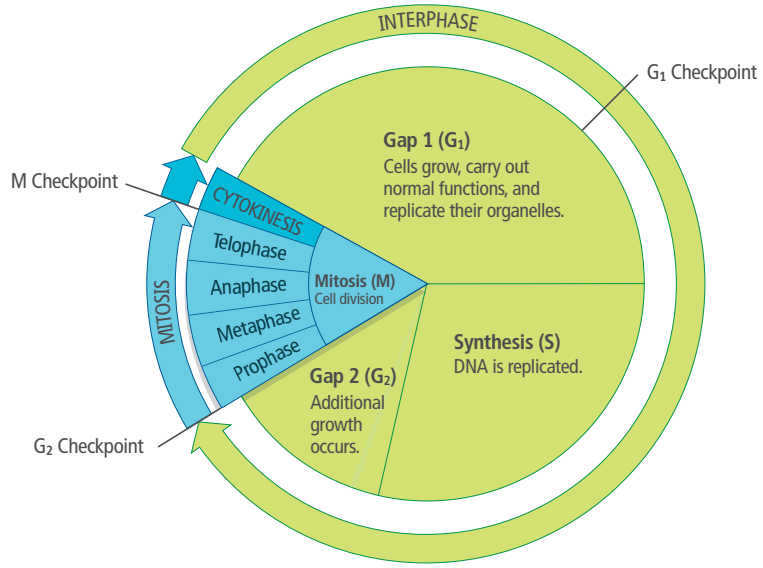
Mitosis and Cytokinesis

Cells spend most of their time in the interphase part of the cell cycle. Interphase plays an important role in preparing the cell to divide. It provides critical time for the duplication of organelles and DNA replication as well as cell growth. By the end of interphase, the cell's DNA and organelles have been replicated, and the cell is large enough to divide.

FIGURE 6: The cell cycle is an orderly process that prepares the cell for division.



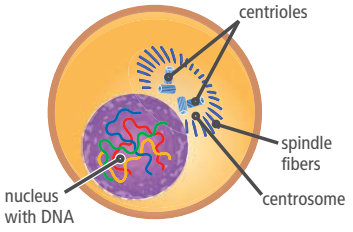
Explain Do you think this model of the cell cycle is accurate for all cells? Explain your answer.

After interphase, the cell undergoes the fourth stage of the cell cycle—mitosis. Mitosis is the stage during which cell division takes place. At the end of mitosis, the process of cytokinesis divides the cell cytoplasm. The result is two daughter cells that are genetically identical to the original, or parent, cell.

Collaborate Discuss this question with a partner: How do you think the cell divides its DNA evenly to give each daughter cell an identical copy of the genetic material?

Specialized structures called centrosomes are involved in mitosis in animal cells. The centrosome is a small region of cytoplasm that produces protein fibers called microtubules. Centrioles are cylinder-shaped organelles made of short microtubules. Before an animal cell divides, the centrosome, including the centrioles, doubles and the two new centrosomes move to opposite ends of the cell. Microtubules grow from each centrosome, forming spindle fibers. These fibers attach to the DNA and help it divide between the two cells.

FIGURE 7: Centrosomes contain structures called centrioles. Spindle fibers are organized at the centrosome.



The Cell Cycle in Detail

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Hands-On Activity

Animating Mitosis Make a flipbook to model the stages of mitosis in action.

The combined processes of mitosis and cytokinesis produce two genetically identical daughter cells. Mitosis divides a cell's nucleus into two genetically identical nuclei, each with its own full set of DNA. This process occurs in all of your body cells—except sex cells, the cells that form eggs or sperm—and prepares them for cytokinesis. Although mitosis and cytokinesis are continuous processes, scientists have divided them into phases to make them easier to understand and discuss. The four main phases of mitosis are prophase, metaphase, anaphase, and telophase. Cytokinesis begins during late anaphase and ends in telophase.

