General Zoology **Lecture 3**

Cell Division

- During cell division, the two "daughter" cells that result are genetically identical (duplicates its chromosomes = genes) to each other and to the original "parent" cell.
- During cell division, each daughter cell receives one identical set of chromosomes from the original parent cell.

Important roles of cell division

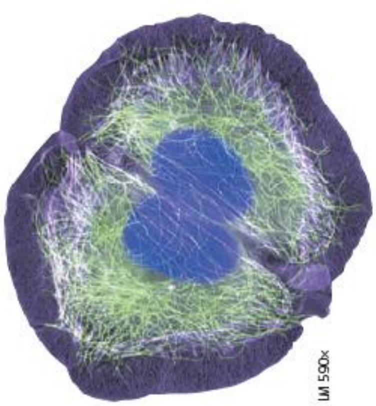
- Replacement of damaged or lost cells.
- Growth of the organism.
- Reproduction.

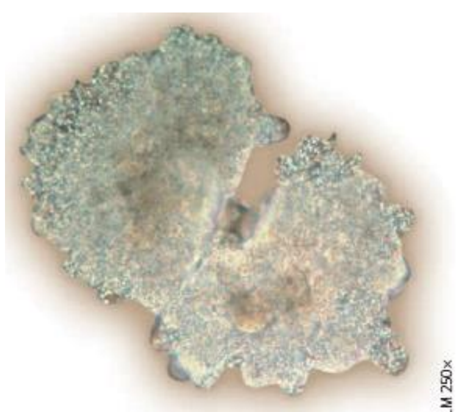
Types of reproduction

- Asexual reproduction (Mitosis).
- Sexual reproduction (Meiosis).

Cell division - Asexual reproduction

- Cells in our body are the result of repeated cell divisions that began in single zygote cell.
- Asexual reproduction: reproduction by dividing cell in half, and the offspring are genetic replicas of the parent (*Amoeba*, skin cell, kidney cell, sea star cell).





- Asexual reproduction: No fertilization of egg by sperm.
- Offspring produced by asexual reproduction inherit all of their chromosomes (genes) from a single parent and are thus genetic duplicates.

Cell division – Mitosis

- Cell division is responsible for asexual reproduction and for the growth and maintenance of multicellular organisms.

Cell division – Sexual reproduction

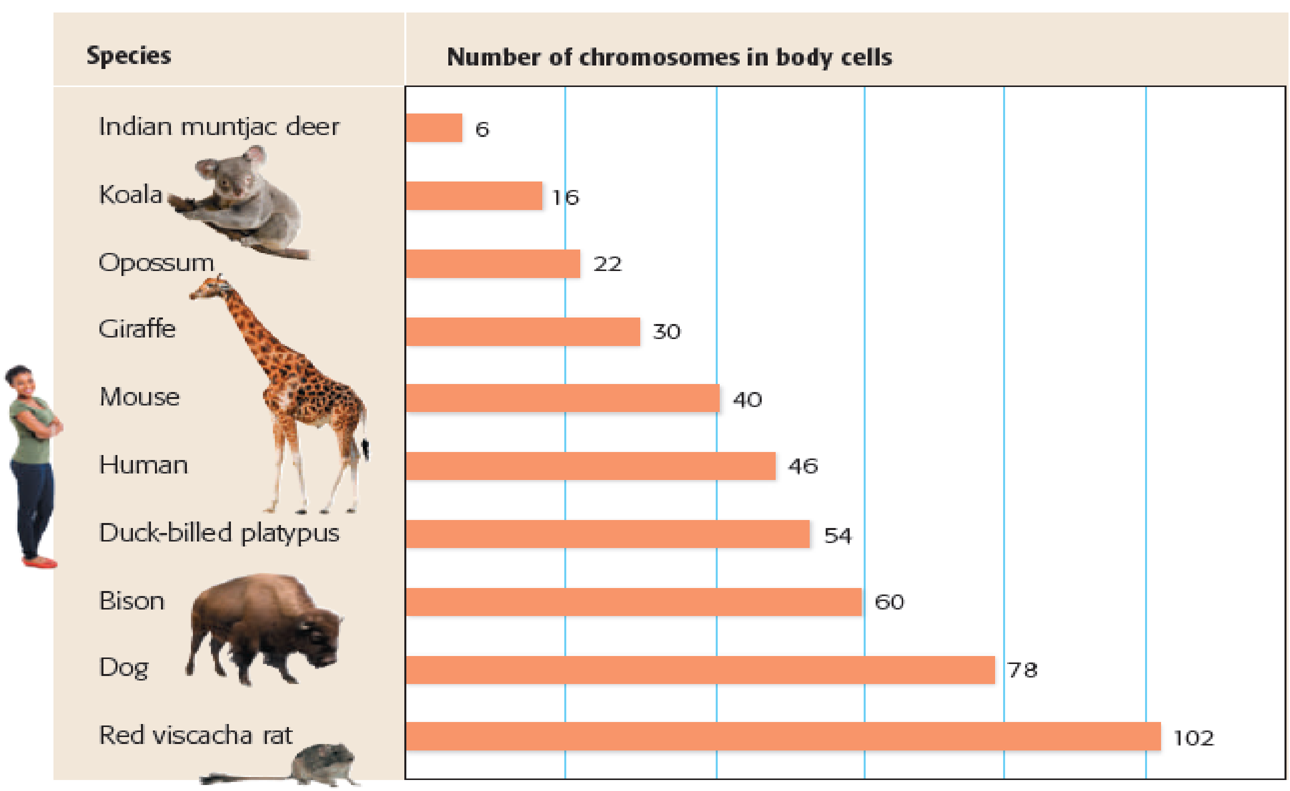
- Cell division requires fertilization of an egg by a sperm (gametes) (= Meiosis).
- Occurs only in reproductive organs.
- Gamete has only half as many chromosomes as the parent cell.

