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Chapter 8 DNA Replication, Binary Fission, and Mitosis

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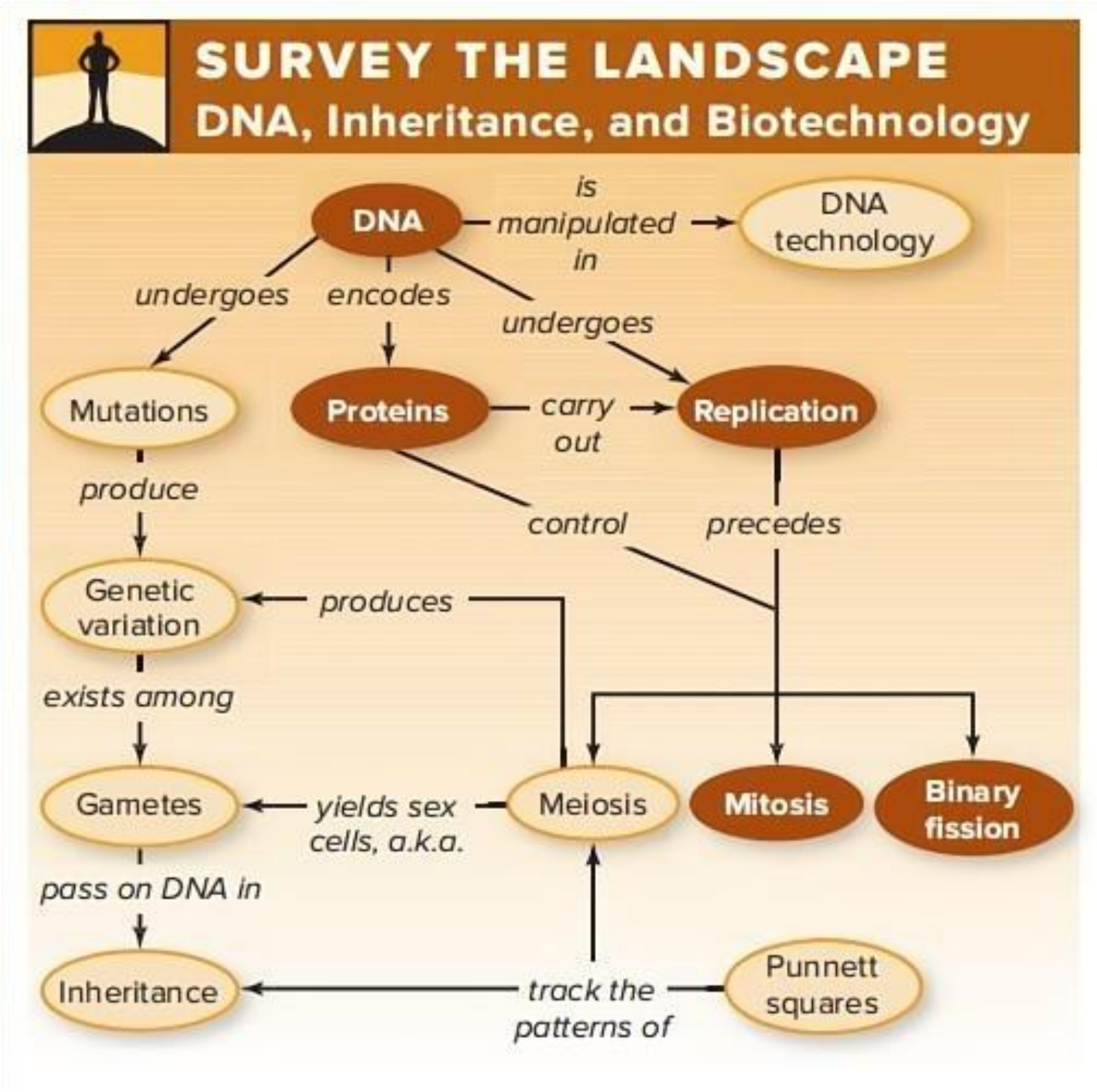
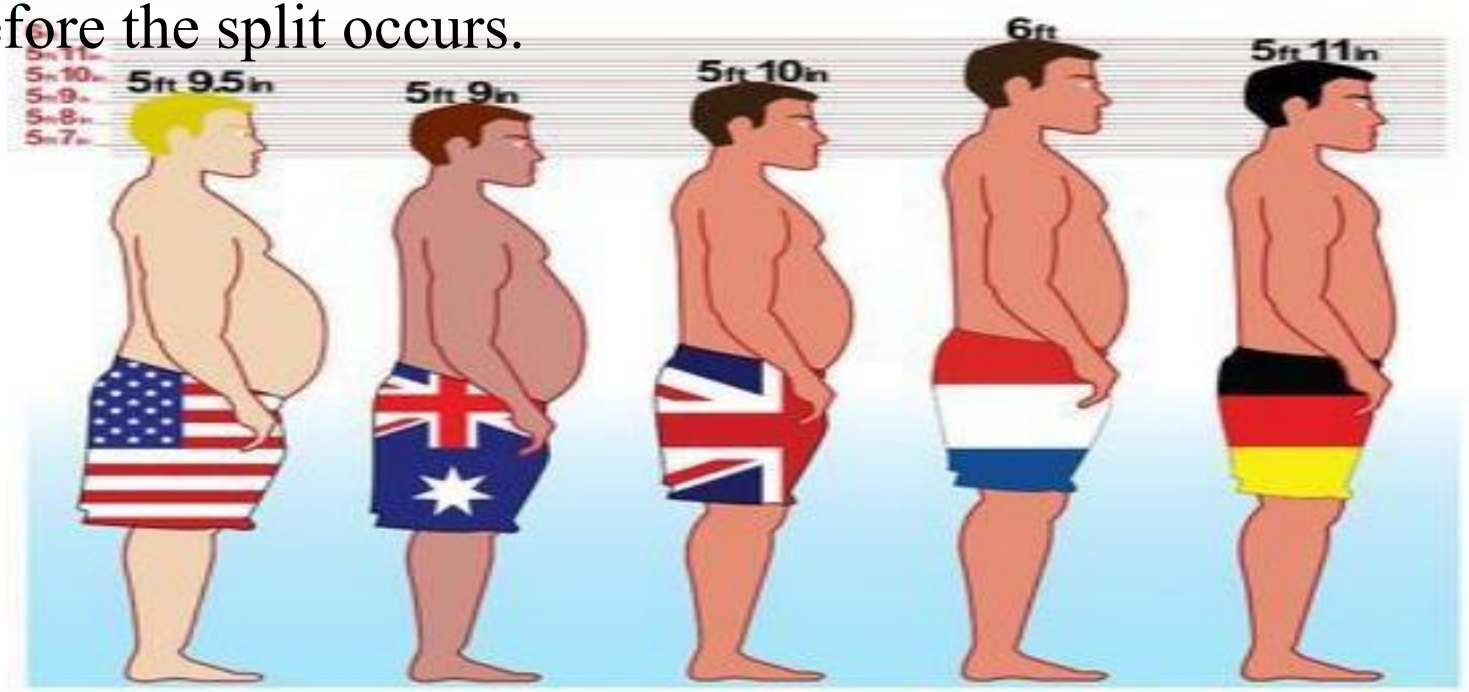

