



# UNIT 6: LIFE CYCLE



Khaled bin Sultan  
Living Oceans  
Foundation

# CORAL REEF ECOLOGY CURRICULUM



# Khaled bin Sultan

---

# Living Oceans

Foundation

This unit is part of the *Coral Reef Ecology Curriculum* that was developed by the Education Department of the Khaled bin Sultan Living Oceans Foundation. It has been designed for secondary school students, but can be adapted for other uses. The entire curriculum can be found online at [lof.org/CoralReefCurriculum](http://lof.org/CoralReefCurriculum).

**Author and Design/Layout:** Amy Heemsoth, Director of Education

**Editorial assistance provided by:** Andrew Bruckner, Ken Marks, Melinda Campbell, Alexandra Dempsey, and Liz Rauer Thompson

**Illustrations by:** Amy Heemsoth

**Cover Photo:** ©Michele Westmorland/iLCP

©2014 Khaled bin Sultan Living Oceans Foundation. All rights reserved.

Unless otherwise noted, photos are property of the Khaled bin Sultan Living Oceans Foundation. The Khaled bin Sultan Living Oceans Foundation and authors disclaim any liability for injury or damage related to the use of this curriculum. These materials may be reproduced for education purposes. When using any of the materials from this curriculum, please include the following attribution: Khaled bin Sultan Living Oceans Foundation *Coral Reef Ecology Curriculum* [www.lof.org](http://www.lof.org)

The Khaled bin Sultan Living Oceans Foundation (KSLOF) was incorporated in California as a 501(c)(3), public benefit, Private Operating Foundation in September 2000. The Living Oceans Foundation is dedicated to providing science-based solutions to protect and restore ocean health through research, outreach, and education. The educational goals of the Khaled bin Sultan Living Oceans Foundation and development of the *Coral Reef Ecology Curriculum* are generously supported by Prince Khaled bin Sultan of Saudi Arabia. For more information, visit [www.lof.org](http://www.lof.org).

Follow Us on Social Media:

**Facebook:** [facebook.com/livingoceansfoundation](https://facebook.com/livingoceansfoundation)

**Twitter:** [@LivingOceansFdn](https://twitter.com/LivingOceansFdn)

**Instagram:** [livingoceansfoundation](https://instagram.com/livingoceansfoundation)

**Pinterest:** [pinterest.com/livingoceansfdn](https://pinterest.com/livingoceansfdn)

Khaled bin Sultan Living Oceans Foundation  
7 Old Solomons Island Road, Suite 200  
Annapolis, MD, 21401, USA  
(443) 221.6844  
[education@lof.org](mailto:education@lof.org)

SCIENCE WITHOUT BORDERS®



Khaled bin Sultan  
Living Oceans  
Foundation

## STANDARDS

- **CCSS:** RST.9-10.1, 2, 4, 5, 6, 8, 10; RST.11-12.1, 2, 4, 6
- **NGSS:** HS-LS1-1, HS-LS1-4, HS-LS3-2
- **OLP:** 5.C.44, 5.C.47, 5.C.48, 5.C.53, 5.C.55, 5.C.56

## ONLINE CONTENTS

- [Life Cycle Quiz](#)

# LIFE CYCLE

This lesson is a part of the *Life Cycle* unit, which explains the cell cycle and the life cycle of corals. Below is a summary of what is included in the entire unit.

## UNIT CONTENTS

### A. [Background Information](#)

- Coral Life Cycle
- Cell Cycle
- Mitosis
- Meiosis
- Coral Cycles

### B. Lessons

#### [Coming Full Circle](#)

- An activity to make a story wheel of the coral life cycle

#### [Dividing the Parts](#)

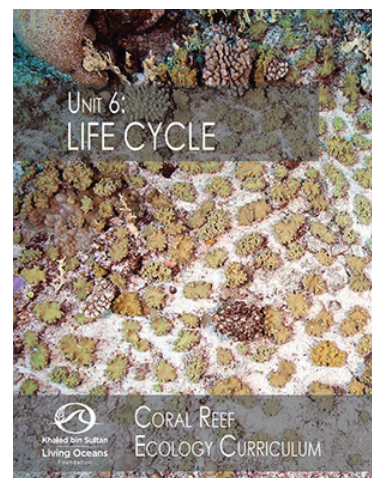
- A crossword puzzle to match the mitosis cell structures to their function

#### [Label It!](#)

- A worksheet to label the structures of a chromosome and a cell undergoing mitosis

#### [Read it! Coral Recruitment](#)

- A worksheet to accompany the [Coral Recruitment in the Garden of Good and Evil: How Baby Corals Get Started on Coral Reefs](#) field blog



# BACKGROUND INFORMATION

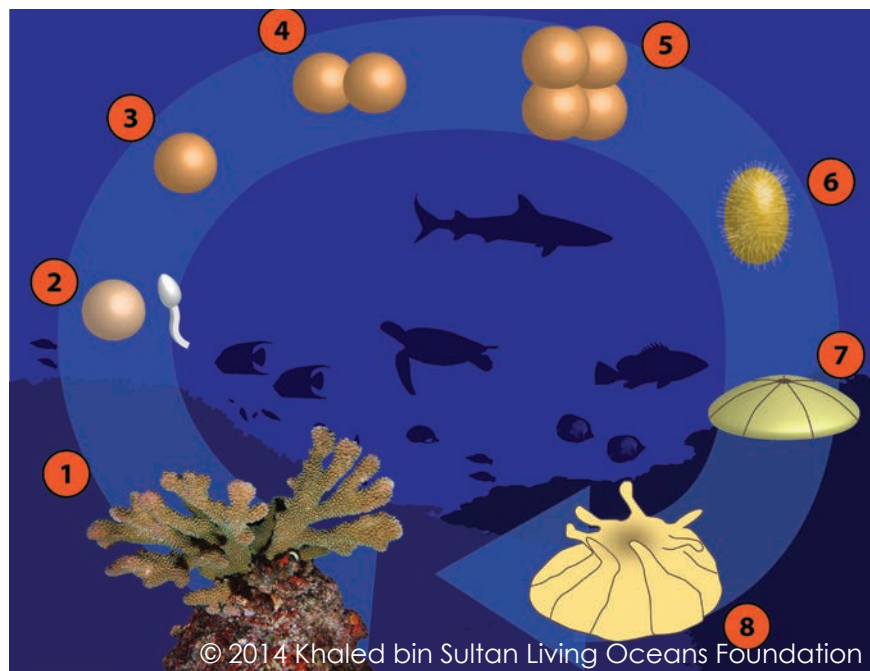
## A) CORAL LIFE CYCLE

A **life cycle** is a series of events in an organism's life, as it changes from one form to the next, and eventually returns to the starting state, by means of reproduction. In this lesson, we will learn about the cell cycle and the life cycle of corals.

In *Unit 5: Coral Reproduction*, we learned that there are two ways that corals undergo **sexual reproduction**. There are **broadcast spawners** and **brooders**. The broadcast spawner's life cycle is shown in figure 6-1. The numbers referenced below correlate with the numbers on the diagram.

Broadcast Spawners:

1. Mature corals use energy to produce gametes. Gametes are produced through meiosis (see section 2) *Meiosis*).
2. When the environmental conditions are right, corals release their gametes (egg and sperm) into the water column. The gametes float to the surface because they are **positively buoyant**. External **fertilization** takes place between male and female gametes (see *Unit 5: Coral Reproduction*).
3. The egg is now fertilized and begins to develop. The fertilized egg is called a **zygote**. During this phase, the zygote drifts in the current.
4. The zygote continues to drift and begins to go through cell division. This type of cell division is known as mitosis (see section 1) *Mitosis*). After the first division, there are now two cells.
5. Each of these two cells undergo mitosis, creating 4 new cells. These cells continue to go through mitosis, dividing over and over again, creating an **embryo**.
6. A **larva** forms called a **planula**. The planula is a type of **zooplankton**. In this case, it's a coral plankton. The planula is able to maneuver by the **cilia** that covers its body. These planulae are microscopic and although they have the ability to move, they are not strong enough to swim against the current. During this phase, the planula is looking for a suitable solid substrate to settle on.
7. The planula settles on a hard substrate and begins undergoing metamorphosis. **Metamorphosis** occurs when an organism develops from a juvenile to an adult.
8. The juvenile **polyp** begins to lay down a calcium carbonate ( $\text{CaCO}_3$ ) **corallite**. If the coral is colonial, then the polyp will go through **asexual reproduction** to form more polyps, expanding the size of the coral colony and increasing the number of coral polyps. When the adult polyps become sexually mature, the life cycle will begin all over again (steps 1-8).