In summary:

- two kinds of cell division are involved in the lives of sexually reproducing organisms:
- Mitosis for growth and maintenance.
- Meiosis for reproduction.

Eukaryotic chromosomes

- In human: 21,000 genes located on all 46 chromosomes.
- Each eukaryotic chromosome contains one very long DNA molecule, bearing thousands of genes.
- The number of chromosomes in a eukaryotic cell depends on the species.



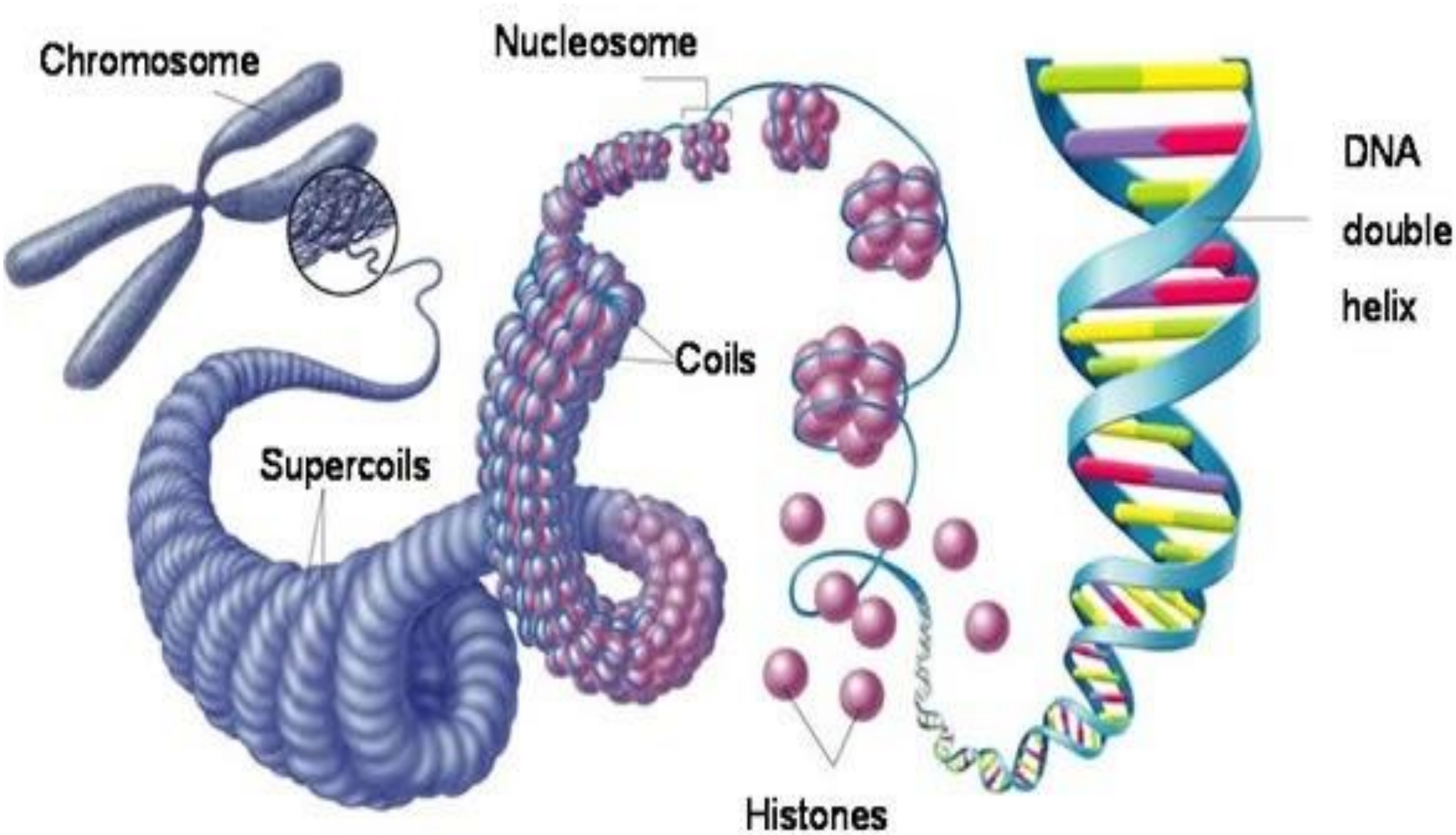
Structure of chromosome

- Chromosomes are made up of a fiber material called chromatin.
- Chromatin fibers are composed of roughly equal amounts of DNA and protein molecules (histone).
- Histones attach to the DNA which appears as beads on a string.
- Each "bead," called a nucleosome, consists of DNA wound around several histone molecules.
- Protein molecules (histone) help:

A. Organize the chromatin.

B. Control the activity of its genes.

- Most of the time, the chromosomes exist as thin fibers (difficult to see by light microscope) that are much longer than the nucleus, they are stored in.
- If fully extended, the DNA in just one of your cells would be more than 6 feet (= 182 cm). long!