SURVEY THE LANDSCAPE
DNA, Inheritance, and Biotechnology
DNA
is manipulated in
DNA technology
undergoes
encodes
undergoes
Mutations
Proteins
carry out
Replication
produce
control
precedes
Genetic variation
produces
exists among
Gametes
yields sex cells, a.k.a.
Meiosis
Mitosis
Binary fission
pass on DNA in
Inheritance
track the patterns of
Punnett squares

- A quick glance at any crowd reveals that not everyone is the same height. In the United States, the average height is about 1.76 meters (5 feet, 9.5 inches) for men and about 1.62 m (5 feet, 4 inches) for women.
- A person's adult height reflects cell division during child-hood and adolescence, especially in the ends of the bones. Each new cell grows as it produces proteins and takes in water and other nutrients.
- **Tissue growth and repair rely on cell division.**
- Prokaryotic cells (原核生物细胞) divide by binary fission (二分裂); eukaryotic cells (真核细胞) use mitotic or meiotic division. Proteins regulate the entire process and copy all of the cell's DNA shortly before the split occurs.



8.1

Cells Divide and Cells Die

- Our cells are too small to see without a microscope, so it is hard to appreciate just how many you lose as you sleep, work, and play.

- If you did not have a way to replace these lost cells, your body would literally wear away. Instead, cells in your deep skin layers divide and replace the ones you lose. Each new cell lives an average of about 35 days, so you will gradually replace your entire skin in the next month or so.

- Cell division produces a continuous supply of replacement cells, both in your skin and everywhere else in your body. But cell division has other functions as well. No living organism can reproduce without cell division, and the growth and development of a multicellular organism also require the production of new cells.

8.1

Cells Divide and Cells Die

A.Sexual Life Cycles Include Mitosis, Meiosis, and Fertilization

- Organisms must reproduce—generate other individuals like themselves—for a species to persist.

- For a single-celled organism, the most straightforward (and ancient) method is **asexual reproduction（无性繁殖）**, in which one cell replicates its genetic material and splits into two.

- Except for the occasional mutation, asexual reproduction generates genetically identical offspring. Bacteria and archaea(古细菌), reproduce asexually via a simple type of cell division called binary fission . Many protists（原生动物） and multicellular eukaryotes（真核生物） also reproduce asexually.

- **Sexual reproduction（有性生殖）**, in contrast, is the production of offspring whose genetic makeup comes from two parents. Each parent（亲本）contributes a sex cell, and the fusion of these cells signals the start of the next generation. Because sexual reproduction mixes up and recombines traits, the offspring are genetically different from each other and their parents.

8.1

Cells Divide and Cells Die

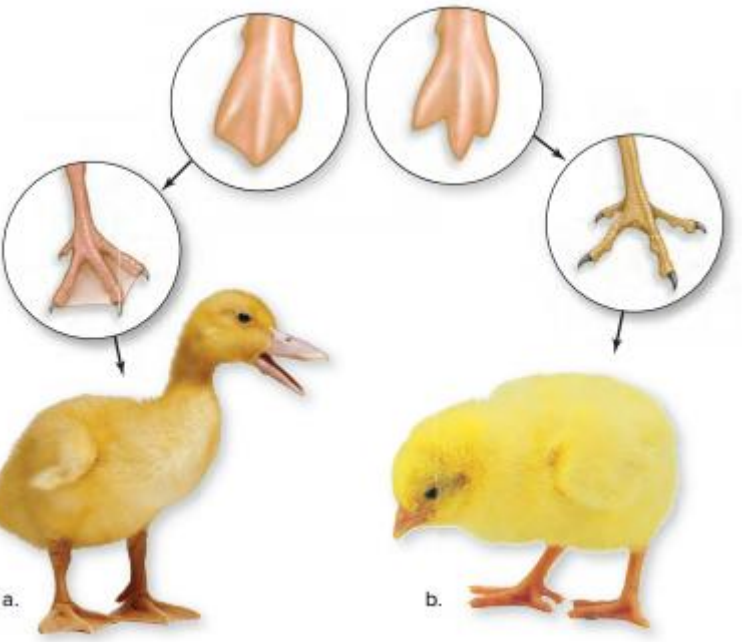
A.Sexual Life Cycles Include Mitosis, Meiosis, and Fertilization

- **Meiosis** is a specialized process that gives rise to nuclei that are genetically different from one another. In humans and many other species, these nuclei are packaged into gametes: sperm cells (produced by males) and egg cells (produced by females). The variation among gametes explains why siblings（同胞兄弟姐妹） generally look different from one another (except for identical twins).

- Fertilization（受精过程） is the union of the sperm and the egg cell, producing a zygote（受精卵） (the first cell of the new offspring). Immediately after fertilization, the other type of cell division—mitosis—takes over. Mitosis divides a eukaryotic cell's genetic information into two identical nuclei.Mitotic cell division explains how you repair damage after an injury, how you replace the cells that you lose every day, and how you grew from a single-celled zygote into an adult . Likewise, mitotic cell division accounts for the growth and development of plants, mushrooms, and other multicellular eukaryotes and for asexual reproduction in protists and many other eukaryotes.

8.1

Cells Divide and Cells Die



B.Cell Death Is Part of Life

- The development of a multicellular organism requires more than just cell division. Cells also die in predictable ways, carving distinctive structures. **Apoptosis(细胞凋亡)**, also called “programmed cell death,” is a normal part of development.

- **During early development, both cell division and apoptosis shape new structures**. For example, the feet of both ducks and chickens start out as webbed paddles when the birds are embryos（胚胎）. The webs of tissue remain in the duck’s foot throughout life. In the chicken, however, individual toes form as cells between the digits（脚趾） die.

- **Throughout an animal’s life, cell division and cell death are in balance**, so tissue neither overgrows nor shrinks. Cell division compensates for the death of skin and blood cells. **Both cell division and apoptosis also help protect the organism.** For example, cells divide to heal a scraped knee; apoptosis peels away sunburnt skin cells that might otherwise become cancerous.