**FIGURE 6-1.**  
Broadcast  
spawner's life  
cycle

© 2014 Khaled bin Sultan Living Oceans Foundation

Brooders:

1. Corals expend more energy to create a fully developed planula.
  - a. Brooding corals release only **negatively buoyant** (when an object does not float in a liquid) sperm into the water column.
  - b. The sperm finds unfertilized eggs in an egg-carrying coral. Fertilization takes place within the coral.
  - c. The fertilized egg (zygote) undergoes mitotic cell division (see section 1) *Mitosis*) forming an embryo.
  - d. The embryo grows into the planula within the brooding coral.
2. The planula is released from the coral polyp. Steps 6-8 are the same as broadcast brooders. See the steps above.

## B) CELL CYCLE

All life begins with a single cell. Just like living organisms go through a life cycle (which we just saw with corals in Section A), all cells go through a cell cycle.

How do we go from a single cell to a complex, multicellular organism? The answer is cell division. **Cell division** is when a **parent cell** divides into two **daughter cells**. From one cell, the cell divides, creating two cells. Then the two new cells divide creating four cells, and so on and so on. Our bodies are made of trillions of cells and they are constantly dividing!

Cell division is necessary for life. Not only do cells divide as organisms grow and develop, but more cells are created to repair damaged or old and worn out cells. For instance, if you scrape your knee, you bleed, a scab forms, and eventually new skin replaces the scab. This all occurs because new cells are being created. Your skin cells divide to create more skin cells to replace the ones that were damaged.

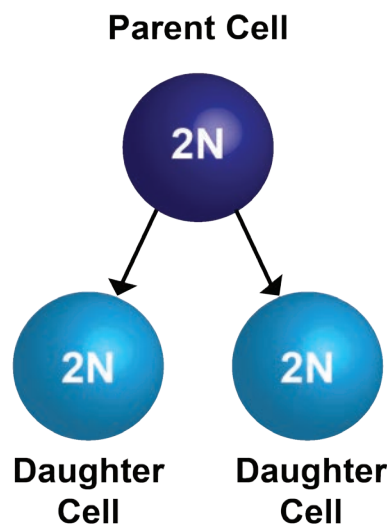
**Cell theory** states that cells can only arise from other living cells. The theory also states that all organisms are composed of one or more cells and cells are the most basic unit of life.

Organisms from the Domain **Eukarya** have complex cells that divide and replicate in a **cell cycle**. Eukaryotes have two different cell cycles: meiosis and mitosis. Each of these cell cycles plays a vital role in the larger life cycle of an organism.

As we dive into cell cycles, refer to the Appendix if you need to review the parts of a chromosome or cell.

### 1) MITOSIS

The first cell cycle we will look at includes a type of division called **mitosis**. During this cycle, one parent cell divides to create two identical daughter cells that have their own nucleus and identical chromosomes. During mitosis, organisms have **diploid** cells ( $2N$ ), which are cell cycles that have two copies of each chromosome (figure 6-2).



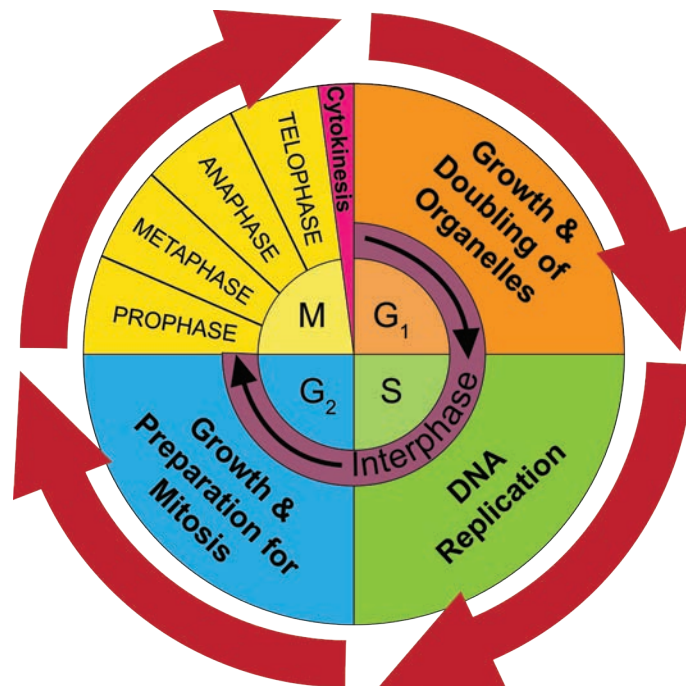
**FIGURE 6-2.** Mitosis: cells produced by each division and number of chromosomes



There are two parts that make up this cell cycle – interphase and mitosis. Before cell division begins, the cell is in interphase. **Interphase** makes up the majority of the cell cycle (figure 6-3). This phase prepares the cell for division during mitosis and can be broken into three phases: the growth one phase or **Gap 1 (G<sub>1</sub>)**, followed by **Synthesis (S)**, and then growth two phase or **Gap 2 (G<sub>2</sub>)**.

Phase	What happens?
G <sub>1</sub>	The cell grows, doubling in mass and organelles in preparation for cell division.
S	DNA is replicated. Each chromosome gains an identical copy.
G <sub>2</sub>	Microtubules are replicated. They help the cell separate chromosomes during mitosis. The cell is ready to enter mitosis.

The mitotic phase, sometimes referred to as the *M* phase, only lasts for a short period of time. During this phase, the chromosomes separate and undergo cytokinesis. **Cytokinesis** is the division of the parent cell into two daughter cells (figure 6-2). There are several different mitotic phases (figure 6-3).



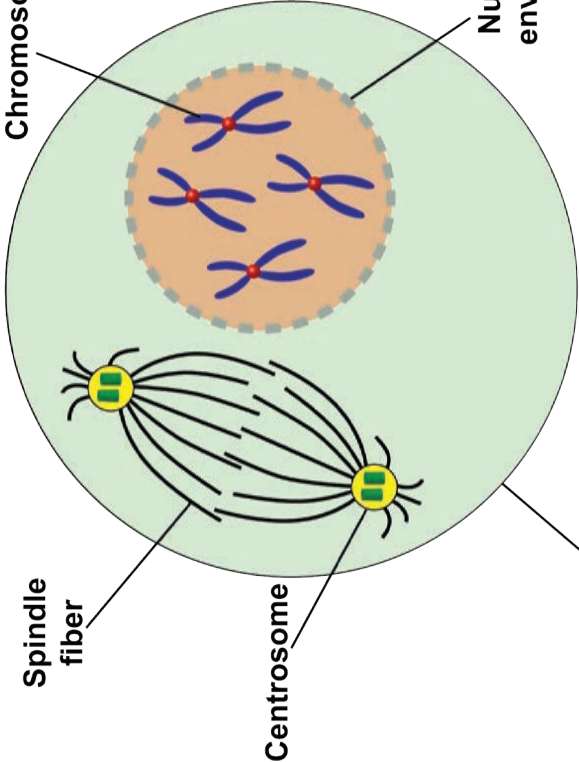
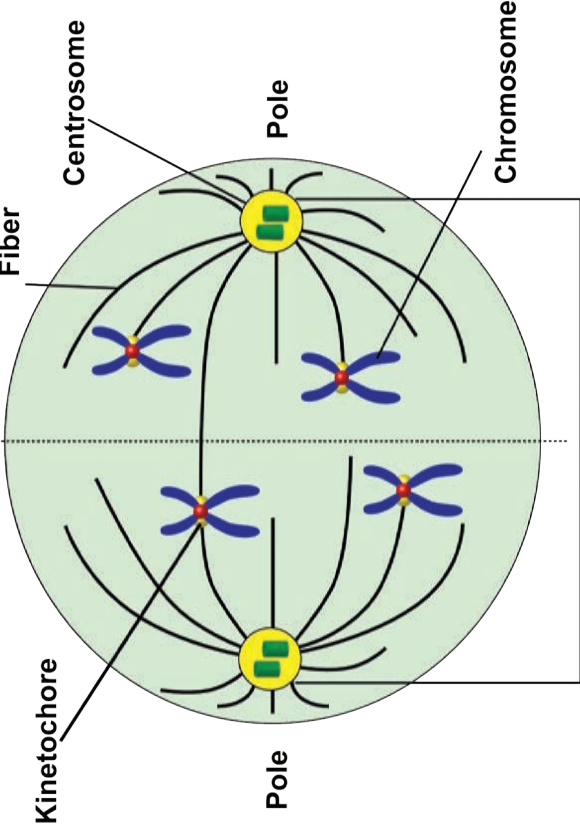
**FIGURE 6-3.** Mitosis is only the M part. The cell cycle is continuous, which is illustrated by the red arrows.