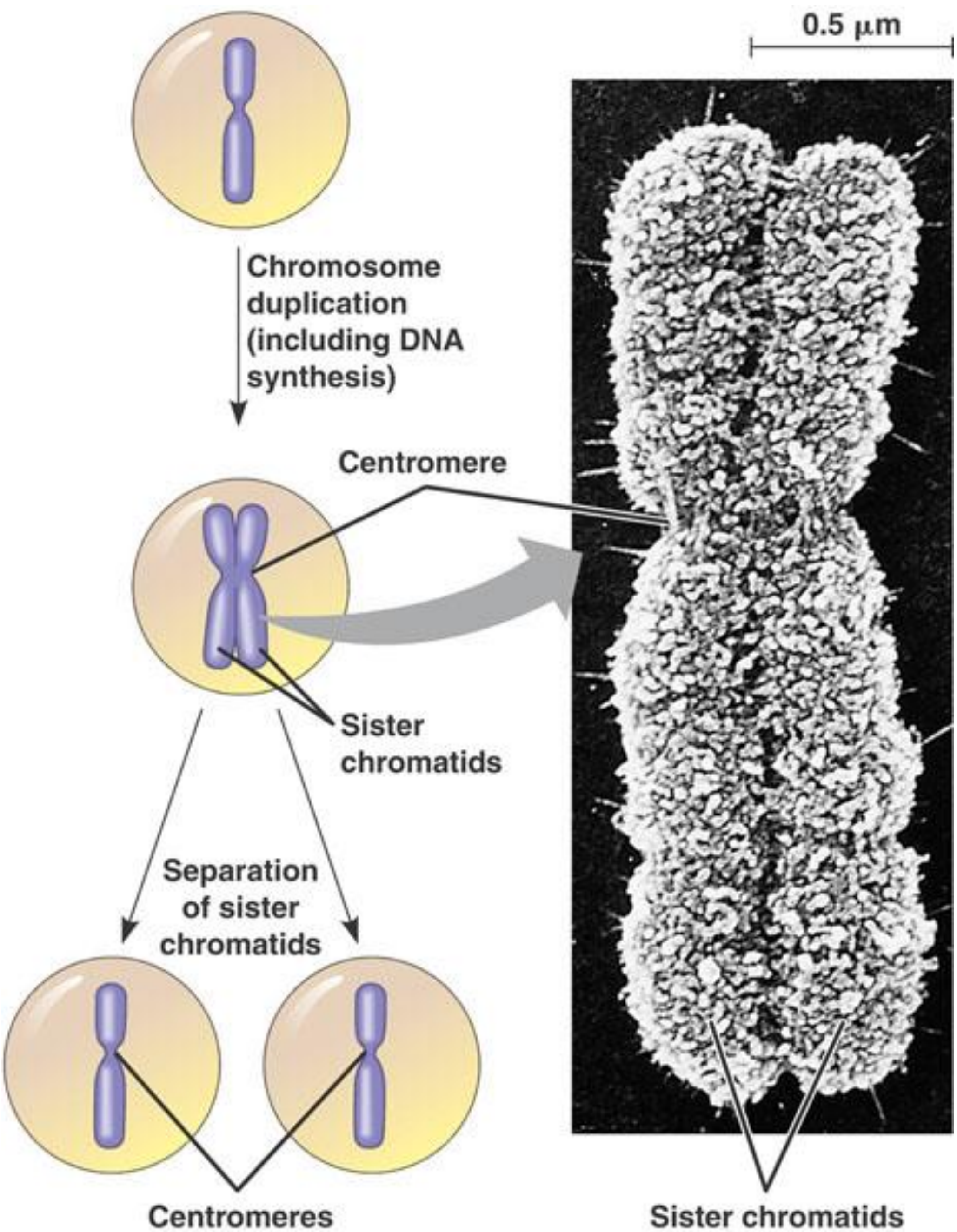


Chromatin

- As a cell prepares to divide, its chromatin fibers coil up, forming compact chromosomes that become visible under a light microscope.

Duplicating chromosome

- The DNA molecule of each chromosome is copied through the process of DNA replication, and new histone protein molecules attach as needed.
- Production of two sister chromatids which contain identical genes.
- Two sister chromatids are joined together at a narrow "waist" called the centromere.



- During the cell division, the sister chromatids of a duplicated chromosome separate from each other.
- Once separated from its sister, each chromatid is considered a full-fledged chromosome, and it is identical to the original chromosome.