8.2

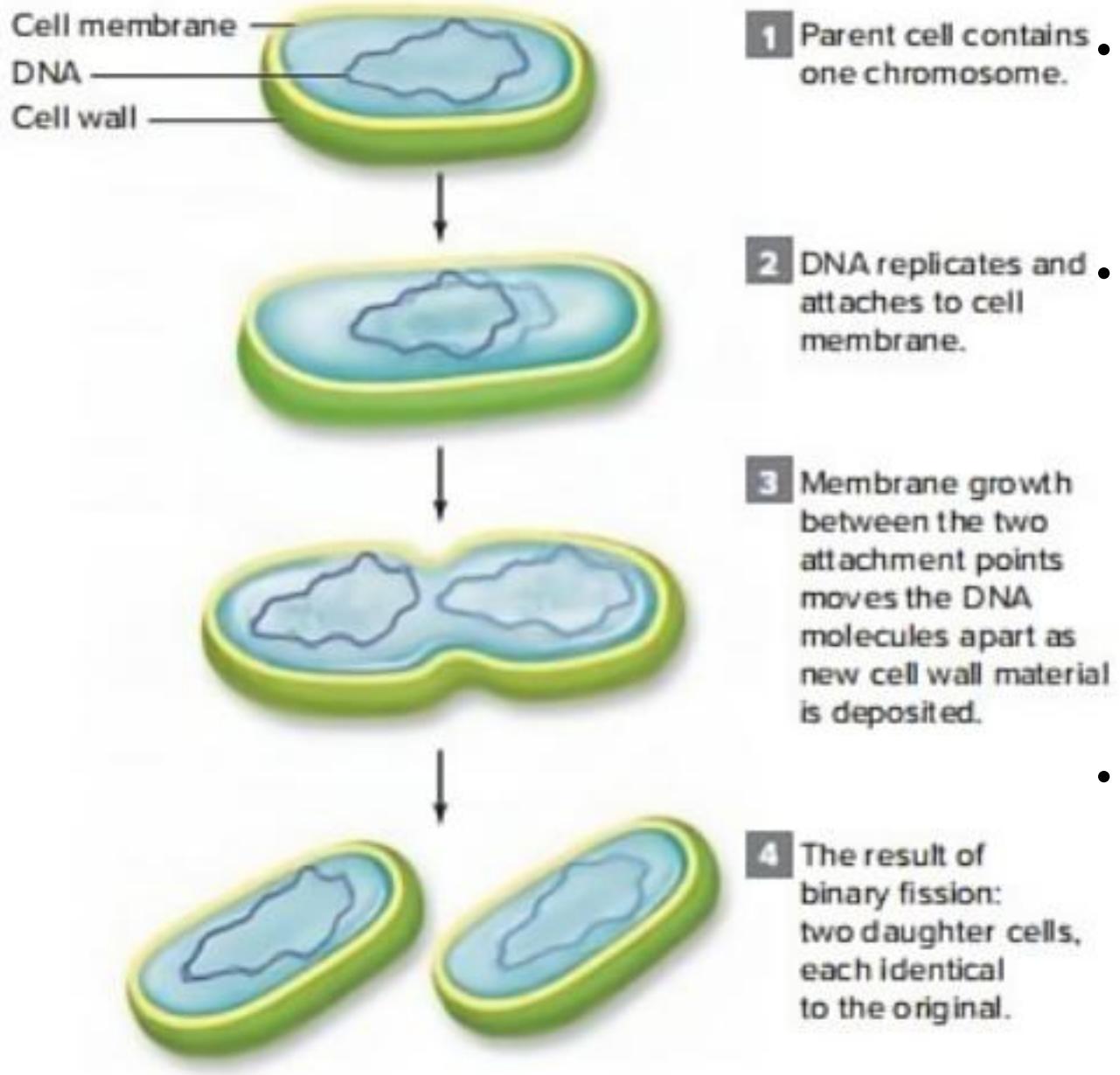
DNA Replication Precedes Cell Division

- **DNA replication is incredibly accurate.** DNA polymerase（聚合酶）"proofreads"（校对）as it goes, discarding mismatched nucleotides and inserting correct ones. After proofreading, DNA polymerase has an error rate of only about one in a billion nucleotides. Other repair enzymes help ensure the accuracy of DNA replication by cutting out and replacing incorrect nucleotides.

- Nevertheless, **mistakes occasionally remain.** The result is a mutation, which is any change in a cell's DNA sequence.

- Overall, **DNA replication requires a great deal of energy** because a large, organized nucleic acid contains much more potential energy than do many individual nucleotides. Energy from ATP is required to **synthesize nucleotides and to create the covalent bonds** that join them together in the new strands of DNA. Many of the enzymes that participate in DNA replication, including helicase（解旋酶）and ligase（连接酶）, also require energy to catalyze their reactions.

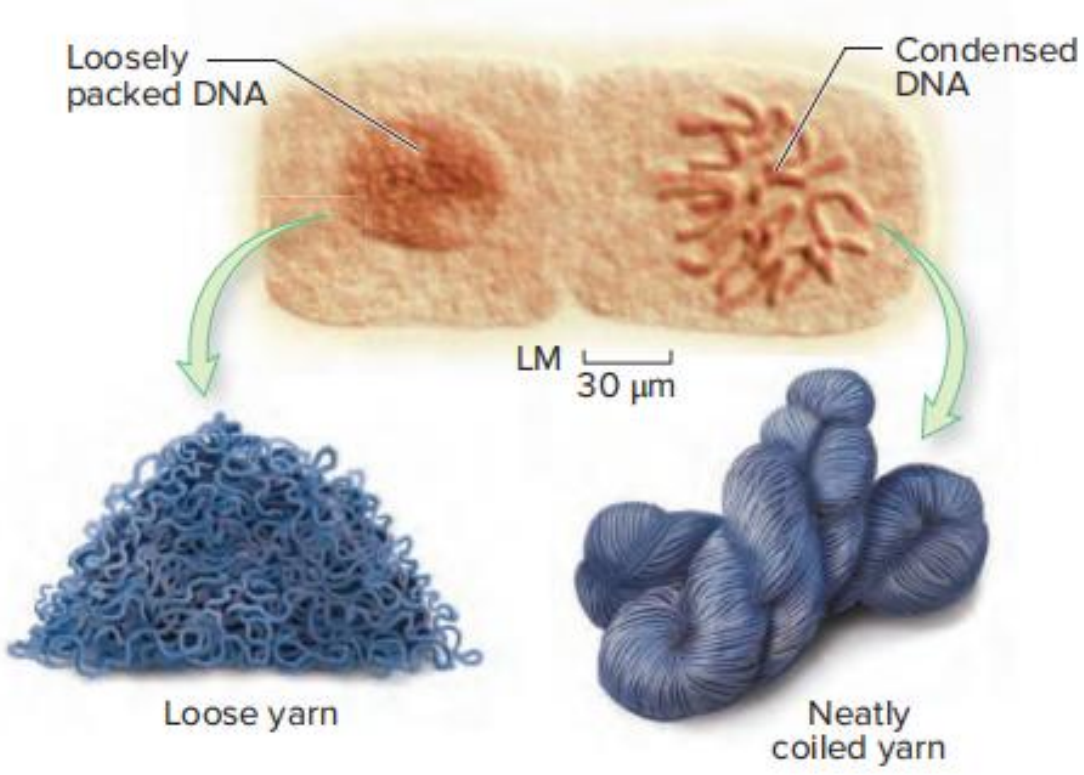
8.3 Prokaryotes Divide by Binary Fission



- In prokaryotes, reproduction occurs by binary fission, an asexual process that replicates DNA and distributes it into two daughter cells .
- Each prokaryotic cell contains one circular chromosome. As the cell prepares to divide, its DNA replicates. The chromosome and its duplicate attach to the inner surface of the cell. The cell membrane grows between the two DNA molecules, separating them. Then the cell pinches in half to form two daughter cells from the original one.
- In optimal conditions, some bacterial cells can divide every 20 minutes. Those few microbes that remain after you brush your teeth therefore easily repopulate your mouth as you sleep; their metabolic activities produce the foul smelling “morning breath.”

