Mitosis

Introduction

•Sexual reproduction involves passing traits from parents to the next generation.

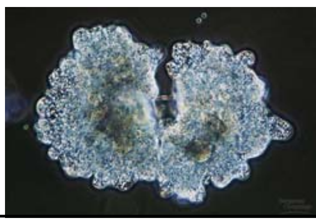
•Asexual reproduction involves passing traits from only one parent to the next generation.

•Cell division is the basis of all the processes (developmental or reproductive) that link phases in a life cycle.

Like begets like, more or less

•This is strictly true only for organisms reproducing asexually.

•Single-celled organisms, like protozoans, can reproduce asexually by dividing into two. Each daughter cell receives an identical copy of the parent's genes.



•For multicellular organisms (and many single-celled organisms), the offspring are not genetically identical to the parents, but each is a unique combination of the traits of both parents.

•Breeders of plants and animals manipulate sexual reproduction to get desired traits.

Cell arise only from preexisting cells

•This principle was formulated in 1858 by German physician Rudolf Virchow.

•Cell reproduction is called cell division.

Cell reproduction has two major roles:

(1) It allows a fertilized egg to develop through various embryonic stages, and an embryo to develop into an adult.

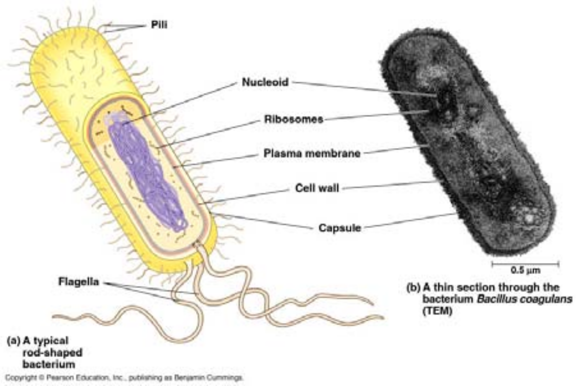
(2) It ensures the continuity from generation to generation.

Prokaryotes reproduce by binary fission

•Genes of most prokaryotes are carried on a circular DNA molecule. Prokaryotic chromosomes are simpler than eukaryotic chromosomes.

•Packaging is minimal: The DNA is complexed with a few proteins and attached to the plasma membrane at one point.

•Most of the DNA lies non-membrane-bounded, in the center of the cell.



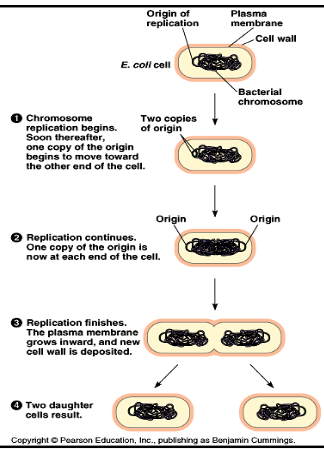
Binary fission:

(1) Prior to dividing an exact copy of the chromosome is made.

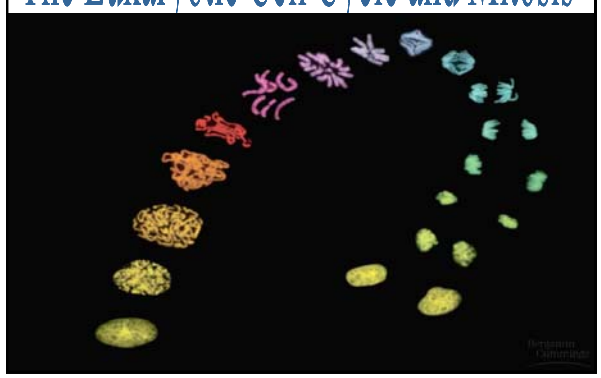
(2) The attachment point divides so that two new chromosomes are attached at separate parts of the plasma membrane.

(3) As the cell elongates the new plasma membrane is added, the attachment points of the two chromosomes move apart.

(4) Finally, the plasma membrane and new cell wall "pinch" through the cell, separating the two chromosomes into two genetically identical cells.



The Eukaryotic Cell Cycle and Mitosis



The large complex chromosomes of eukaryotes duplicate with each cell division

•Whereas a typical bacterium might have 3000 genes, human cells, for example, have 50,000-100,000.

•The majority of these genes are organized into several separate, linear chromosomes that are found inside the nucleus.

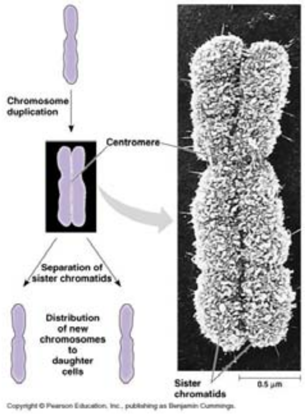
•The DNA in eukaryotic chromosomes is complexed with protein in a much more complicated manner. This organizes and allows expression of much greater numbers of genes.

•During the process of cell division, chromatin condenses and the chromosomes become visible under the light microscope.

•In multicellular plants and animals, the body cells (somatic cells) contain twice the number of chromosomes as the sex cells. Humans have 46 chromosomes in their somatic cells and 23 chromosomes in their sex cells.