© 2014 Khaled bin Sultan Living Oceans Foundation

We can remember the acronym **PMAT** to help us remember the order of the phases during cell division.

- **P**rophase
- **M**etaphase
- **A**naphase
- **T**elophase

The four phases of mitotic division are: Prophase, Metaphase, Anaphase, and Telophase, which is then followed by cytokinesis.

Phase	What happens?	Diagrams
<p>Prophase</p>	<ul style="list-style-type: none"> <li>The chromosomes condense (shorten).</li> <li>Centrosomes begin moving toward opposite poles.</li> </ul>	 <p><b>FIGURE 6-4</b></p>
<p>Prometaphase</p> <p>NOTE: There are many steps that take place during prophase and metaphase that scientists often add this additional phase.</p>	<ul style="list-style-type: none"> <li>The nuclear envelope disappears. The <b>nuclear envelope</b> is a double-layered membrane that surrounds the nucleus, separating the nucleus from the cytoplasm.</li> <li>Two kinetochores form at each centromere.</li> <li>Spindle fibers attach to the kinetochores.</li> <li>Chromosomes begin migrating toward the center of metaphase plate.</li> </ul>	 <p><b>FIGURE 6-5</b></p>



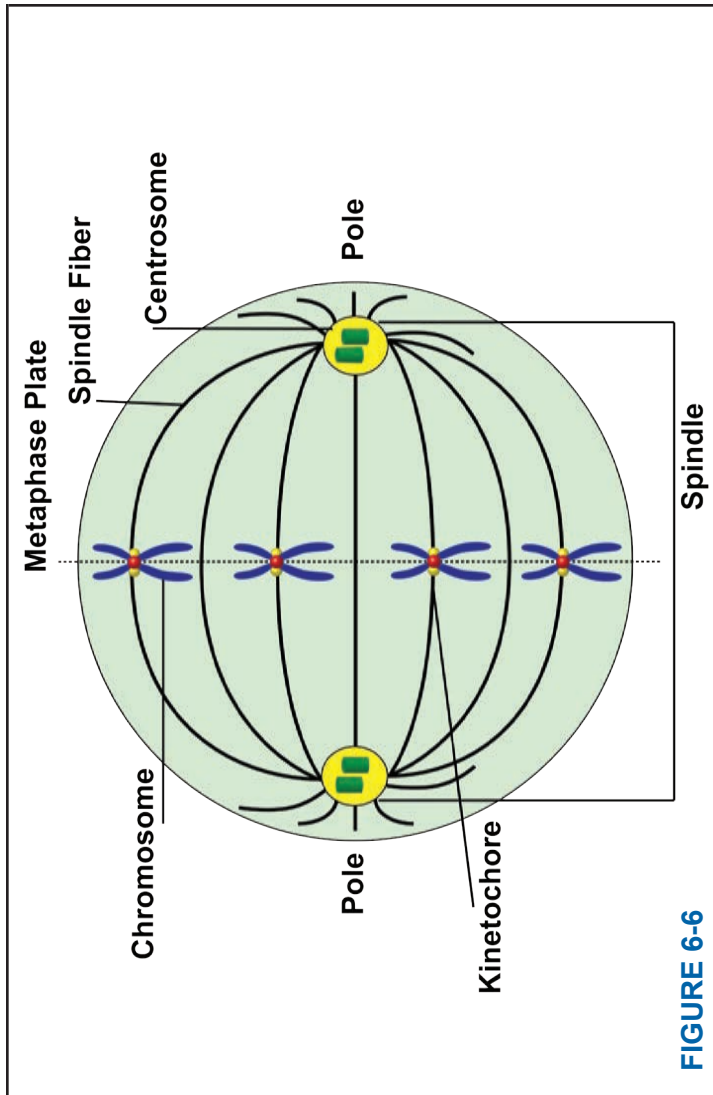


FIGURE 6-6

- Chromosomes align at the metaphase plate.