- One of the new chromosomes goes to one daughter cell, and the other goes to the other daughter cell.
- In this way, each daughter cell receives a complete and identical set of chromosomes.
- Example; a dividing human skin cell, for each of the two daughter cells that result from it has 46 single chromosomes.

Cell cycle

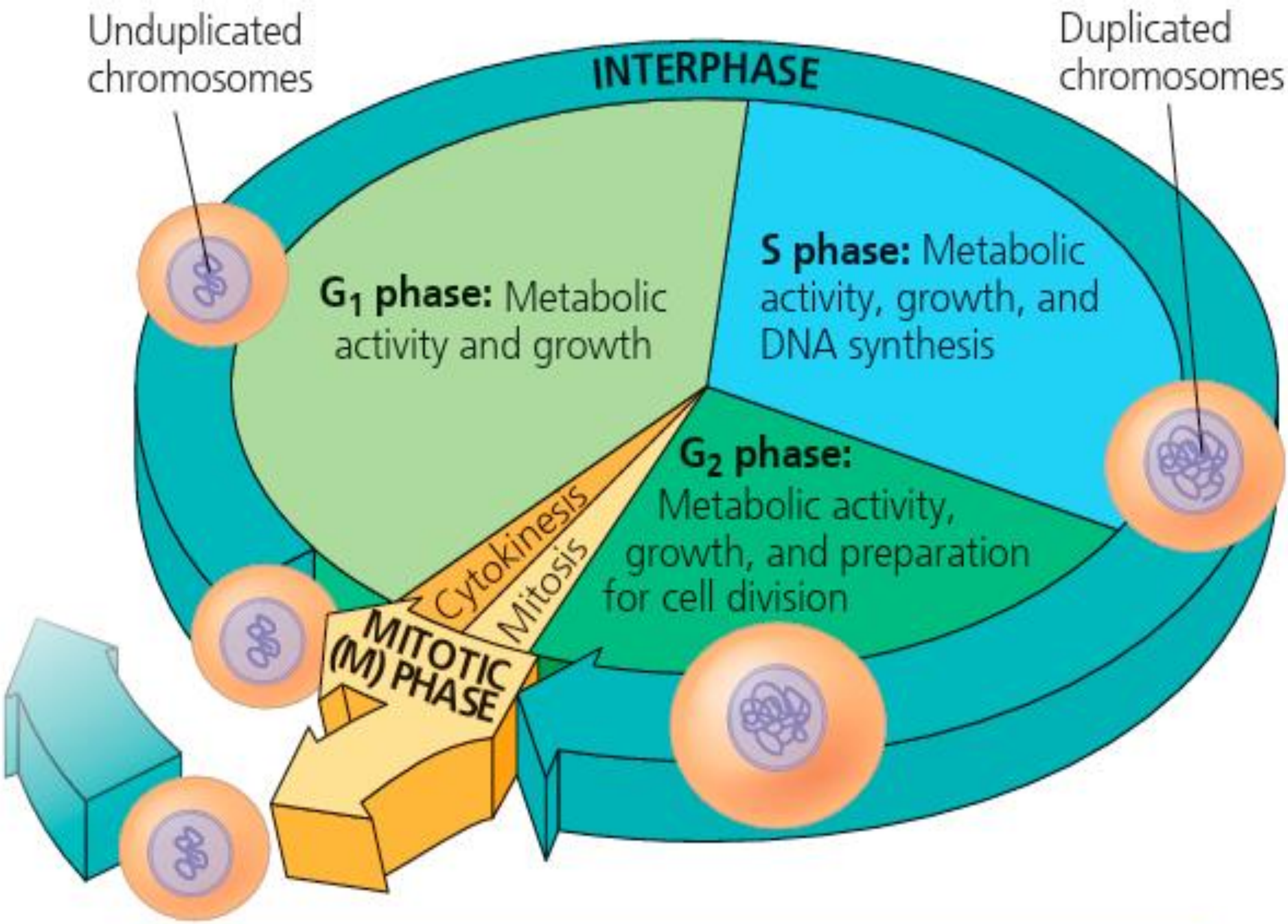
- The rate at which a cell divides depends on its role within the organism's body.
- Some cells divide once a day, others less often, and some highly specialized cells, such as mature muscle cells, do not divide at all.
- The cell cycle is the ordered sequence of events that extends from the time a cell is first formed from a dividing parent cell until its own division into two cells.

