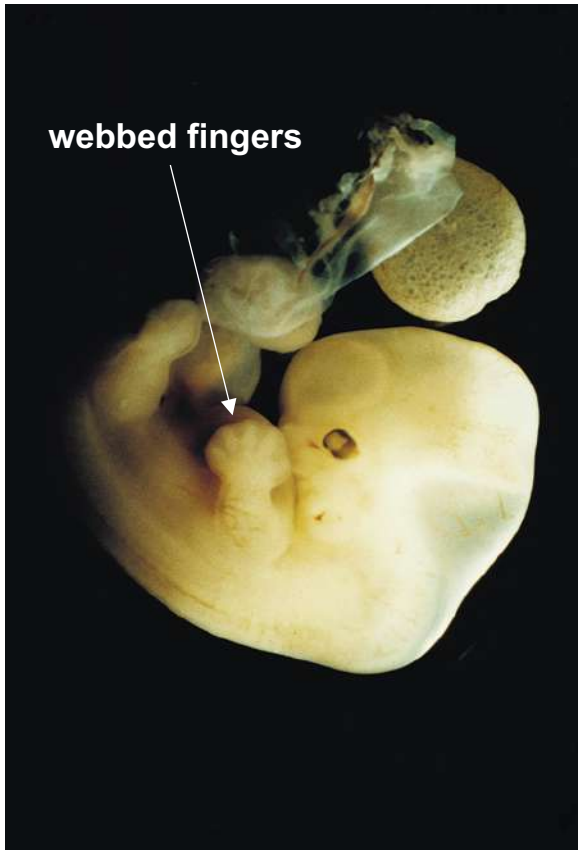
- Two of the most important internal factors are kinases and cyclins.

External factors trigger internal factors, which affect the cell cycle.

5.3 Regulation of the Cell Cycle

Apoptosis is programmed cell death.

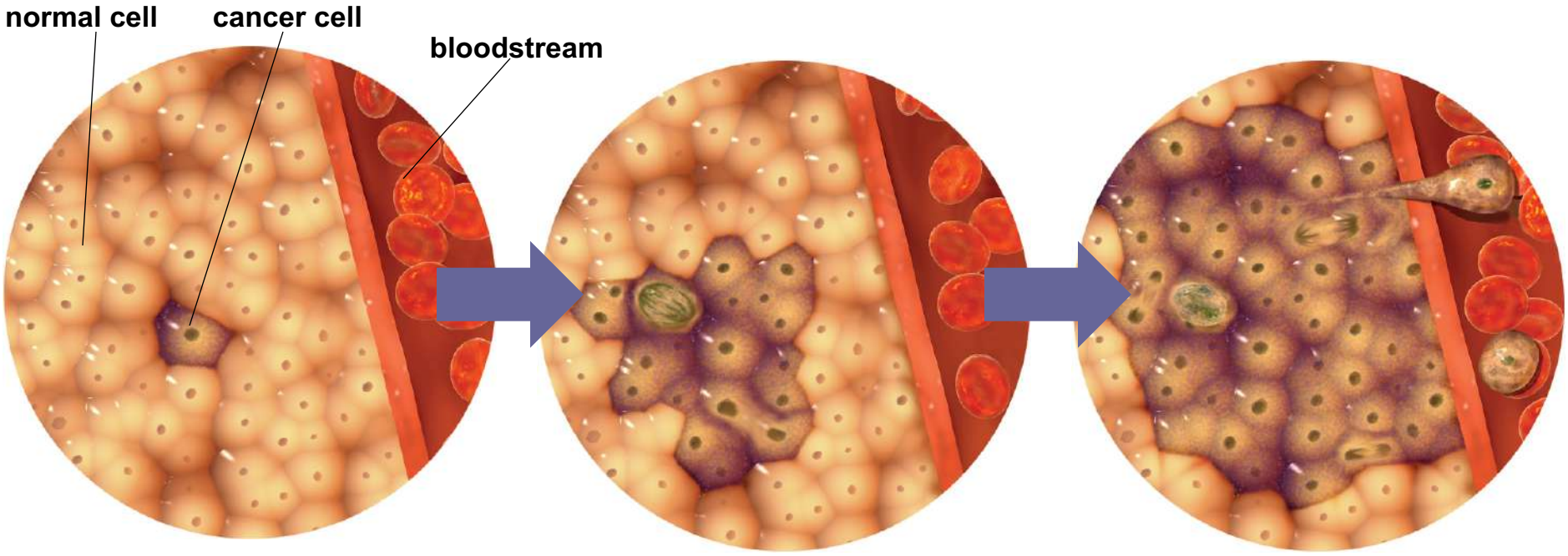
- a normal feature of healthy organisms
- caused by a cell's production of self-destructive enzymes
- occurs in development of infants



Cell division is uncontrolled in cancer.