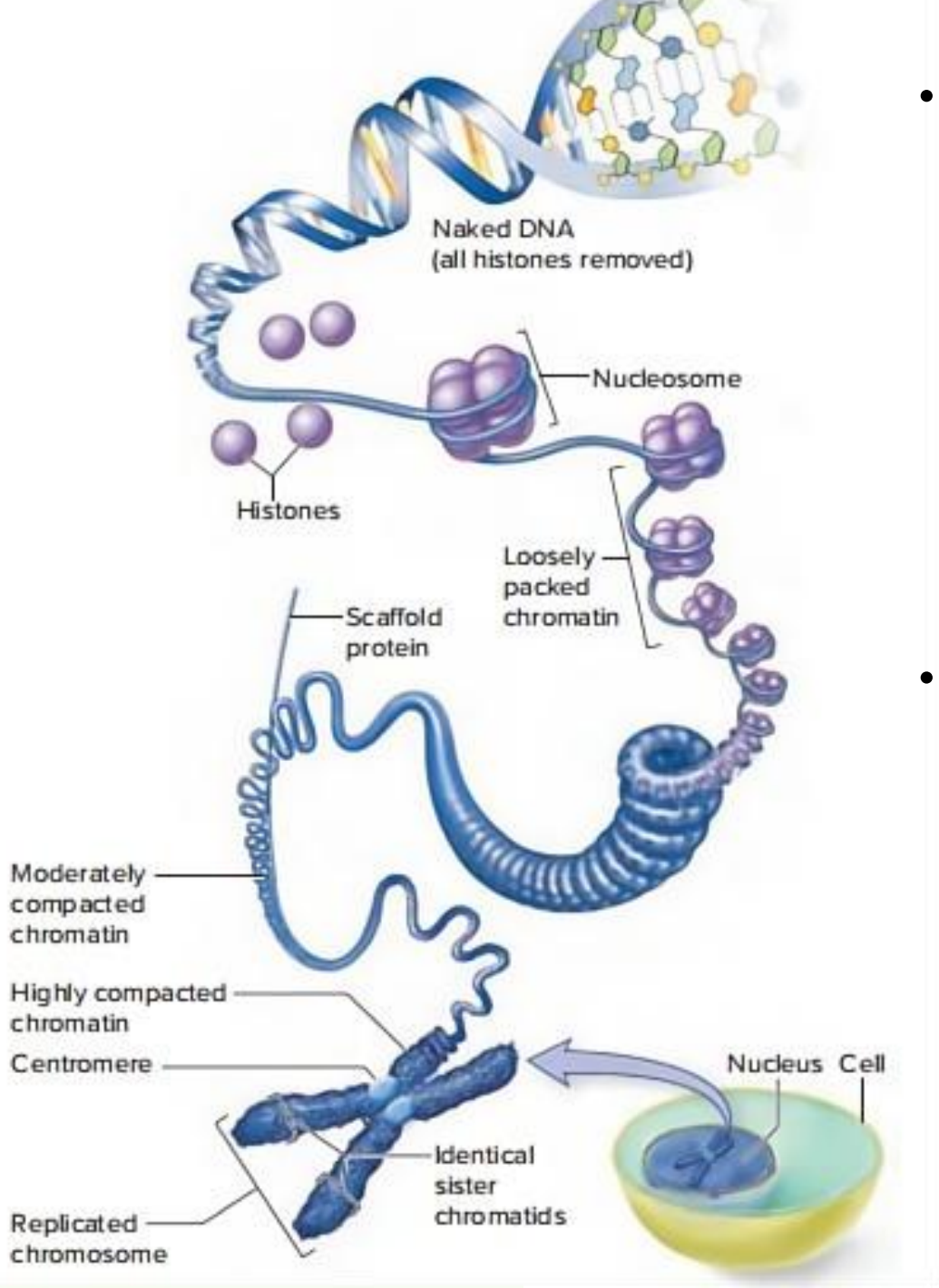
8.4

Chromosomes Condense Before Cell Division



- The genetic information in a eukaryotic cell consists of multiple chromosomes inside a nucleus. Each species has a characteristic number of chromosomes. A mosquito's cell has 6 chromosomes; grasshoppers, rice plants, and pine trees all have 24; humans have 46; dogs and chickens have 78; carp have 104. In all of these species, the amount of information is immense.

- With so much genetic information, a eukaryotic cell must balance two needs. On one hand, the cell must have access to the information in its DNA. On the other hand, a dividing cell must package its DNA into a portable form that can easily move into the two daughter cells (figure 8.8). DNA packing is therefore comparable to winding yarn into a compact ball. Just as a ball of yarn occupies less space and is more portable than a pile of loose yarn, condensed DNA is easier for the cell to manage than is an unwound chromosome.