Cell cycle – Interphase

- Most of the cell cycle is spent in interphase.
- Interphase is a time when a cell goes about its usual business, performing its normal functions within the organism (example, cell lining stomach).
- Typically, interphase lasts for at least 90% of the cell cycle

What is happened during Interphase?

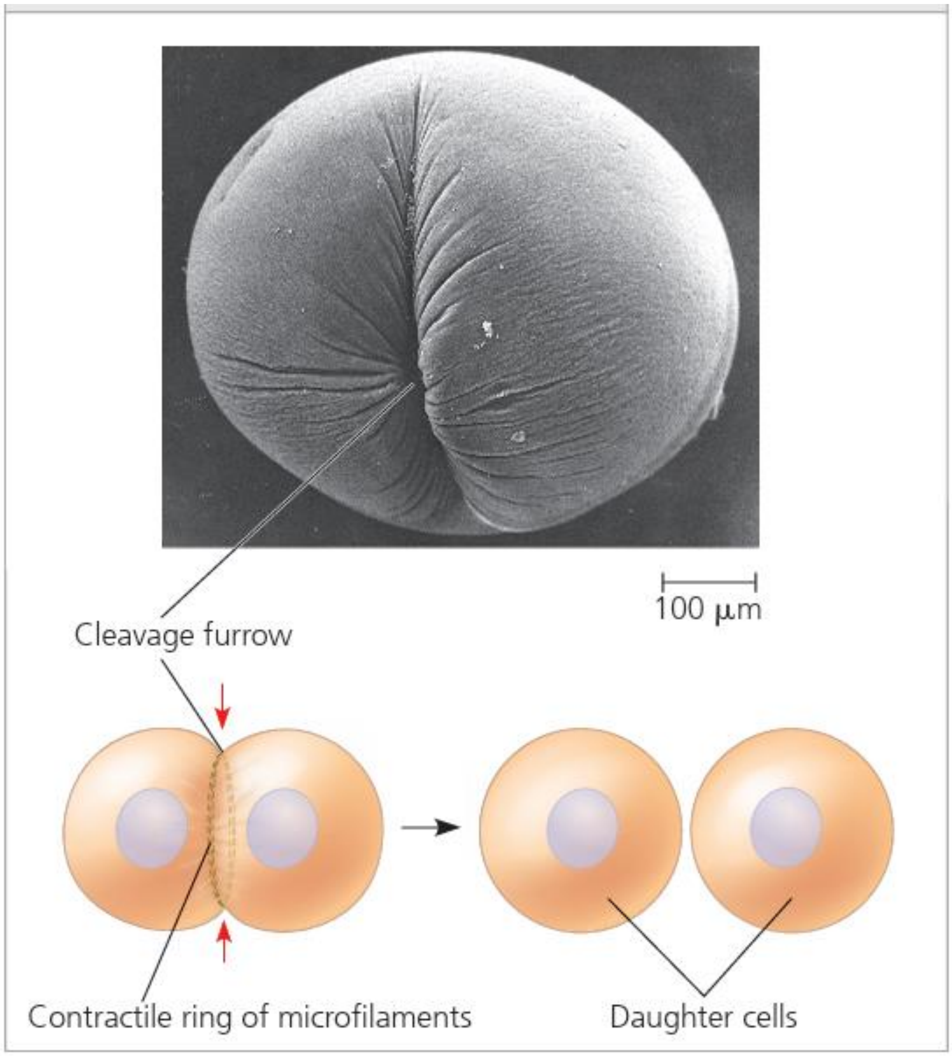
- Chromosome duplication, when the DNA in the nucleus is precisely doubled S phase (for DNA synthesis).
- Cell roughly doubles everything in its cytoplasm.
- Increases its supply of proteins.
- Increases the number of many of its organelles (such as mitochondria and ribosomes).
- Grows in size.