FIGURE 8: The Cell Cycle

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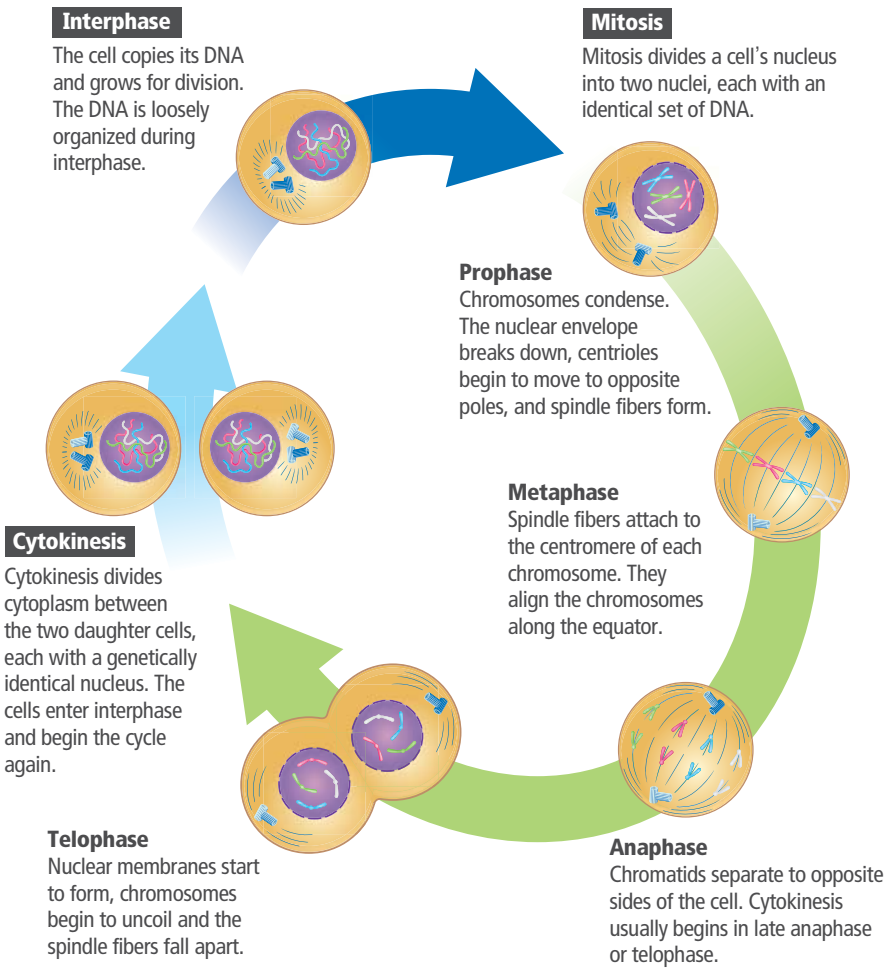


Analyze What mechanisms ensure that each cell receives an identical set of DNA during mitosis? Use evidence from Figure 8 to support your answer.

Systems and System Models

Use the model of the cell cycle shown in Figure 8 to answer the following questions.

1. Human cells have 46 chromosomes. How many chromosomes should be present during the G_2 phase of the cell cycle? How many should be in each daughter cell after cytokinesis? Explain your answers.
2. How would you describe the phases of mitosis in your own words?

Asexual Reproduction

Reproduction is a process that makes new organisms from one or more parent organisms and can occur in one of two ways—sexually and asexually. Sexual reproduction involves the joining of two specialized cells called gametes (eggs and sperm cells), one from each of two parents. Sexual reproduction requires two parents and takes longer, but it produces offspring that are genetically unique because they have a mixture of genes from both parents.

Asexual reproduction can occur relatively quickly, and the offspring are genetically identical to the parent organism. Prokaryotes and some eukaryotes reproduce asexually. Remember that prokaryotes do not have a nucleus. This typically allows prokaryotic cells to divide much faster. Because prokaryotes are single-celled, the resulting daughter cells are new single-celled organisms. The offspring that result are, for the most part, genetically identical to each other and to the original single-celled parent.

Predict Although bacteria and other single-celled organisms can produce genetically identical offspring, they sometimes still exchange DNA by passing it from bacterium to bacterium. What might be the advantage of exchanging DNA in this way?

Binary Fission and Mitosis

Prokaryotes, such as bacteria, lack not only a nucleus but also membrane-bound organelles and spindle fibers. Prokaryotes also have much less DNA than most eukaryotes have. The DNA of most bacteria is in the form of a single circular chromosome, instead of the linear chromosomes found in your cells.