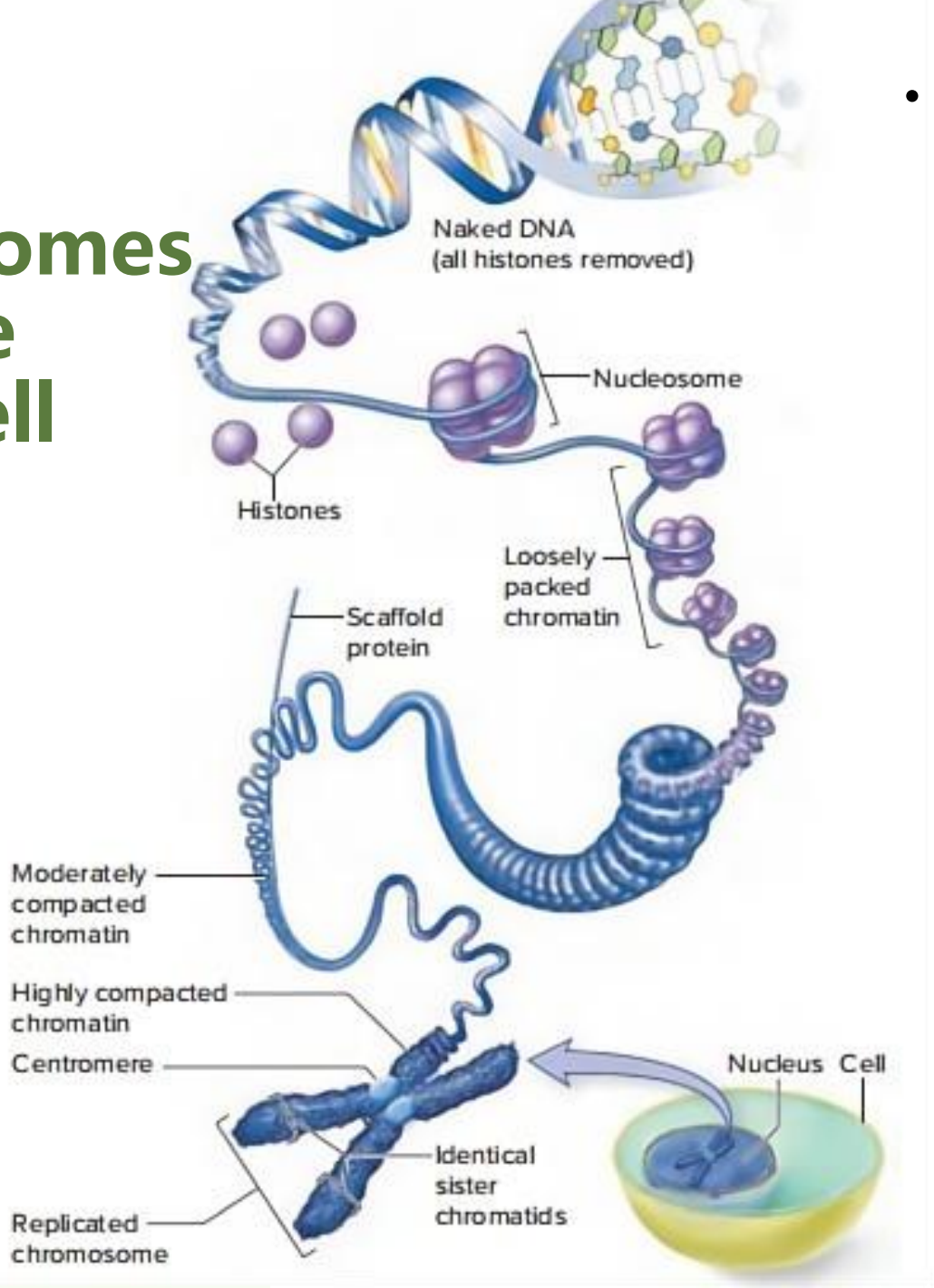


- To learn how cells maintain this balance, we must look closely at a chromosome's structure. Eukaryotic chromosomes consist of chromatin（染色质）, which is a collective term for all of the cell's DNA and its associated proteins. These proteins include the many enzymes that help replicate the DNA and transcribe it to RNA. Others serve as scaffolds（脚手架） around which DNA entwines（缠绕）, helping to pack the DNA efficiently inside the cell.

- Chromatin is organized into nucleosomes（核小体）, each consisting of a stretch of DNA wrapped around eight proteins (histones组蛋白). A continuous thread of DNA connects nucleosomes like beads on a string. When the cell is not dividing, chromatin is barely visible because the nucleosomes are loosely packed together. The cell can therefore access the information in the DNA to produce the proteins that it needs. DNA replication in preparation for cell division also requires that the cell's DNA be unwound.

8.4

Chromosomes Condense Before Cell Division



- The chromosome's appearance changes shortly after DNA replication. The nucleosomes gradually fold into progressively larger structures, making the DNA portable but unavailable for transcription. Once fully condensed, the chromosome has readily identifiable parts. Two chromatids(染色单体) make up the replicated chromosome. Because these paired chromatids have identical sequences, they are called "sister chromatids." The centromere（着丝粒） is a small section of DNA and associated proteins that attaches the sister chromatids to each other. As a cell's genetic material divides, the centromere splits, and the sister chromatids move apart. At that point, each chromatid becomes an individual chromosome.

8.5

Mitotic Division Generates Exact Cell Copies

- Biologists divide the cell cycle into stages. **Interphase** is the interval between successive cell divisions; protein synthesis, DNA replication, and many other events occur during interphase. Next is **mitosis**, during which the contents of the nucleus divide. In **cytokinesis**, the cell splits into daughter cells. After cytokinesis is complete, each daughter cell enters interphase, and the cell cycle begins a new.

- Mitotic cell division occurs some 300 million times per minute in your body, replacing cells lost to abrasion or cell death. **In each case, the products of cell division are two daughter cells, each receiving complete, identical genetic instructions plus the molecules and organelles they need for their own metabolism.**