MITOTIC (M) PHASE:
Mitosis: Distribution of chromosomes into two daughter nuclei
Cytokinesis: Division of cytoplasm, producing two daughter cells. Each daughter cell can start a new cell cycle.

- **The interphase periods before and after the S phase are called the G1 and G2 phases, respectively (G stands for *gap*).**
- **During G1, each chromosome is single, and the cell performs its normal functions.**
- **During G2 (after DNA duplication during the S phase), each chromosome in the cell consists of two identical sister chromatids, and the cell prepares to divide.**

Cytokinesis



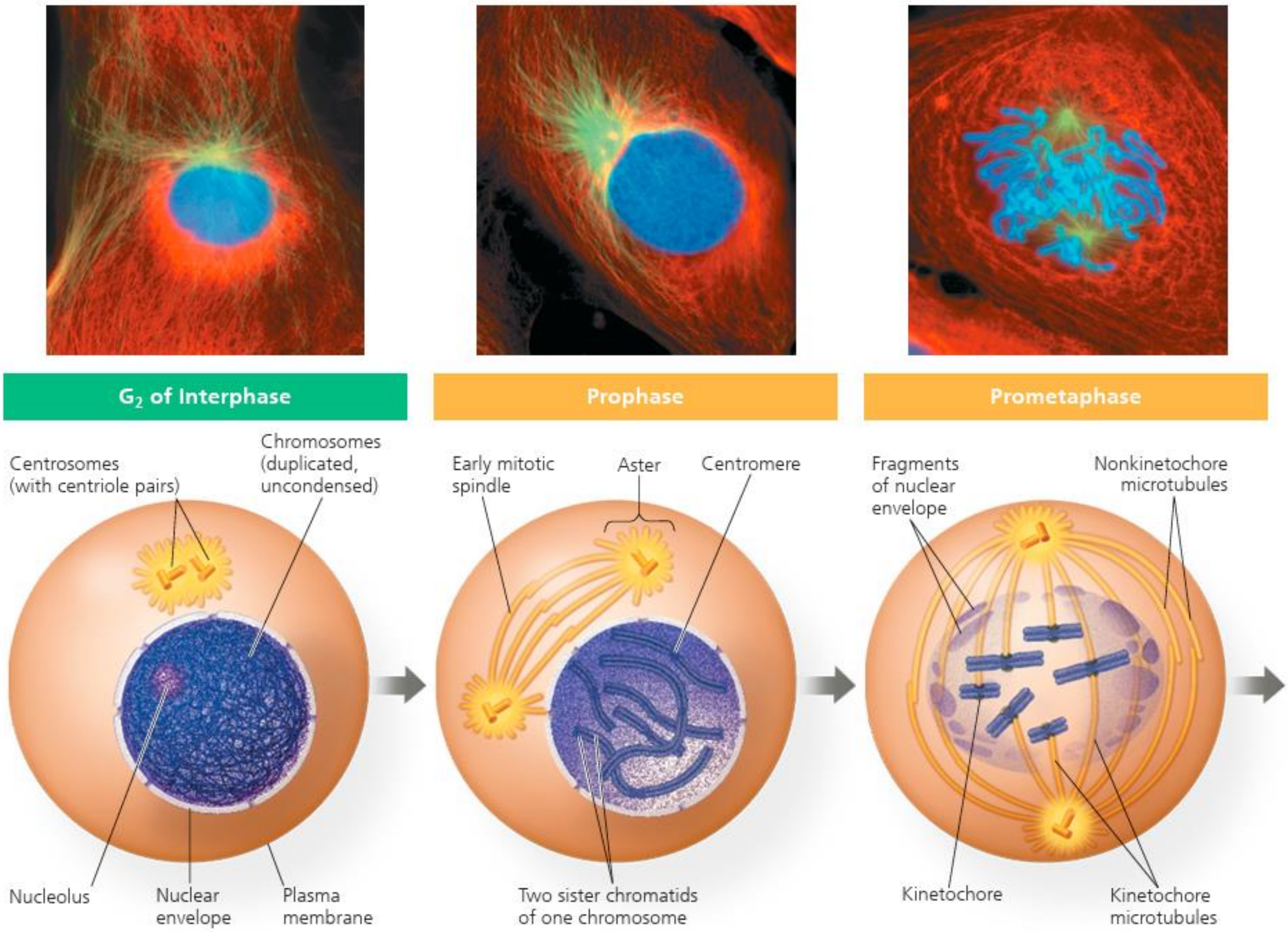
Mitotic (M) phase

- **Mitotic (M) phase is the part of the cell cycle when the cell is actually dividing.**
- **It lasts for at least 10% of the cell cycle.**
- **It includes two overlapping stages, mitosis and cytokinesis.**
- **In mitosis, the nucleus and its contents, most importantly the duplicated chromosomes, divide and are evenly distributed, forming two daughter nuclei.**
- **During cytokinesis, the cytoplasm (along with all the organelles) is divided in two. The combination of mitosis and cytokinesis produces two genetically identical daughter cells, each fully equipped with a nucleus, cytoplasm, organelles, and plasma membrane.**

Cytokinesis in animal cell