Metaphase

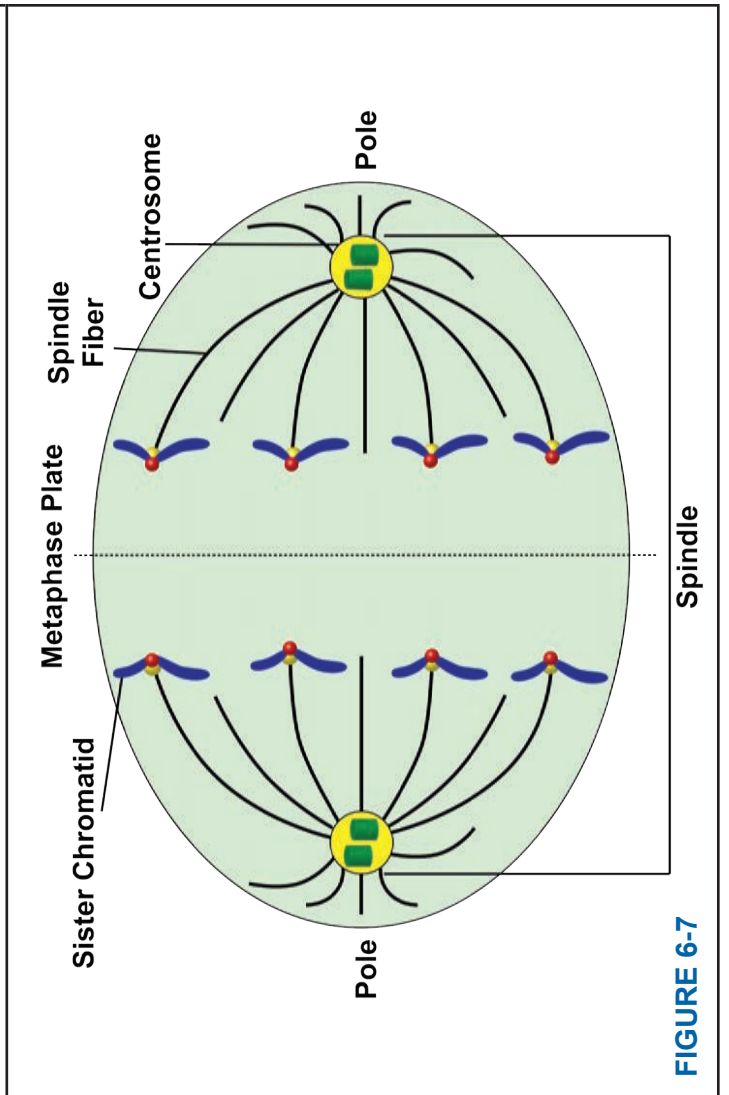
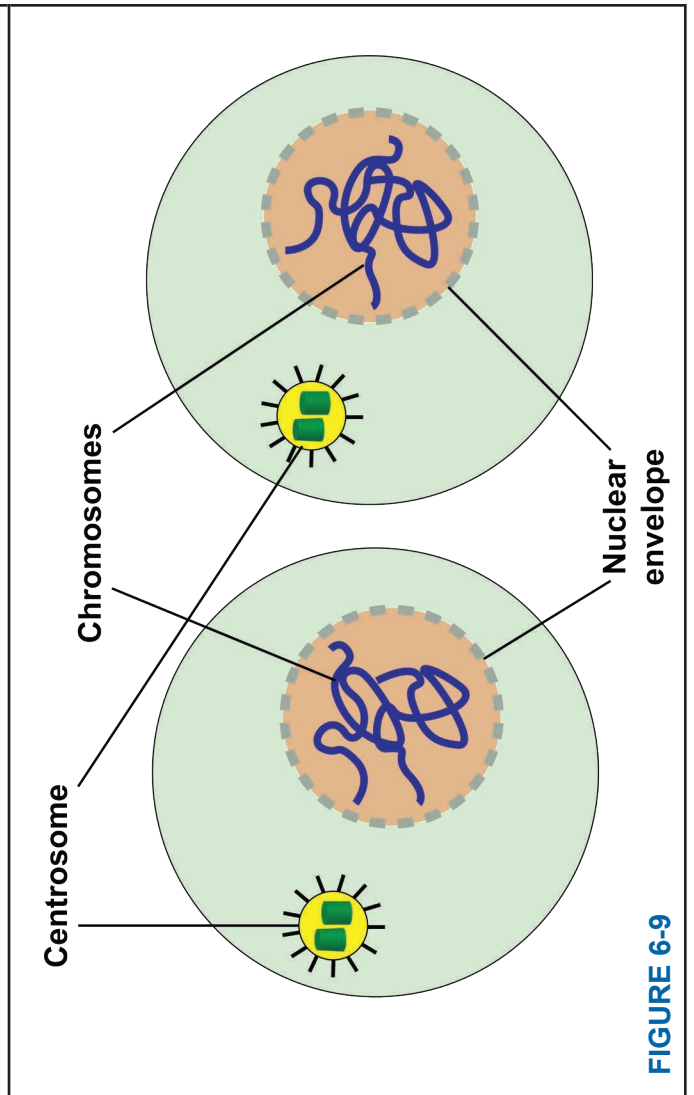
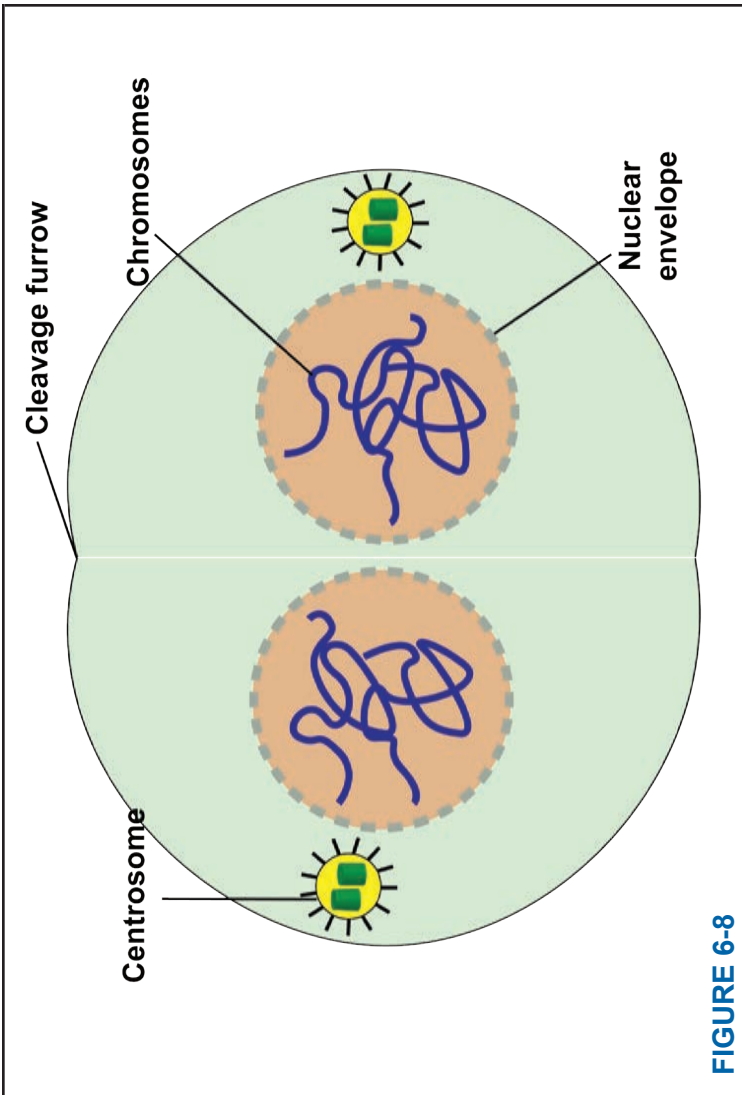


FIGURE 6-7

- Chromosomes split apart into **sister chromatids** (identical copies of chromatids).
- The spindle fibers move the chromatids toward opposite poles.
- The cell starts to elongate in preparation for division.

Anaphase





**Telophase**

- In preparation for division, the cell continues to elongate, forming a **cleavage furrow** (an indentation of the cell's surface).
- The chromosomes uncoil.
- A new nuclear envelope forms. The spindle fibers disappear.

**Cytokinesis**

- The parent cell divides into two daughter cells. After cytokinesis takes place, the cell cycle continues again with the new cells going into interphase.

**Telophase**

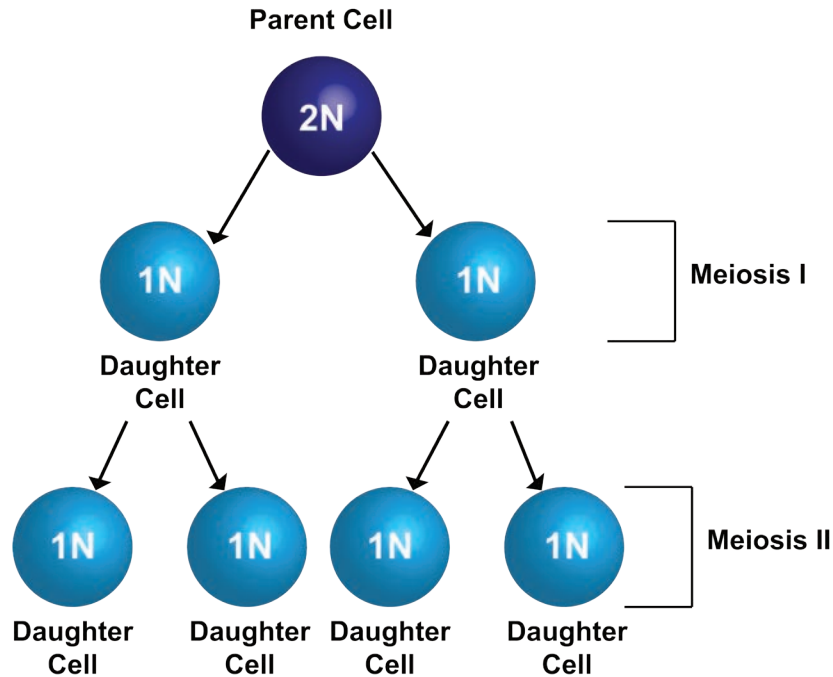
**Cytokinesis**



## 2) MEIOSIS

All sexually reproductive organisms create mature reproductive sex cells (egg and sperm) called **gametes**. They create these cells through a process known as **meiosis**.

Meiosis consists of two different stages – Meiosis I and Meiosis II (figure 6-10). Before meiosis can begin, the parent cell must undergo interphase. In mitosis and meiosis, interphase goes through the same steps. See section 1) *Mitosis* for more information about interphase. Note that interphase does not occur between Meiosis I and Meiosis II.



**FIGURE 6-10.** Meiosis: cells produced by each division and number of chromosomes

The process of meiosis begins with one parent cell, which is diploid ( $2N$ ) meaning it has two copies of the chromosomes (figure 6-10). During Meiosis I, cell division takes place creating two daughter cells, which are **haploid** ( $1N$ ) meaning that there are half the number of chromosomes of the parent cell (figure 6-10). These two haploid cells then enter Meiosis II and the cells undergo division again, without replication of the DNA. The result of this division is four daughter cells that are each haploid ( $1N$ ) (figure 6-10).