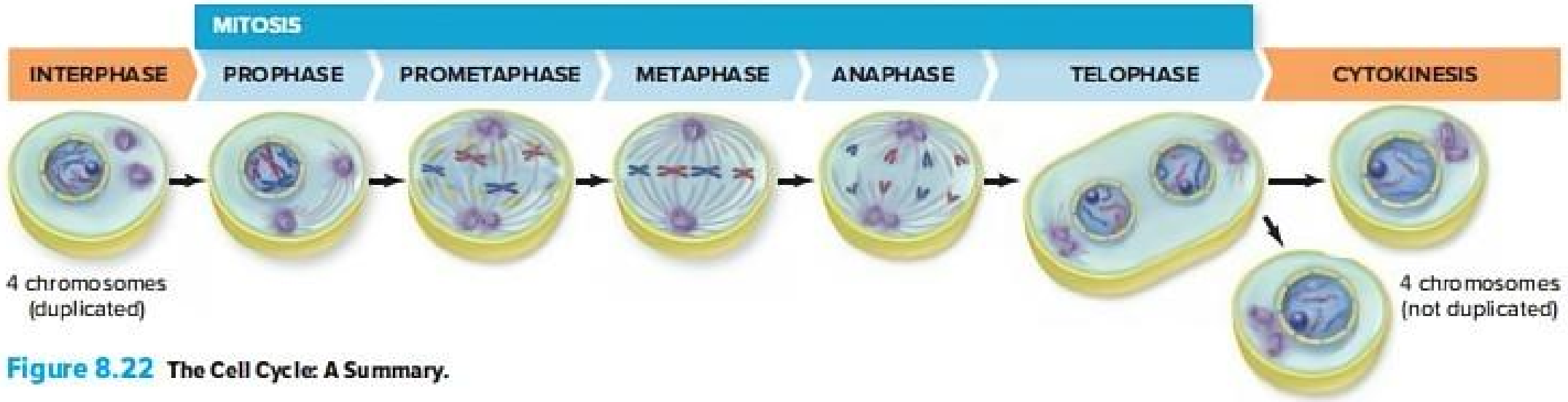
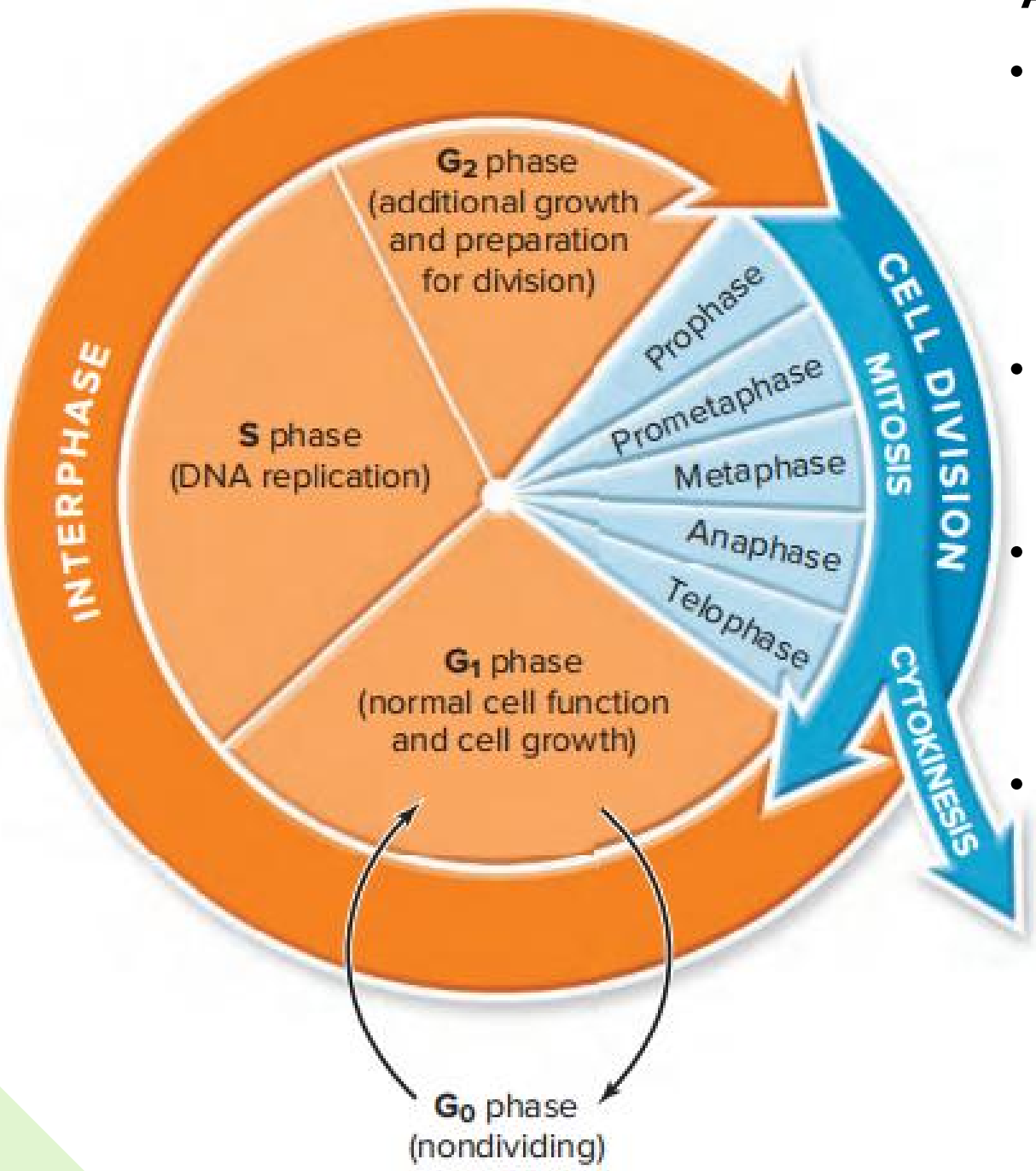
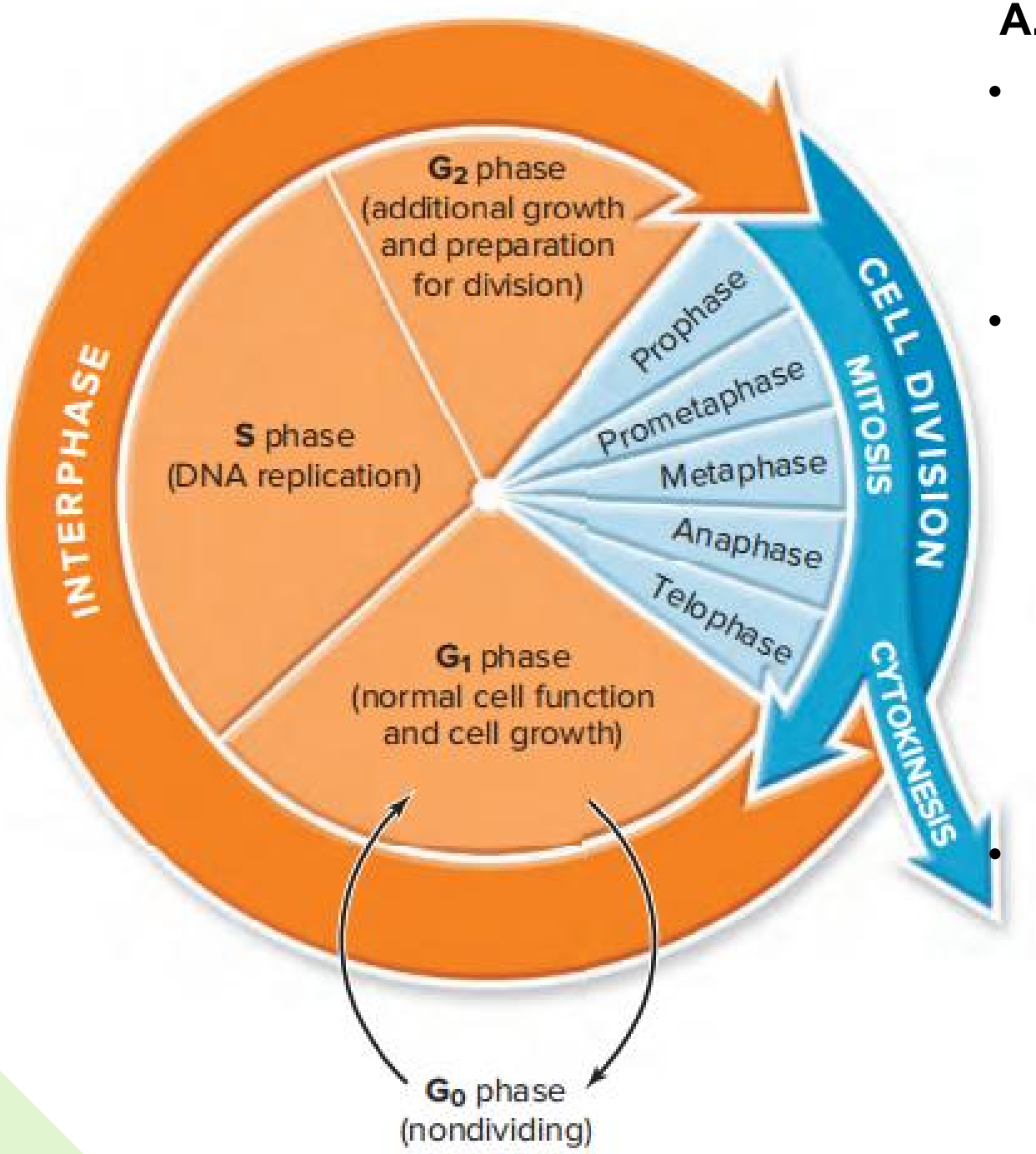


Figure 8.22 The Cell Cycle: A Summary.



A. DNA Is Copied During Interphase

- **Interphase** is actually a very active time. The **cell produces proteins and carries out its functions**, from photosynthesis to muscle contraction to insulin（胰岛素） production to bone formation. **DNA replication also occurs during this stage**.
- Interphase is divided into **“gap” phases** (designated **G1, G0, and G2**), separated by a **“synthesis” (S) phase.**
- During **G1 phase**, **the cell grows,** carries out its basic functions, **and produces the new organelles**（细胞器） **and other components** it will require if it divides.
- **A cell in G1 may enter a nondividing stage called G0.** In G0 phase, a cell continues to function, **but it does not replicate its DNA or divide.** At any given time, most cells in the human body are in G0. Nerve cells in the brain are permanently in G0, which explains both why the brain does not grow after it reaches its adult size and why brain damage is often irreparable.