•The DNA molecule in each chromosome is copied prior to the chromosomes' becoming visible.

•As the chromosomes become visible, each is seen to be composed of two identical sister chromatids, attaches at the centromere.



•It is the sister chromatid that are parceled out to the daughter cells (the chromatids are then referred to as chromosomes). Each new cell gets a complete set of identical chromosomes.

The cell cycle multiplies cells

•Most cells in growing, and fully grown, organisms divide on a regular basis (once an hour, once a day), although some have stopped dividing. This process allows organisms to replace worn-out or damaged cells.

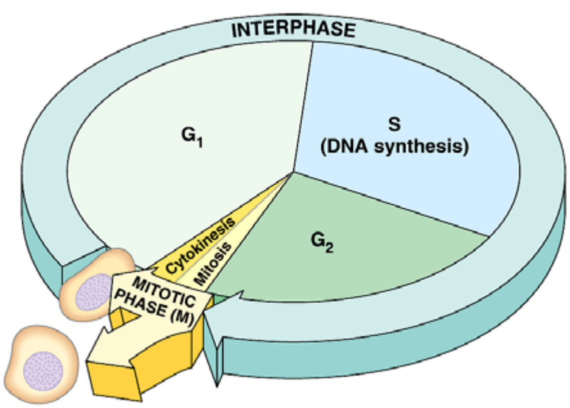
•Such dividing cells undergo a cycle, a sequence of steps that is repeated from the time of one division to the time of the next.

•**Interphase** represents 90% or more of the total cycle time and is divided into $\mathbf{G_1}$, **S**, and $\mathbf{G_2}$ subphase.

•During $\mathbf{G_1}$, the cell increases its supply of proteins and organelles and grows in size.

•During **S**, DNA synthesis (replication) occurs.

•During $\mathbf{G_2}$, the cell continues to prepare for the actual division, increasing supply of other proteins, particularly those used in the process.



•Cell division itself is called the mitotic phase (it excludes interphase) and involves to subprocesses, **mitosis** (nuclear division, the **M phase**) and **cytokinesis** (cytoplasmic division).

•The overall result is two daughter cells, each with identical sets of chromosomes.

•Mitosis is very accurate. In yeasts, one error occurs every 100,000 divisions.

Cell division is a continuum of dynamic changes

Interphase: duplication of genetic material; ends when chromosomes become visible.

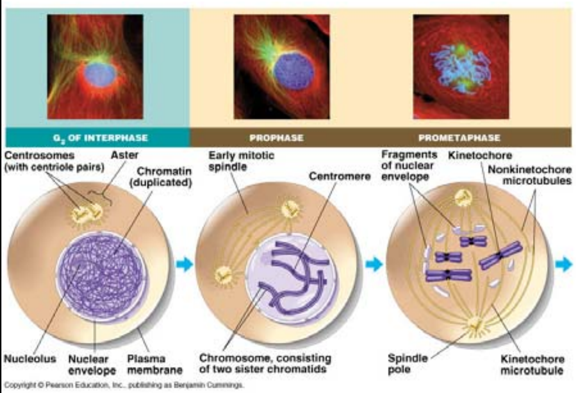
Prophase (the first stage of mitosis): mitotic spindle is forming, emerging from centrosomes (**MTOCs**). Prophase ends when chromatin has completely coiled into chromosomes; nucleoli and and nuclear membrane disperse. The mitotic spindle provides a scaffold for the movement of chromosomes and attaches to chromosomes at their kinetichore.

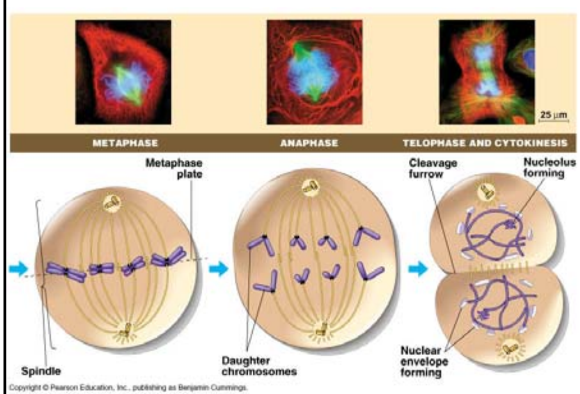
Metaphase: spindle fully formed; chromosomes are aligned single file with centromeres on the metaphase plate (equator).

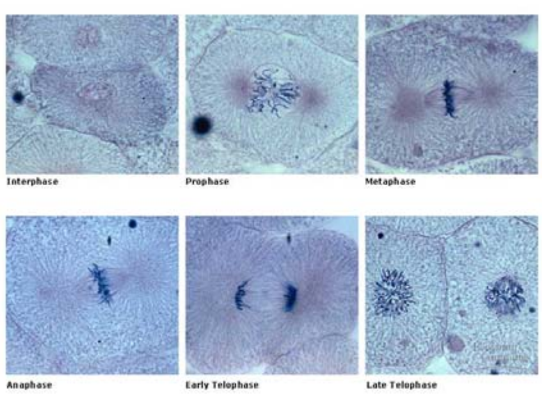
Anaphase: chromosome separation, from centromere dividing to arrival at poles.