Diagrams

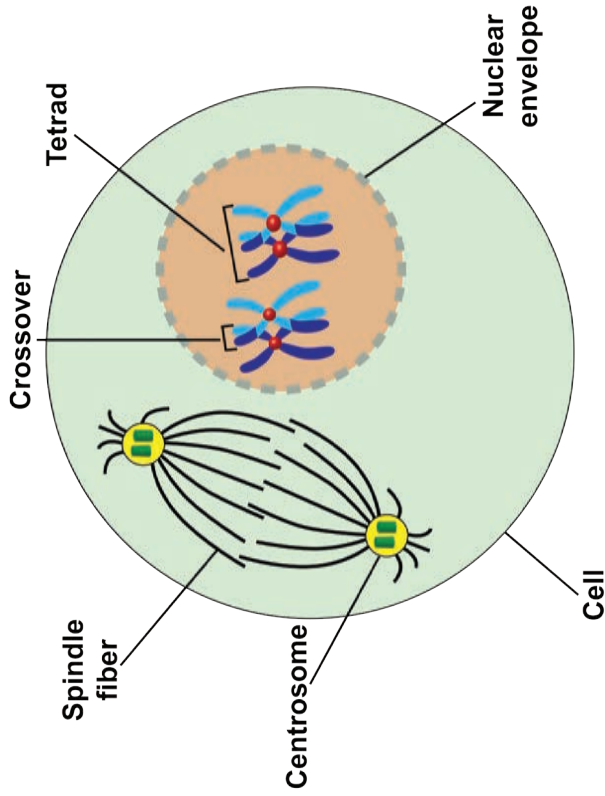


FIGURE 6-11

What happens?

- The chromosomes condense- (shorten).
- The nuclear envelope disappears.
- Centrosomes move towards opposite poles.
- **Homologous chromosomes** (one paternal and one maternal copy of a chromosome) become paired. From this point on they are known as a **tetrad**. Each tetrad is composed of four chromatids.
- Crossover can take place (figure 6-12). **Crossover** is the process of exchanging chromosome segments (DNA) between chromosomes. In other words, segments of chromosomes from mom switch spots with the same part of the chromosomes from dad. The area where crossover takes place is called the **chiasma**.
- This is the longest phase of meiosis.

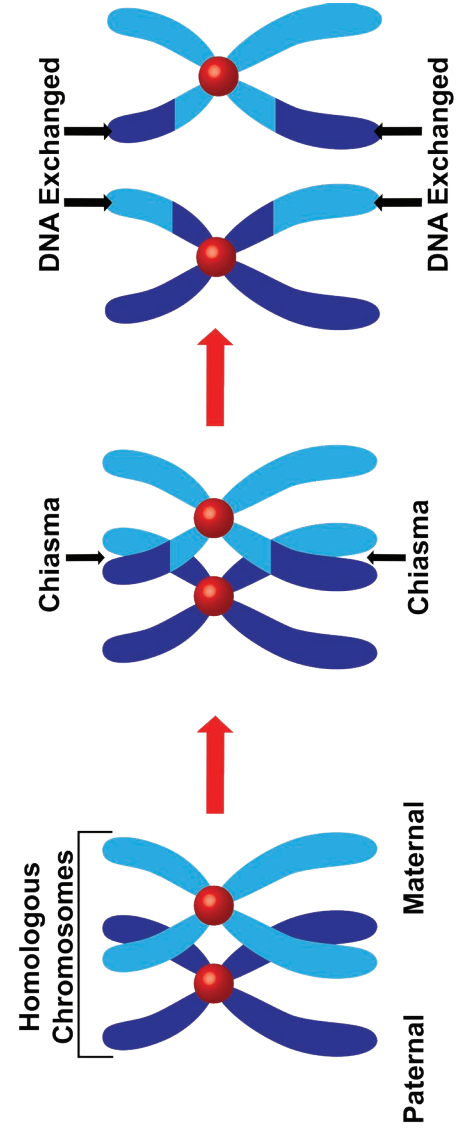


FIGURE 6-12

MEIOSIS I:

Phase

Prophase I



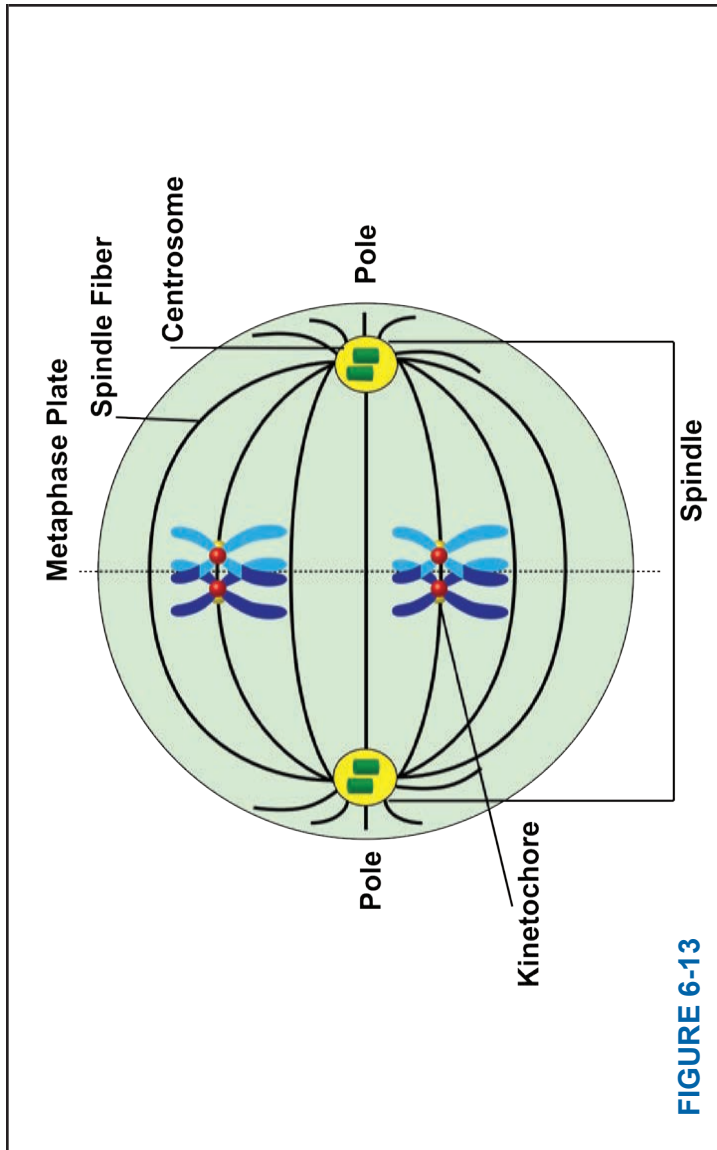


FIGURE 6-13

- Metaphase I
- Spindle fibers attach to the kinetochore.
  - Tetrads become aligned at the metaphase plate.

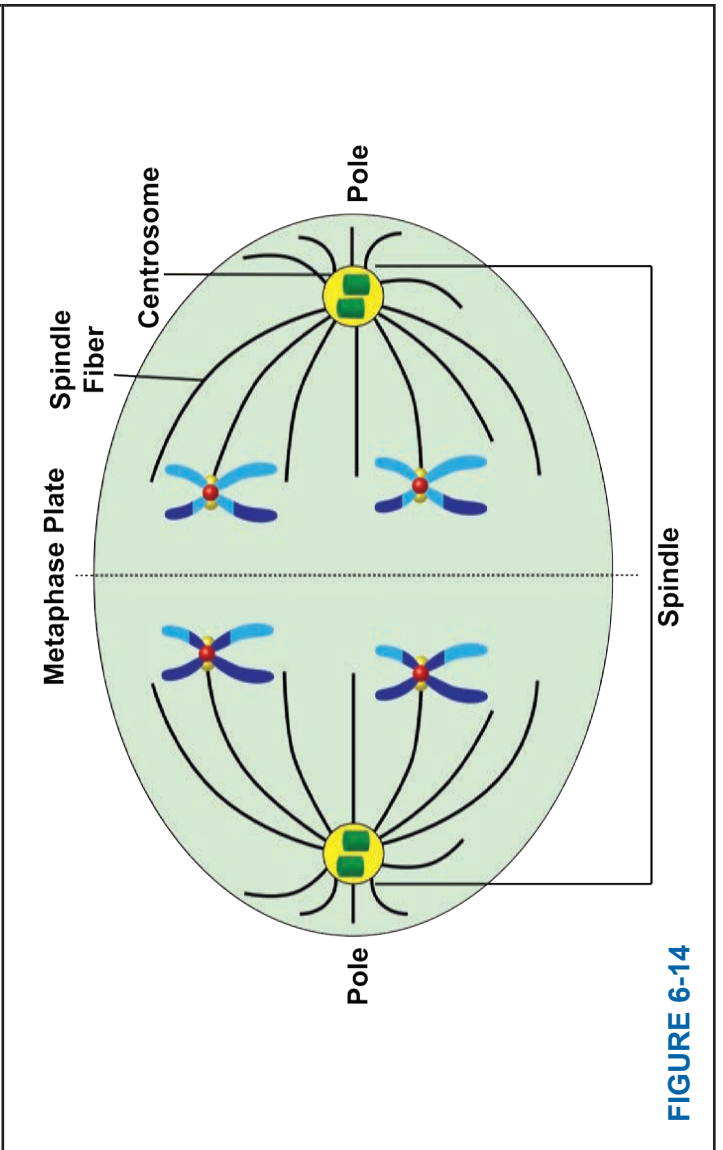


FIGURE 6-14

- Anaphase I
- The spindle fibers split the tetrad and move homologous chromosomes toward opposite poles.
  - The cell starts to elongate in preparation for division.