- Cancer cells form disorganized clumps called tumors.

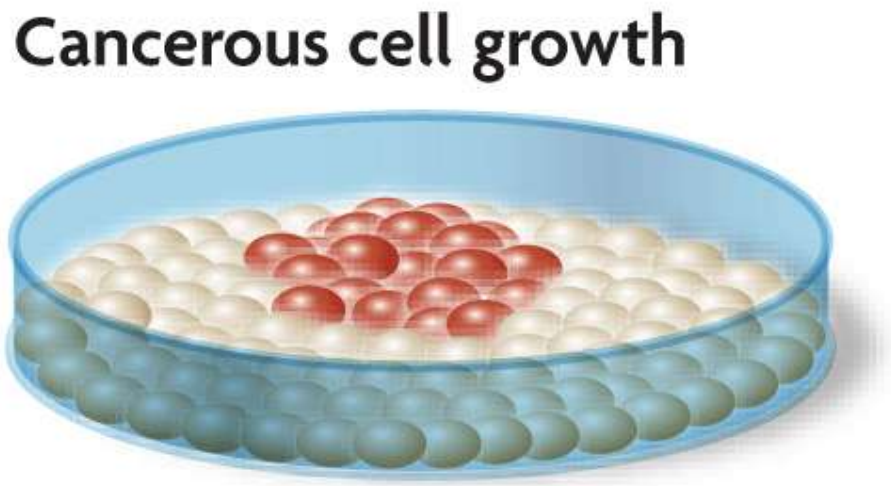
  Benign tumors remain clustered and can be removed.
  Malignant tumors metastasize, or break away, and can form more tumors.



5.3 Regulation of the Cell Cycle

- Cancer cells do not carry out necessary functions.

Cancer cells come from normal cells with damage to genes involved in cell-cycle regulation.



5.3 Regulation of the Cell Cycle

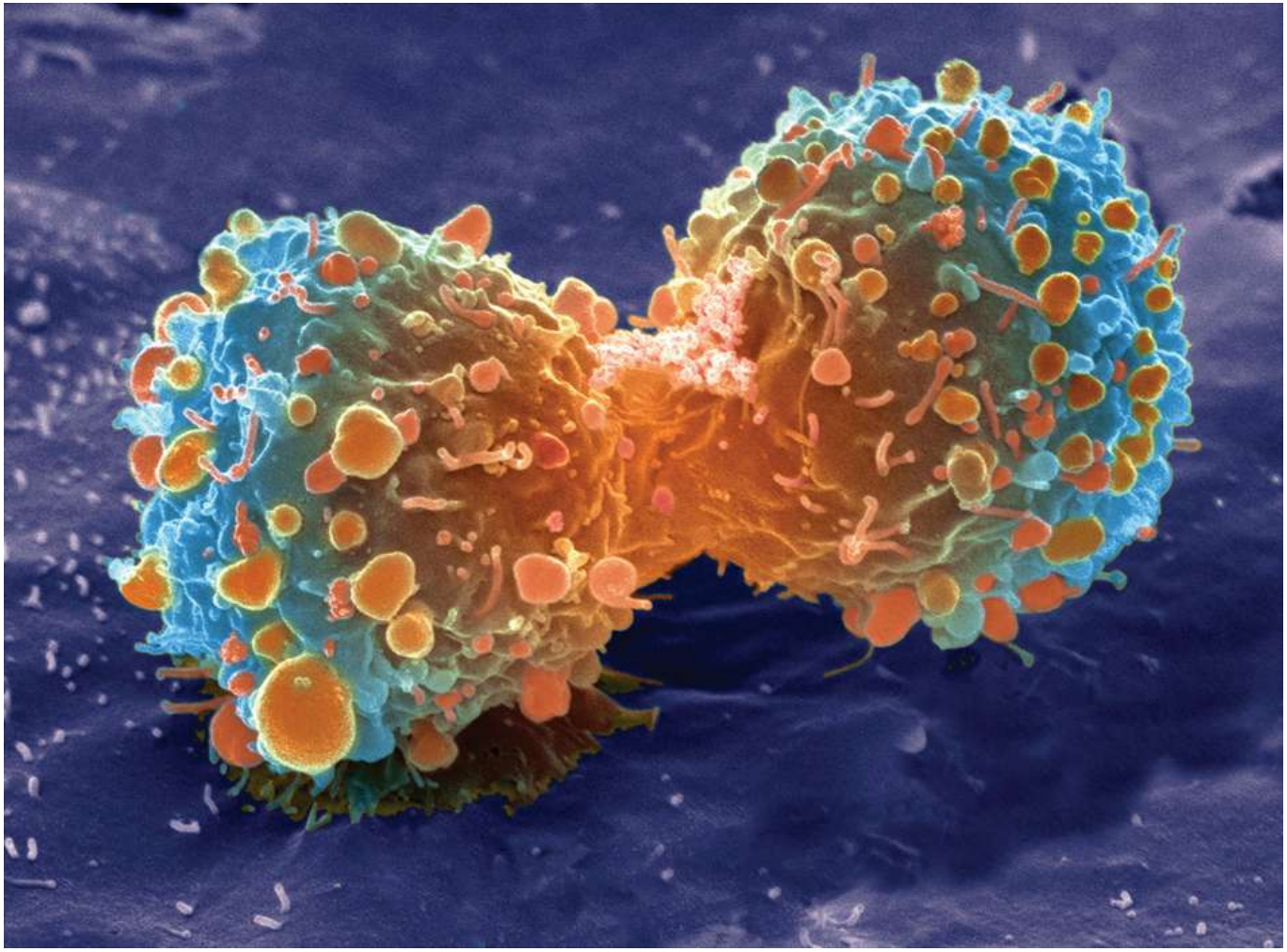
- Carcinogens are substances known to promote cancer.