Telophase: the reverse of prophase.

Cytokinesis: the division of the cytoplasm, usually but not always accompanies telophase.



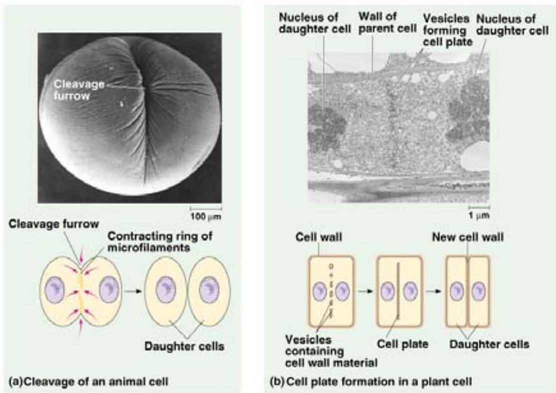




Cytokinesis differs for plant and animal cells

•In animals, a ring of microfilaments contacts around the periphery of the cell, forming a **cleavage furrow** that eventually cleaves the cytoplasm.

•In plants, vesicles containing cell wall materials collect among the spindle microtubules, in the center of the cell, then gradually fuse, from the inside out, forming a **cell plate**.

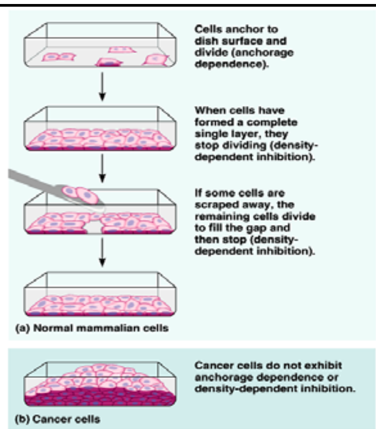


Anchorage, cell density, and chemical growth factors affect cell division

•To grow and develop, or replenish and repair tissues, multicellular plants and animals must control when and where cell divisions take place.

•Most animals and plant cells will not divide unless they are in contact with a solid surface; this is known as **anchorage dependence**.

•Laboratory studies show that cells usually stop dividing when a single layer is formed and the cells touch each other. This **density-dependent inhibition** of cell growth is controlled by the depletion of growth factor proteins in masses of crowded cells.



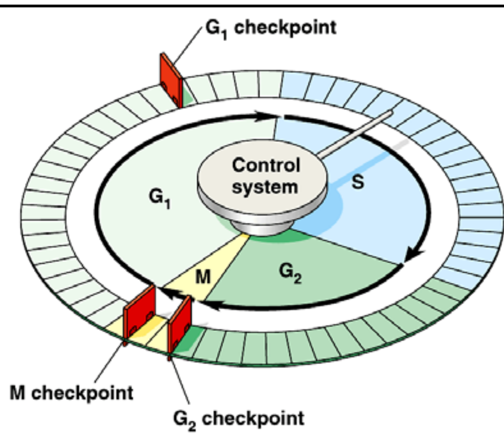
Growth factors signal the cell-cycle control system

•The cell-cycle control system regulates the events of the cell cycle. Three major checkpoints exist.

(a) at $\mathbf{G_1}$ of interphase
(b) at $\mathbf{G_2}$ of interphase
(c) at the **M** phase

•This regulation is a type of **signal transduction**.

•If, at these checkpoints, a growth factor is released, the cell cycle will continue. If a growth factor is not released, the cell cycle will stop.

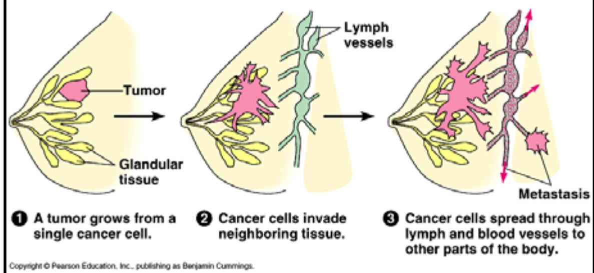


Growing out of control, cancer cells produce malignant tumors

•*Cancer* is a general term for many diseases in many animals and plants involving uncontrolled cell division with the resultant tumor **metastasizing**.

•Cancer cells grown in culture are not affected by the growth factors that regulate density-dependent inhibition of cell division.

•A **malignant tumor** consists of cancerous cells. These tumors metastasize.



- **Benign tumors** do not metastasize.
- Cancers are named according to the tissue or organ of origin.
- Usually, cancer cells do not exhibit density-dependent inhibition.
- Some cancer cells divide even in the absence of growth factors.
- Some cancer cells actually continually synthesize factors that keep them dividing.

- Radiation and chemotherapy are two treatments for cancer.
- **Radiation** disrupts the process of cell division, and since cancer cells divide more often than normal cells, they are more likely to be affected by radiation.
- **Chemotherapy** involves drugs that disrupt cell division.

  i.e.- ***Taxol*** targets mitotic spindles.