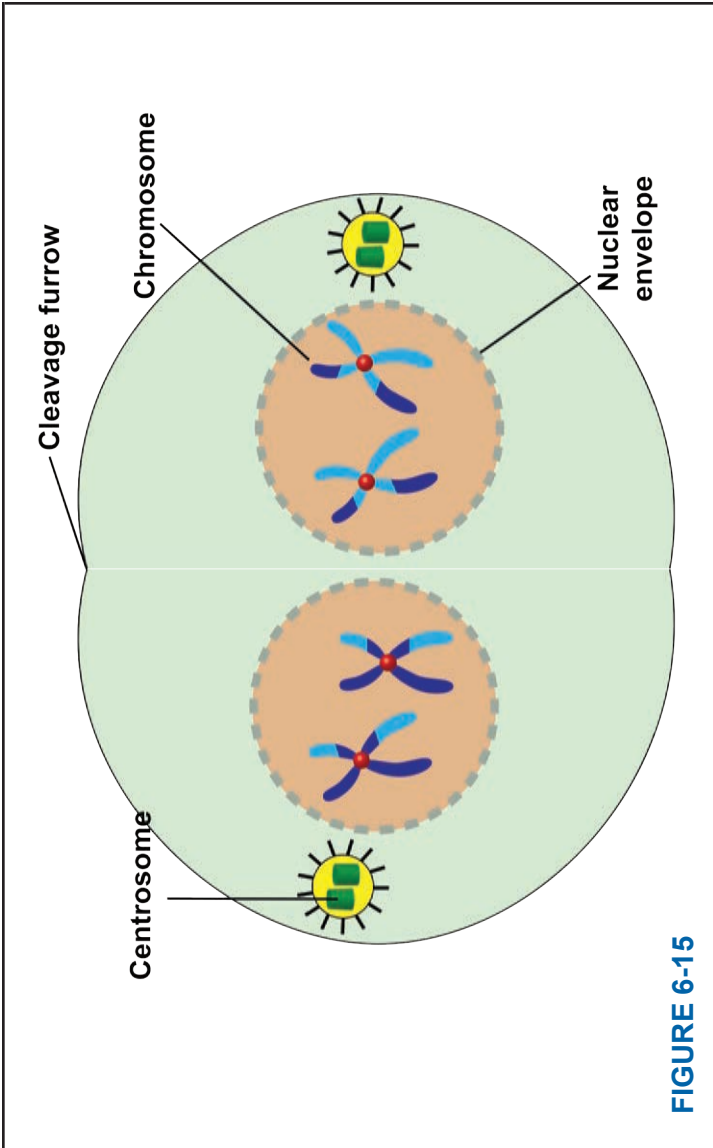


FIGURE 6-15

**Telophase I**

- In preparation for division, the cell continues to elongate, forming a cleavage furrow.
- The nuclear envelope reforms around the chromatids. The spindle fibers disappear.

**Cytokinesis I**

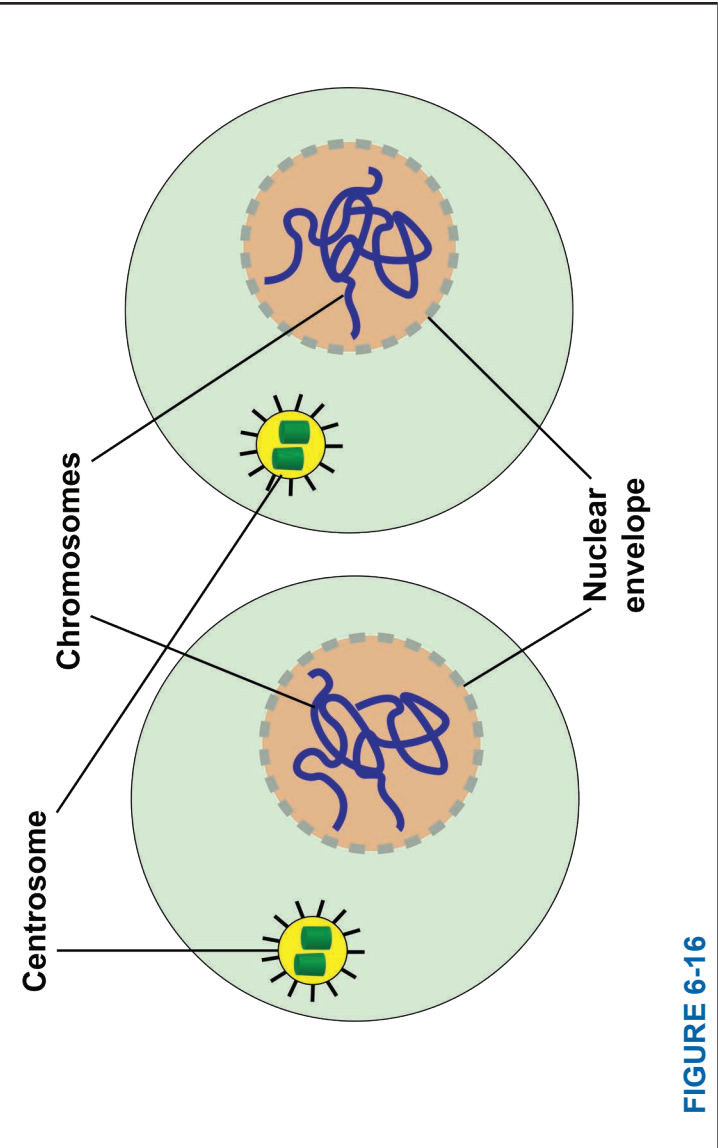


FIGURE 6-16

- The parent cell divides into two daughter cells. After cytokinesis takes place, the cycle continues. Each cell is now haploid. Figure 6-16 shows the chromosomes uncoiled, which does not always happen during telophase I.

**Cytokinesis I**

MEIOSIS II:

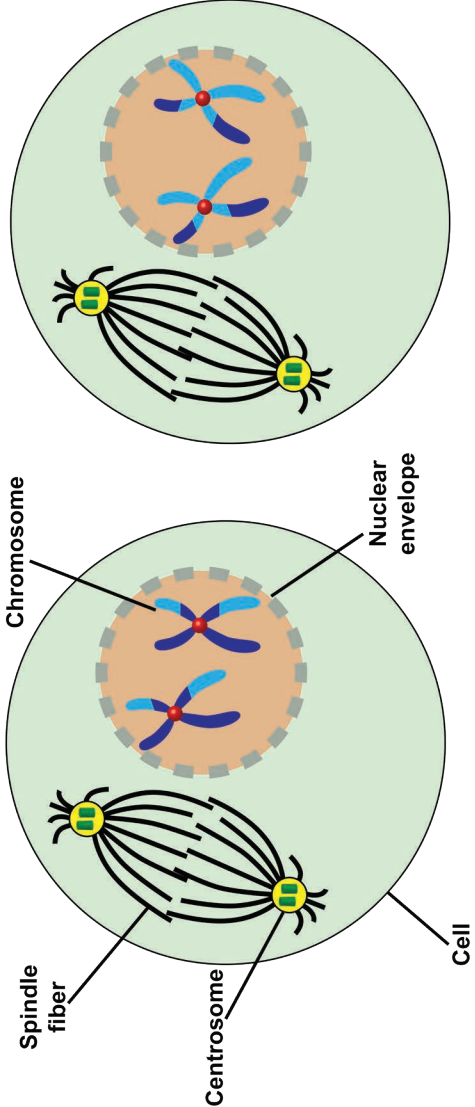
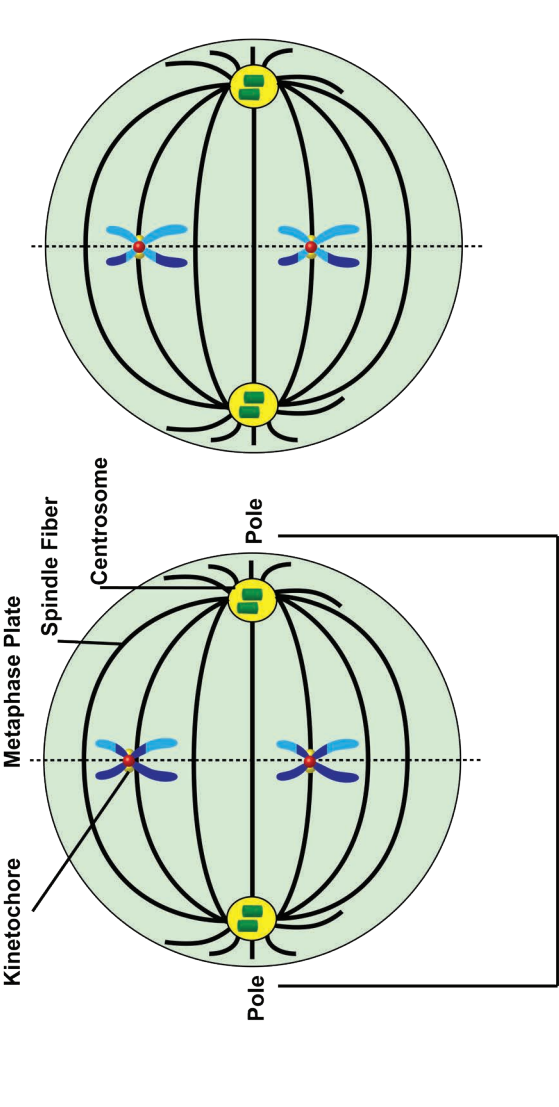
Phase	What happens?	Diagrams
<p>Prophase II</p>	<ul style="list-style-type: none"> <li>• If the chromosomes have decondensed, then they will begin to condense.</li> <li>• The nuclear envelopes disappear and centrosomes move toward opposite poles.</li> </ul>	
<p>Metaphase II</p>	<ul style="list-style-type: none"> <li>• Spindle fibers attach to the kinetochores.</li> <li>• Chromosomes line up at the metaphase plate.</li> </ul>	

FIGURE 6-17

FIGURE 6-18



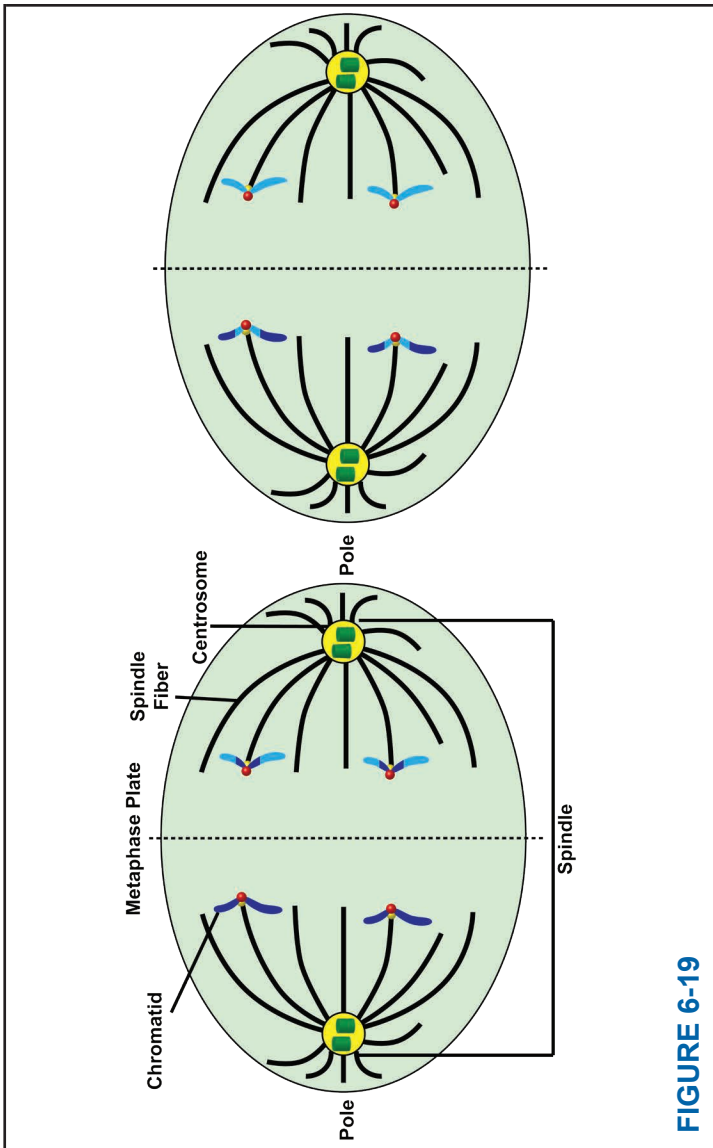


FIGURE 6-19

- Anaphase II
- The chromosomes split and each chromatid heads towards opposite poles.
  - In preparation for division, the cell continues to elongate, forming a cleavage furrow.

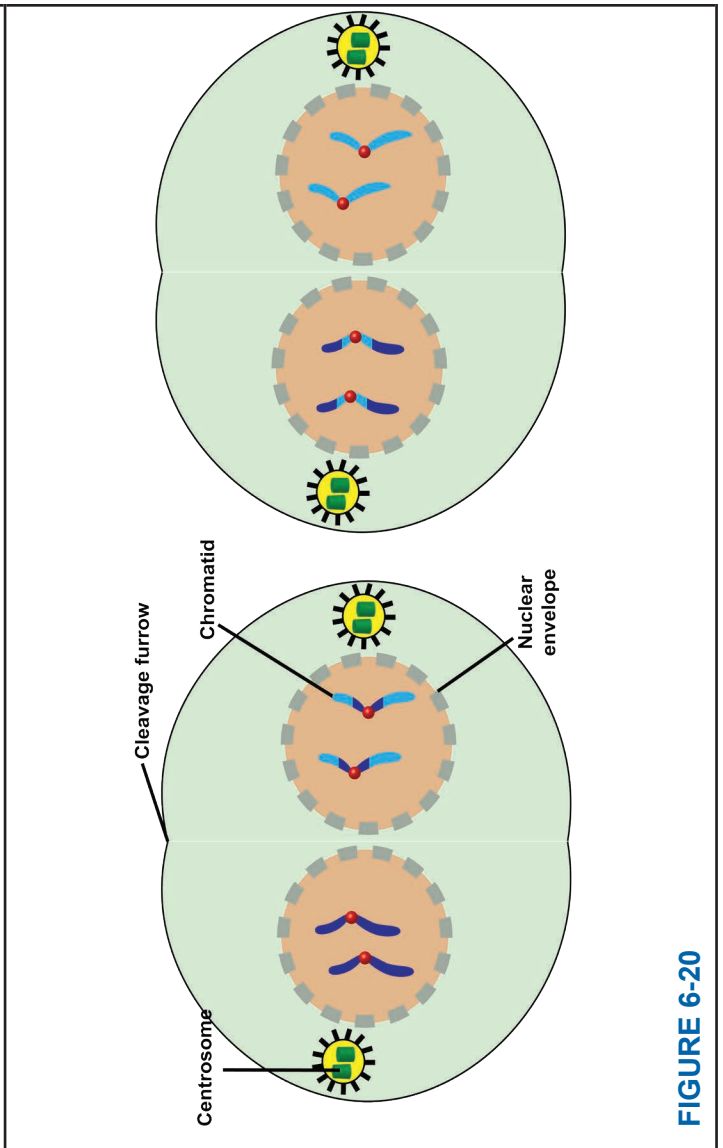


FIGURE 6-20

- Telophase II
- Chromosomes consist of one chromatid.
  - The nuclear envelopes develop around each set of chromatids.
  - The spindle fibers disappear.