Standard cancer treatments typically kill both cancerous and healthy cells.

5.4 Asexual Reproduction

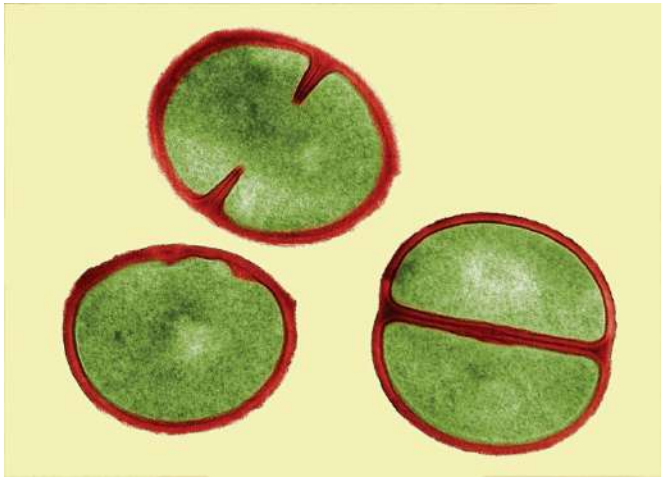
KEY CONCEPT

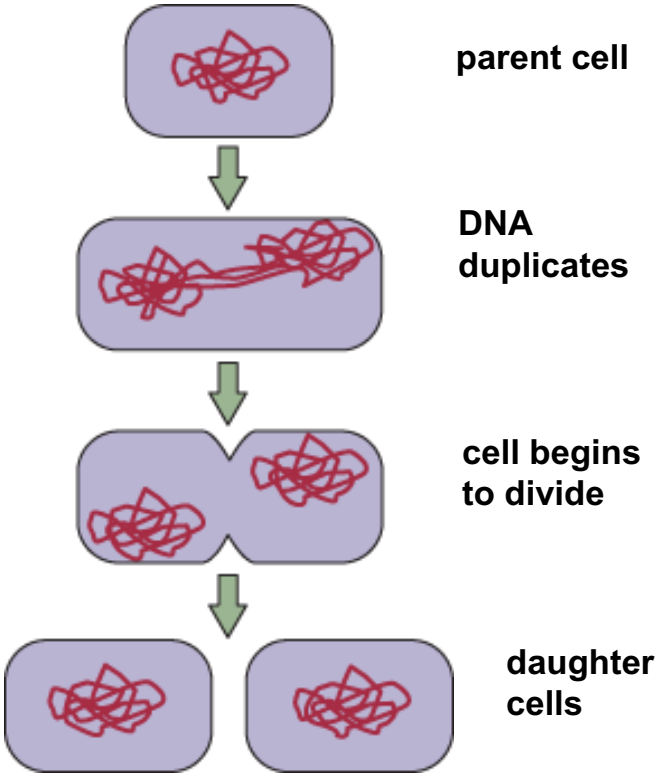
Many organisms reproduce by cell division.