A. DNA Is Copied During Interphase

- **During S phase**, **enzymes replicate the cell's genetic material and repair damaged DNA** . By the end of S phase, each chromosome consists of two attached sister chromatids.
- In an **animal cell,** another event that occurs during S phase is the **duplication of the centrosome.** Centrosomes are structures that organize the mitotic spindle, a set of microtubule proteins that coordinates the movements of the chromosomes during mitosis. Each centrosome includes proteins enclosing a pair of barrel-shaped centrioles（中心粒）. Most plant cells lack centrosomes; they organize their spindle fibers throughout the cell.
- **In G2 phase,** the cell continues to grow but also prepares to divide, **producing the proteins that will help coordinate mitosis**. The DNA winds more tightly around its associated proteins, and this event signals the start of mitosis. Interphase has ended.

Figure It Out

A cell that has completed interphase contains __ times as much DNA as a cell at the start of interphase.

8.5

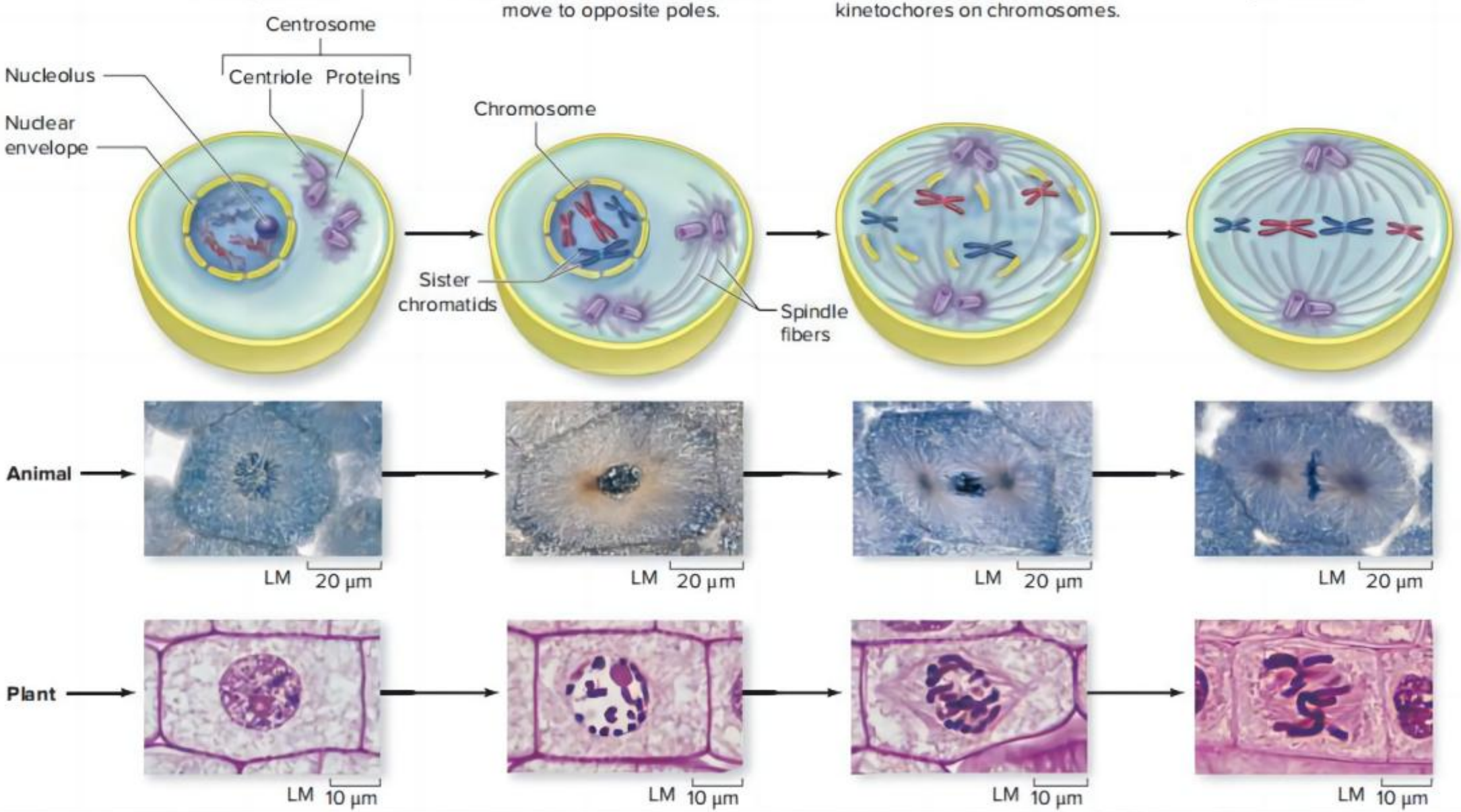
Mitotic Division Generates Exact Cell Copies

B.Chromosomes Divide During Mitosis

- Overall, mitosis separates the genetic material that replicated during S phase. For the chromosomes to be evenly distributed, they must line up in a way that enables them to split equally into two sets that are then pulled to opposite poles of the cell. Mitosis is a continuous process, but biologists divide it into stages for ease of understanding.
- During **prophase（前期）,** DNA coils very tightly, shortening and thickening the chromosomes. As the chromosomes condense, they become visible when stained and viewed under a microscope. Also during prophase, the two centrosomes migrate toward opposite poles of the cell, and the spindle begins to form. The nucleolus（核仁）—the dark area in the nucleus（细胞核）—disappears.
- **Prometaphase（前中期）** occurs immediately after the formation of the spindle（纺锤体）. The nuclear envelope（核膜） breaks into small pieces, as does the surrounding endoplasmic reticulum（内质网）. The spindle fibers（纺锤丝） are now free to reach the chromosomes. Meanwhile, proteins called kinetochores（着丝点） begin to assemble on each centromere（着丝粒）; these proteins attach the chromosomes to the spindle.
- As **metaphase（中期）** begins, the spindle lines up the chromosomes along the center, or equator（赤道板）, of the cell. This arrangement ensures that each cell will receive one copy of each chromosome.

MITOSIS

G_2, LATE INTERPHASE	EARLY PROPHASE	PROMETAPHASE	METAPHASE
Cell checks for complete DNA replication.	Chromosomes condense and become visible. Spindle forms as centrosomes move to opposite poles.	Nuclear envelope breaks up. Spindle fibers attach to kinetochores on chromosomes.	Chromosomes line up along equator of cell.



8.5

Mitotic Division Generates Exact Cell Copies

- In **anaphase（后期）**, the centromeres split, and some spindle fibers shorten as they pull the sister chromatids (now chromosomes) toward opposite poles of the cell. At the same time, other microtubules in the spindle lengthen in a way that moves the poles farther apart, stretching the dividing cell.