Bacteria reproduce through a process called binary fission, which differs from mitosis in several ways. Binary fission starts when the bacterial chromosome is copied. Both chromosomes are attached to the cell membrane on opposite sides of the cell. As the cell grows and gets longer, the chromosomes move away from each other. When the cell is about twice its original size, it undergoes cytokinesis. The membrane pinches inward, and a new cell wall forms between the two chromosomes, which completes the separation into two daughter cells.

FIGURE 10: Models of binary fission and mitosis

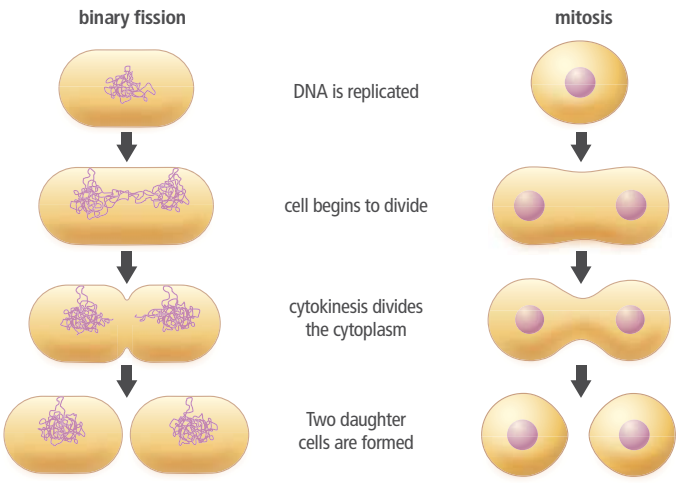
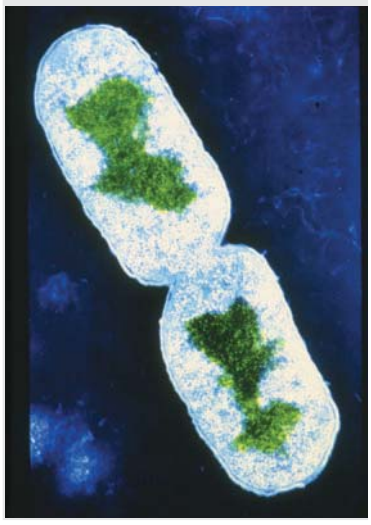


FIGURE 9: In binary fission, the original cell divides into two genetically identical cells.



Model Construct a Venn diagram comparing binary fission and mitosis.

Mitotic Reproduction

Some eukaryotes also reproduce asexually through mitosis. Have you ever grown a new plant from a stem cutting? Or seen a new sea star growing from the arm of another one? These new organisms are the result of mitotic reproduction and are therefore genetically the same as the parent organism. Mitotic reproduction is especially common in simpler plants and animals. It occurs in both multicellular and unicellular eukaryotes. Mitotic reproduction can take several forms depending on the organism. Types of mitotic reproduction include budding, fragmentation, and vegetative reproduction.

FIGURE 11: Forms of mitotic reproduction

Budding A new genetically identical individual cell forms on the body of the parent cell.

Vegetative Reproduction Multicelled structures from an organism develop into a new genetically identical organism.

Fragmentation A piece of an organism grows into a new genetically identical organism.

Both sexual and asexual reproduction are utilized in farming, industry, and scientific research. Food crops such as strawberries and almonds are pollinated by bees. These and other pollinators help plants carry out sexual reproduction and produce fruit. Horticulturists and home gardeners can use fragmentation and vegetative reproduction to produce new plants. For example, a piece of a leaf from an African violet plant can grow into a new African violet plant. Potato plants can be grown by planting a piece of potato that contains an "eye" in the garden.

Binary fission and budding are also widely used in industry. Many drugs, such as vaccines and insulin, are produced by growing colonies of bacteria that have been genetically modified to produce the drug. Millions of people with diabetes use synthetic insulin, which is produced by genetically modified bacteria or yeast.

Collaborate If you wanted to grow a food crop for human consumption, which do you think would be best for the plant to use—sexual or asexual reproduction? Write your argument and explain it to a partner.

Model Develop a model to illustrate how mitosis results in two genetically identical daughter cells. Include chromosomes in your model, and use different colors, materials, or symbols to show how the cell duplicates, organizes, and separates chromosomes during interphase and mitosis.