Binary fission is similar in function to mitosis.

- Asexual reproduction is the creation of offspring from a single parent.
  - Binary fission produces two daughter cells genetically identical to the parent cell.
  - Binary fission occurs in prokaryotes.



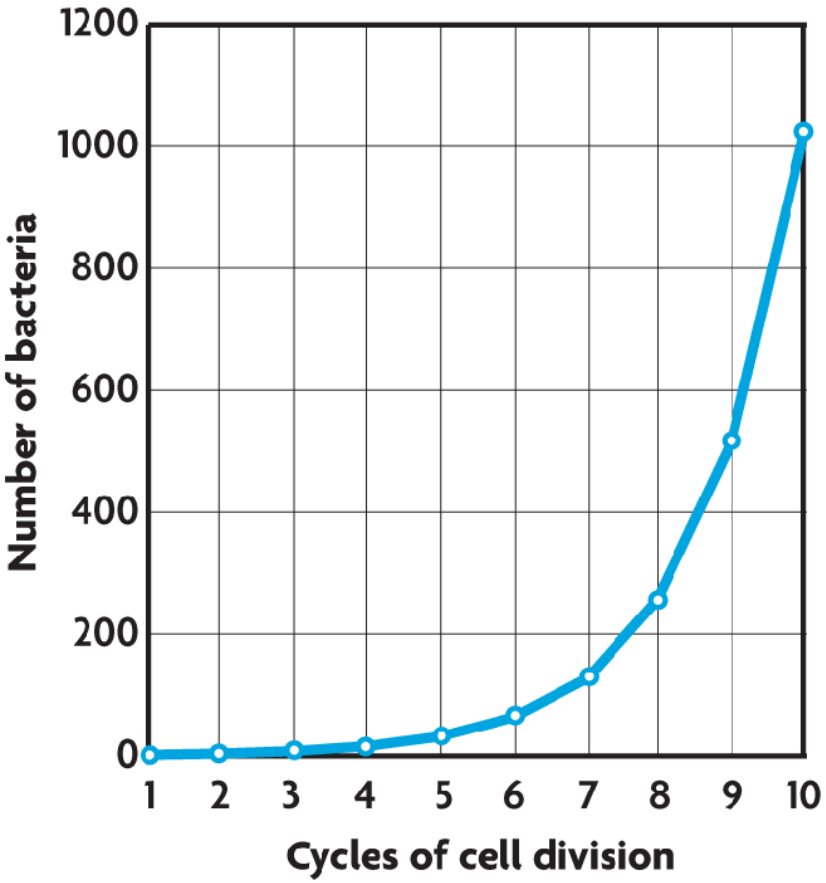


5.4 Asexual Reproduction

- Environment determines what form of reproduction is most advantageous.

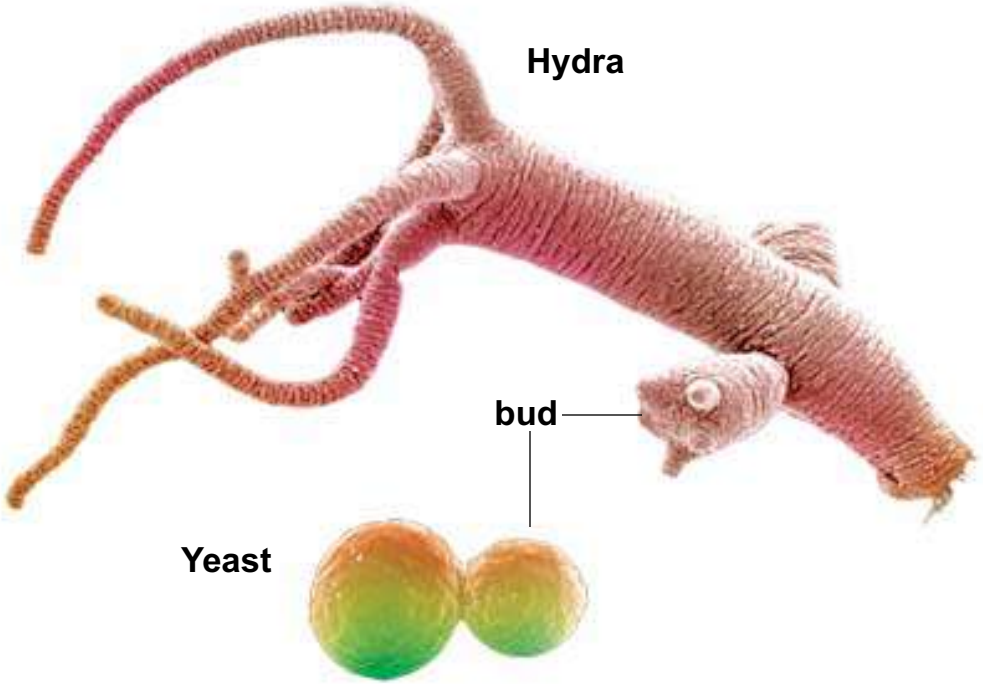
  Asexual reproduction is an advantage in consistently favorable conditions.