- **Telophase（末期）**, the final stage of mitosis, essentially reverses the events of prophase and prometaphase. The spindle is assembles, and the chromosomes begin to unwind. In addition, a nuclear envelope and nucleolus form at each end of the stretched-out cell. As telophase ends, the division of the genetic material is complete, and the cell contains two nuclei—but not for long.

- In **cytokinesis（胞质分裂）**, the cytoplasm and the two nuclei are distributed into the two forming daughter cells, which then physically separate.

ANAPHASE

Centromeres split as sister chromatids separate and move to opposite poles of cell.

TELOPHASE

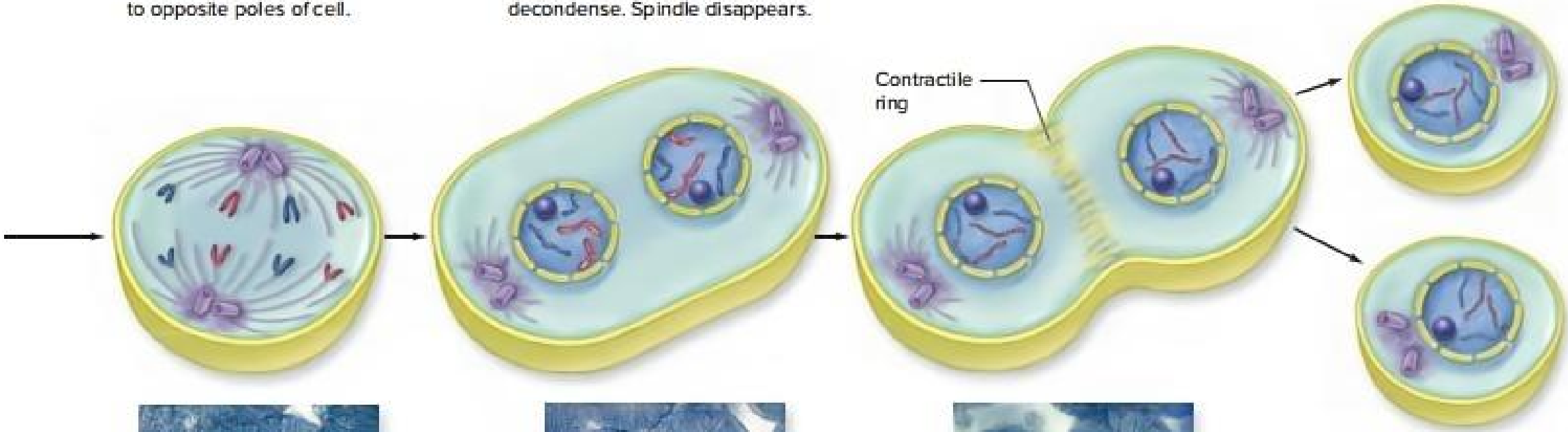
Nuclear envelope and nucleolus form at each pole. Chromosomes decondense. Spindle disappears.

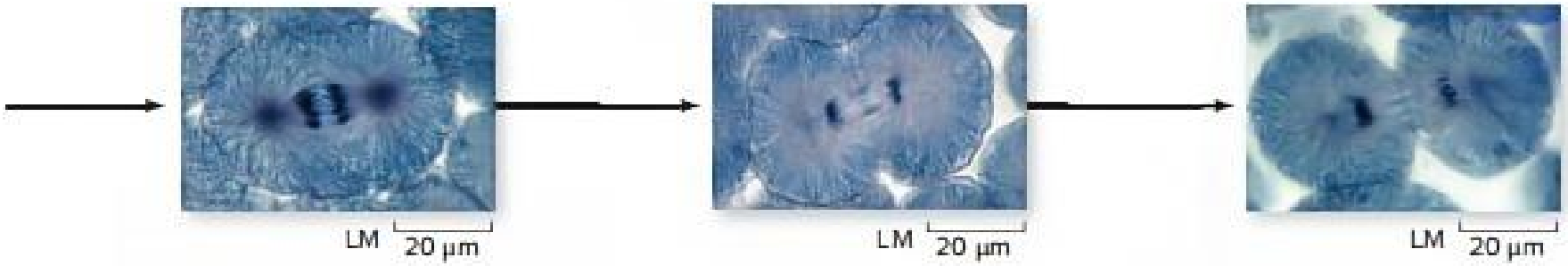
CYTOKINESIS

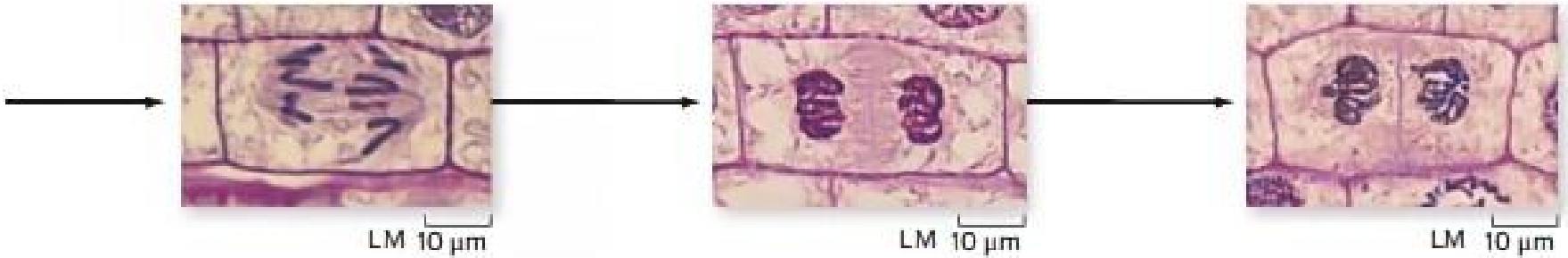
Division of the cytoplasm into two cells.

G_1, EARLY INTERPHASE

Cells resume normal functions or enter another division cycle.







8.6

Apoptosis Is Programmed Cell Death

- Development relies on a balance between cell division and programmed cell death, or apoptosis. Apoptosis is different from necrosis（坏死）, which is the “accidental” cell death that follows a cut or bruise. Whereas necrosis is sudden, traumatic, and disorderly, apoptosis results from a precisely coordinated series of events that dismantle a cell.
- The process begins when a “death receptor（受体）” protein on a doomed cell’s membrane receives a signal to die. Within seconds, apoptosis-specific “executioner”（刽子手）proteins begin to cut apart the cell’s proteins and destroy the cell. Immune system cells descend, and the cell is soon gone.
- Apoptosis has two main functions in animals.
  - First, **apoptosis eliminates excess cells, carving out functional structures** such as fingers, toes, nostrils, and ears as an animal grows. The second on of apoptosis is to **weed out aging or defective cells** that otherwise might harm the organism.but not for long.
- Plant cells die, too, but not in precisely the way that animal cells meet their programmed fate. Instead, plant cells are digested by enzymes in their own vacuoles（液泡）; when the vacuole bursts, the cell dies. Plants also use a form of cell death to kill cells infected by fungi or bacteria, limiting the spread of the pathogen.

HOME WORK

1. What are the three main events of the cell cycle?
2. What happens during interphase?
3. Describe two functions of apoptosis.

THANKS

感谢观看