- **Cytokinesis is the division of the cytoplasm into two cells, usually begins during telophase, overlapping the end of mitosis.**
- **In animal cells, the cytokinesis process is known as cleavage.**
- **The first sign of cleavage is the appearance of a cleavage furrow, an indentation at the equator of the cell.**
- **A ring of microfilaments in the cytoplasm just under the plasma membrane contracts, like the pulling of a drawstring on a hooded sweatshirt, deepening the furrow and pinching the parent cell in two.**

▼ Figure 12.7 Exploring Mitosis in an Animal Cell



G_2 of Interphase

- A nuclear envelope encloses the nucleus.
- The nucleus contains one or more nucleoli (singular, *nucleolus*).
- Two centrosomes have formed by duplication of a single centrosome. Centrosomes are regions in animal cells that organize the microtubules of the spindle. Each centrosome contains two centrioles.
- Chromosomes, duplicated during S phase, cannot be seen individually because they have not yet condensed.

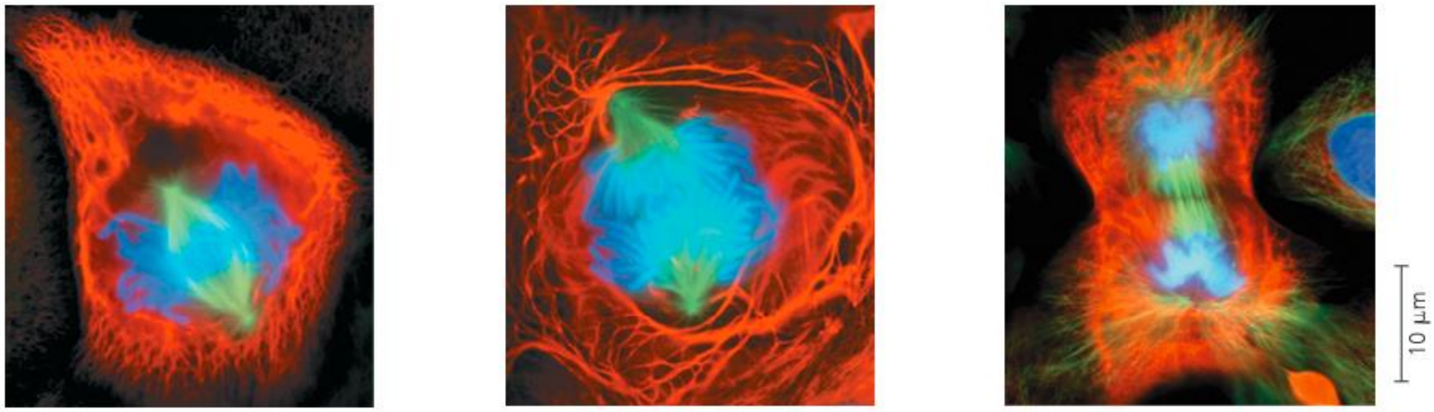
The fluorescence micrographs show dividing lung cells from a newt; this species has 22 chromosomes. Chromosomes appear blue, microtubules green, and intermediate filaments red. For simplicity, the drawings show only 6 chromosomes.