  Sexual reproduction is an advantage in changing conditions.



Some eukaryotes reproduce through mitosis.

- Budding forms a new organism from a small projection growing on the surface of the parent.



5.4 Asexual Reproduction

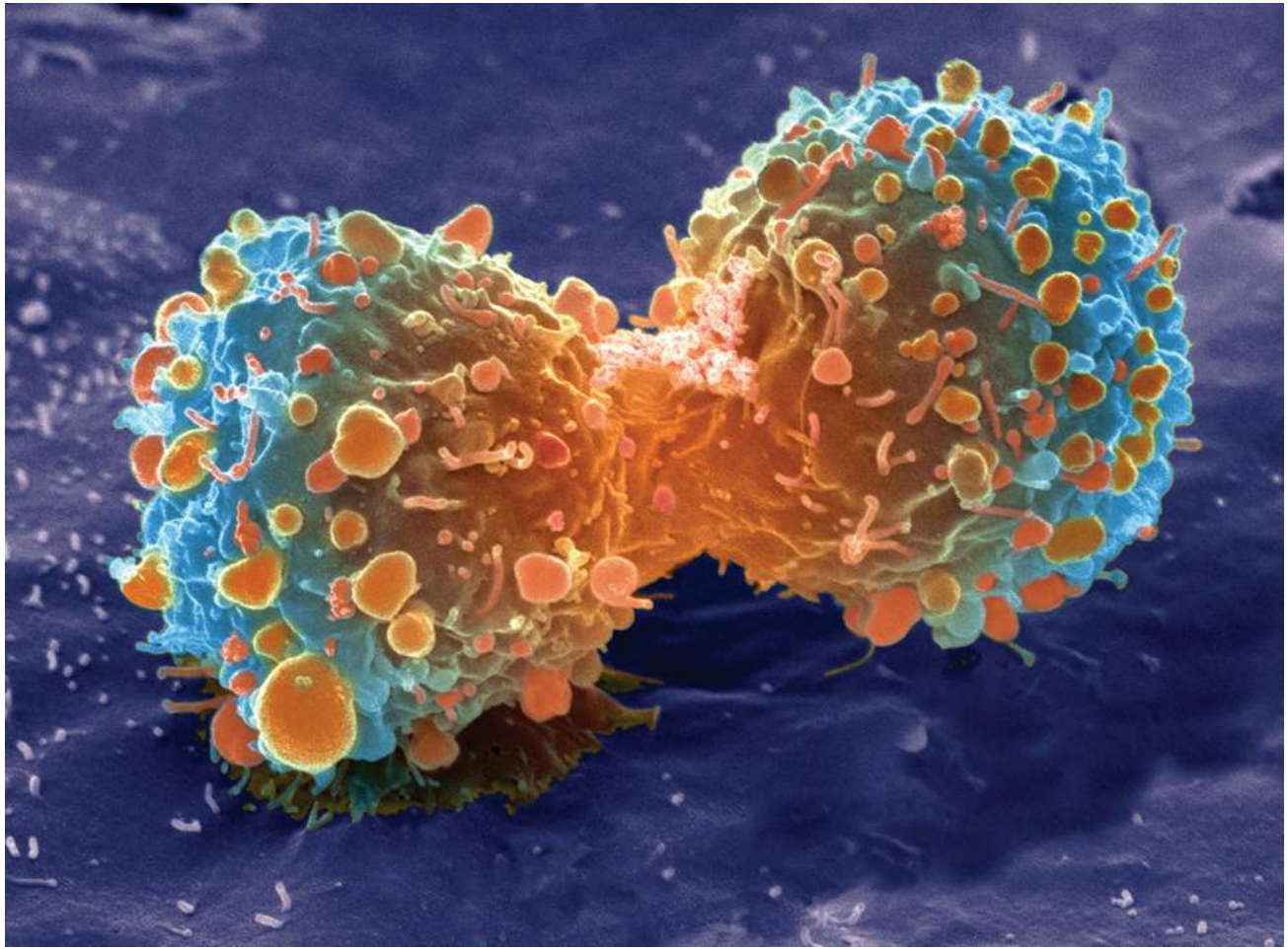
- Fragmentation is the splitting of the parent into pieces that each grow into a new organism.

Vegetative reproduction forms a new plant from the modification of a stem or underground structure on the parent plant.

5.5 Multicellular Life

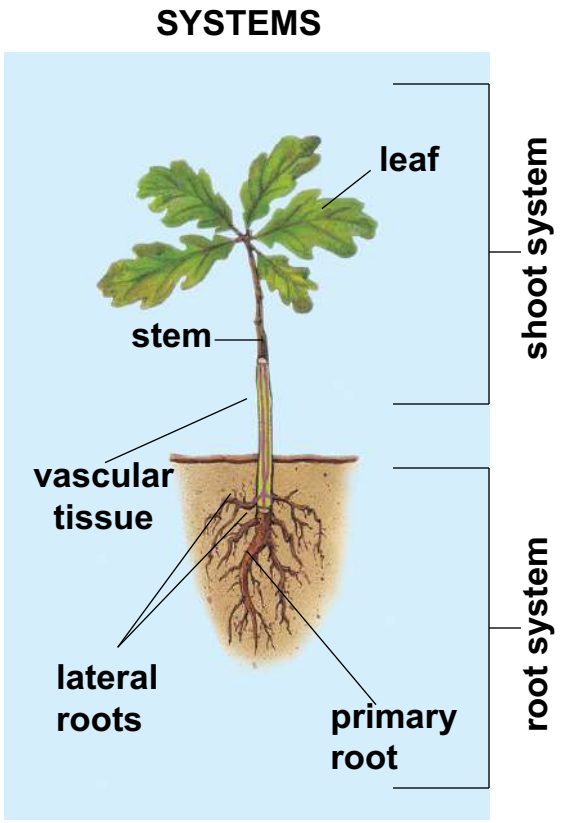
KEY CONCEPT

Cells work together to carry out complex functions.

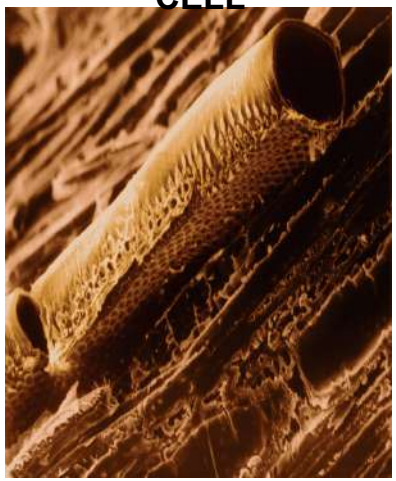


Multicellular organisms depend on interactions among different cell types.

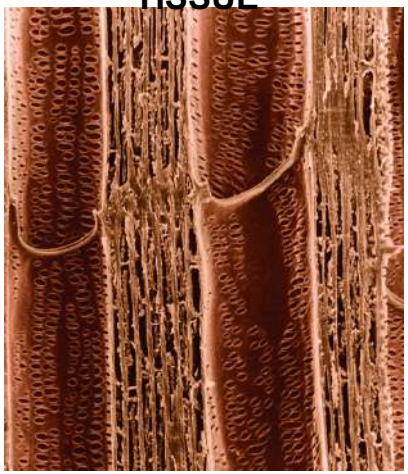
- Tissues are groups of cells that perform a similar function.
- Organs are groups of tissues that perform a specific or related function.
- Organ systems are groups of organs that carry out similar functions.