Prophase

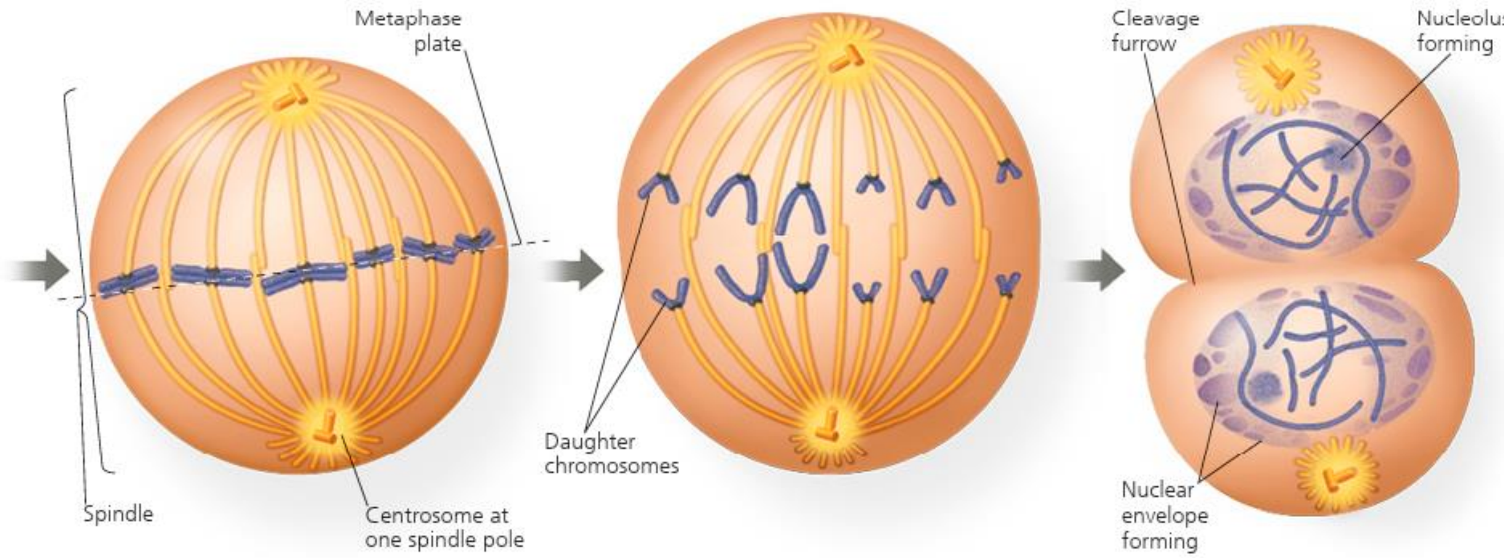
- The chromatin fibers become more tightly coiled, condensing into discrete chromosomes observable with a light microscope.
- The nucleoli disappear.
- Each duplicated chromosome appears as two identical sister chromatids joined at their centromeres and, often, all along their arms by cohesins, resulting in sister chromatid cohesion.
- The mitotic spindle (named for its shape) begins to form. It is composed of the centrosomes and the microtubules that extend from them. The radial arrays of shorter microtubules that extend from the centrosomes are called asters ("stars").
- The centrosomes move away from each other, propelled partly by the lengthening microtubules between them.

Prometaphase

- The nuclear envelope fragments.
- The microtubules extending from each centrosome can now invade the nuclear area.
- The chromosomes have become even more condensed.
- A kinetochore, a specialized protein structure, has now formed at the centromere of each chromatid (thus, two per chromosome).
- Some of the microtubules attach to the kinetochores, becoming "kinetochore microtubules," which jerk the chromosomes back and forth.
- Nonkinetochore microtubules interact with those from the opposite pole of the spindle, lengthening the cell.



Metaphase | Anaphase | Telophase and Cytokinesis



Metaphase

- The centrosomes are now at opposite poles of the cell.
- The chromosomes have all arrived at the *metaphase plate*, a plane that is equidistant between the spindle's two poles. The chromosomes' centromeres lie at the metaphase plate.
- For each chromosome, the kinetochores of the sister chromatids are attached to kinetochore microtubules coming from opposite poles.

Anaphase

- Anaphase is the shortest stage of mitosis, often lasting only a few minutes.
- Anaphase begins when the cohesin proteins are cleaved. This allows the two sister chromatids of each pair to part suddenly. Each chromatid thus becomes an independent chromosome.
- The two new daughter chromosomes begin moving toward opposite ends of the cell as their kinetochore microtubules shorten. Because these microtubules are attached at the centromere region, the centromeres are pulled ahead of the arms, moving at a rate of about 1 μm/min.
- The cell elongates as the nonkinetochore microtubules lengthen.
- By the end of anaphase, the two ends of the cell have identical—and complete—collections of chromosomes.

Telophase

- Two daughter nuclei form in the cell. Nuclear envelopes arise from the fragments of the parent cell's nuclear envelope and other portions of the endomembrane system.
- Nucleoli reappear.
- The chromosomes become less condensed.
- Any remaining spindle microtubules are depolymerized.
- Mitosis, the division of one nucleus into two genetically identical nuclei, is now complete.

Cytokinesis

- The division of the cytoplasm is usually well under way by late telophase, so the two daughter cells appear shortly after the end of mitosis.
- In animal cells, cytokinesis involves the formation of a cleavage furrow, which pinches the cell in two.