CELL



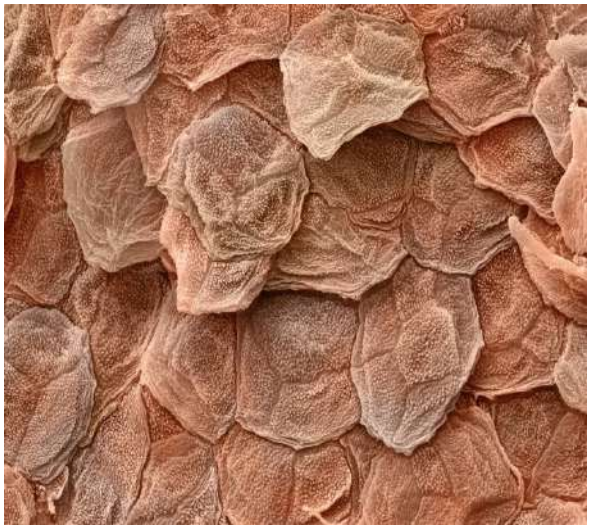
TISSUE



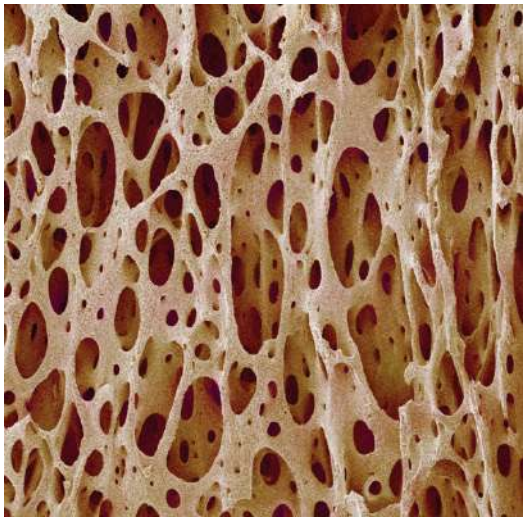
ORGAN

Specialized cells perform specific functions.

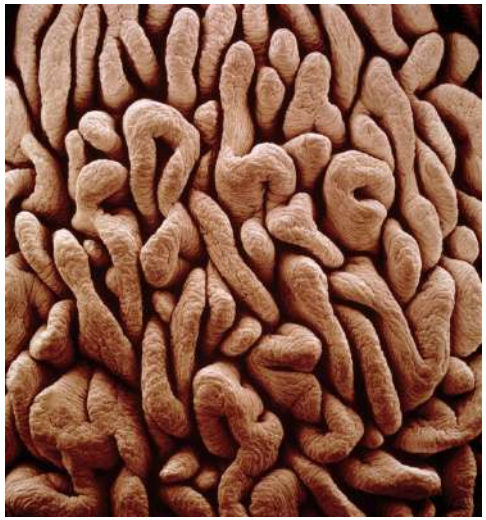
- Cells develop into their mature forms through the process of cell differentiation.
- Cells differ because different combinations of genes are expressed.
- A cell's location in an embryo helps determine how it will differentiate.



Outer: skin cells



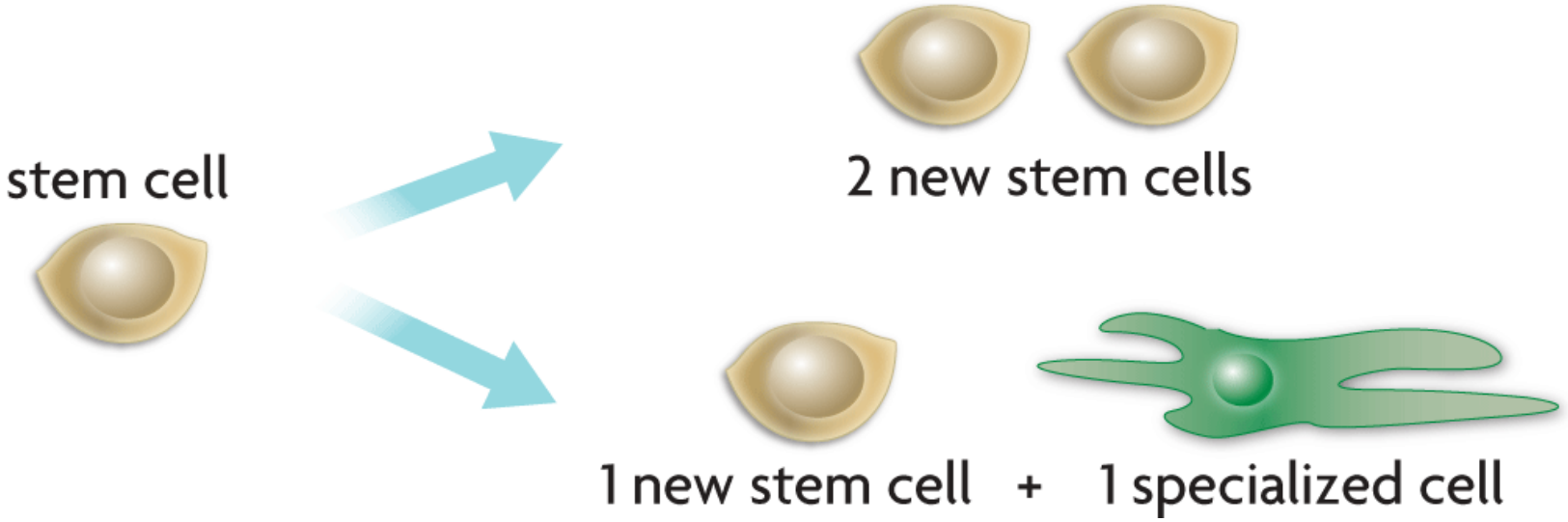
Middle: bone cells



Inner: intestines

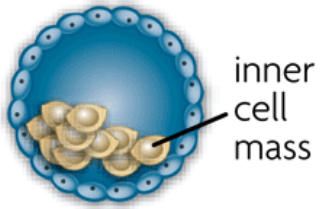
Stem cells are unique body cells.

- Stem cells have the ability to
  - divide and renew themselves
  - remain undifferentiated in form
  - develop into a variety of specialized cell types



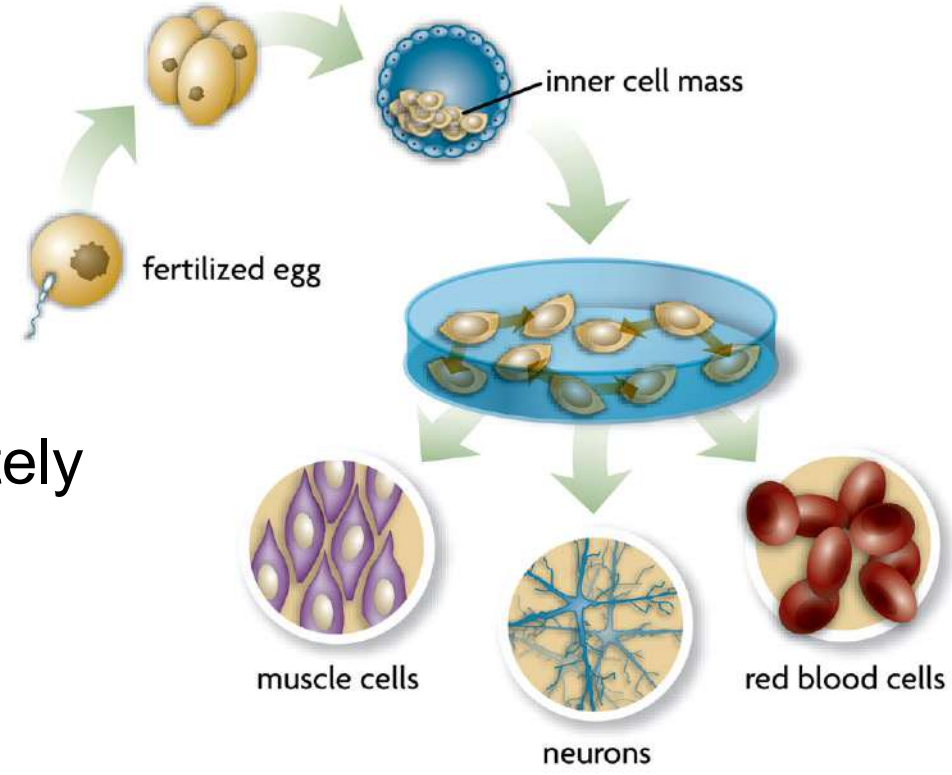
5.5 Multicellular Life

- Stem cells are classified into three types.
  totipotent, or growing into any other cell type
  pluripotent, or growing into any cell type but a totipotent cell
  multipotent, or growing into cells of a closely related cell family

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

5.5 Multicellular Life

- Stem cells come from adults and embryos.
  - Adult stem cells can be hard to isolate and grow.
  - The use of adult stem cells may prevent transplant rejection.
  - The use of embryonic stem cells raises ethical issues
  - Embryonic stem cells are pluripotent and can be grown indefinitely in culture.



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.

5.5 Multicellular Life

- The use of stem cells offers many currently realized and potential benefits.
  Stem cells are used to treat leukemia and lymphoma.
  Stem cells may cure disease or replace damaged organs.
  Stem cells may revolutionize the drug development process.