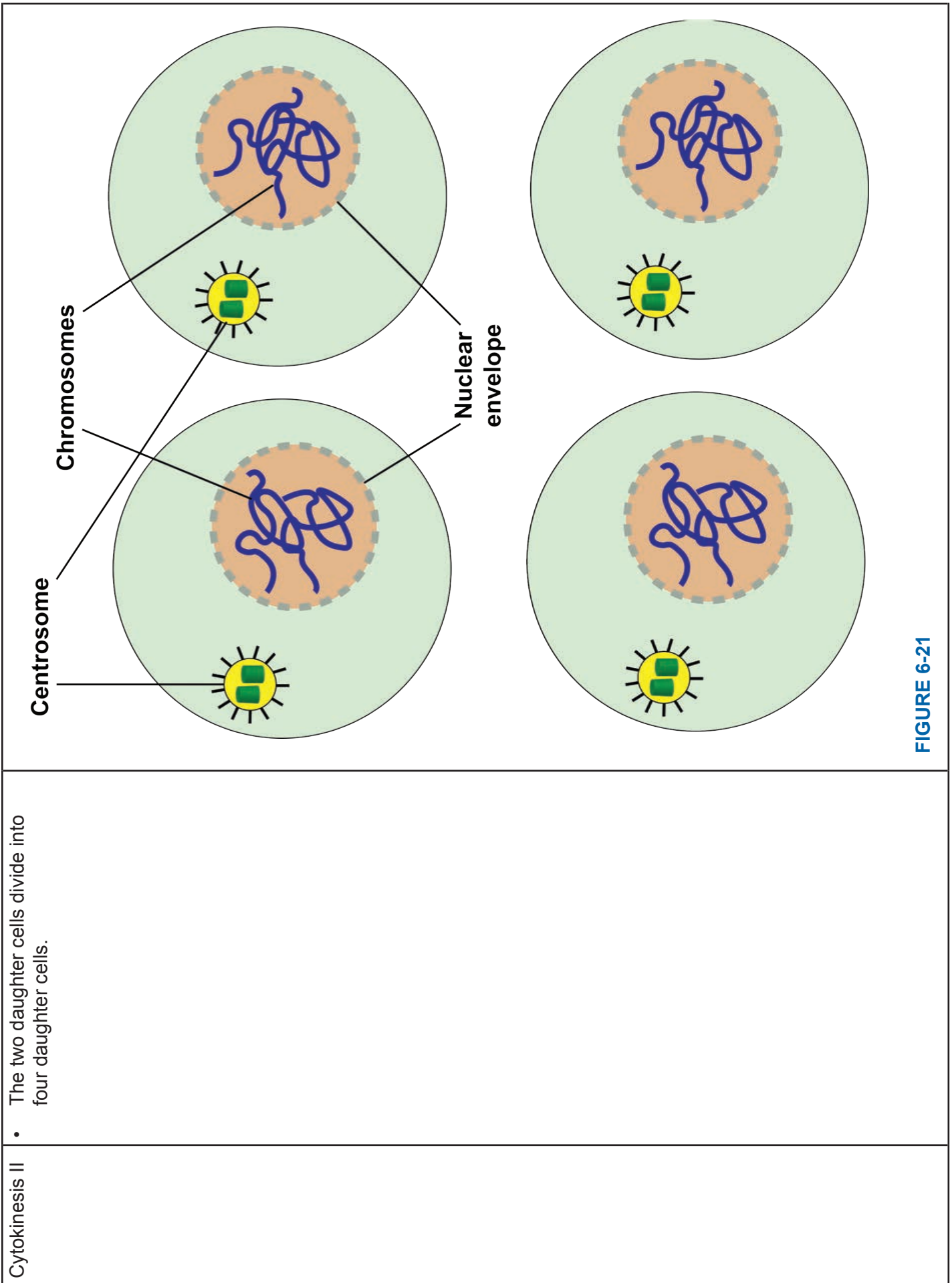
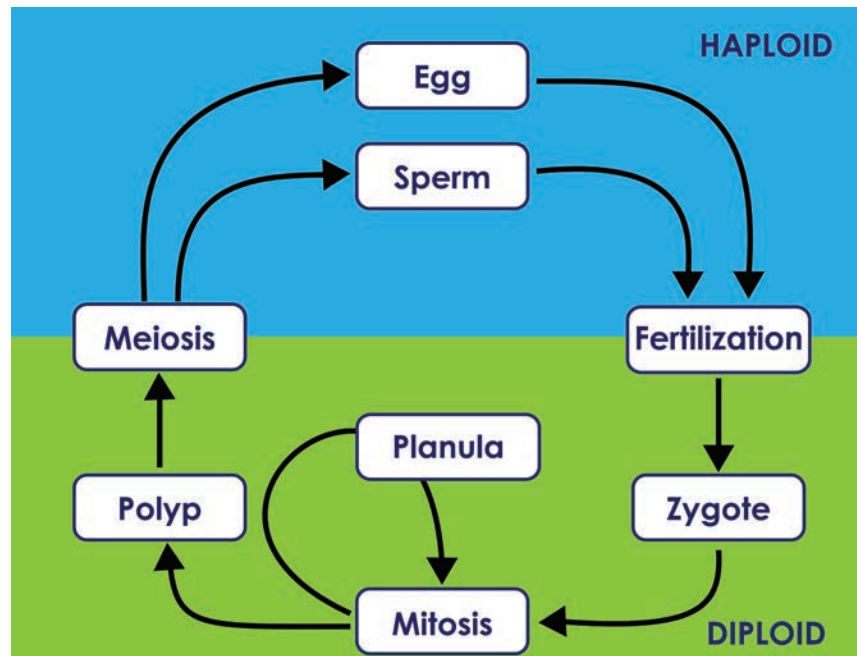


FIGURE 6-21



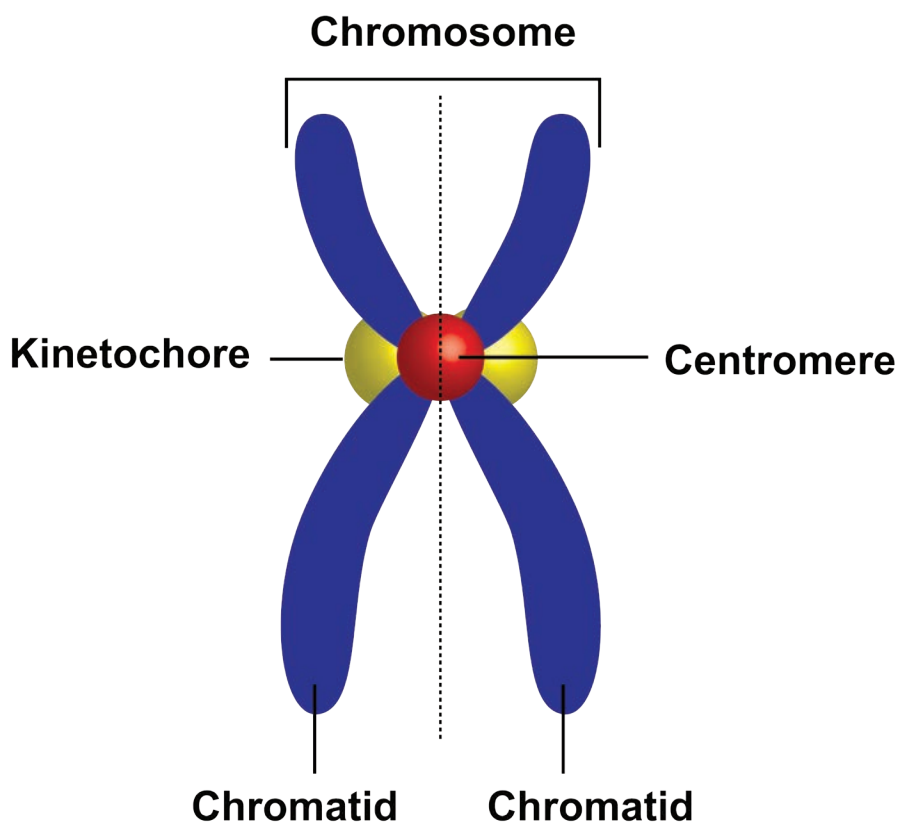
Let's recap the life and cell cycles of corals. Coral polyps become sexually mature and their cells undergo meiosis, producing gametes (egg and/or sperm). The gametes are fertilized, producing a zygote. The zygote continuously creates new cells by the process of mitosis, eventually forming a planula that settles and forms a coral polyp. As the coral grows, its cells continue to go through mitosis. When the coral polyp is sexually mature, it performs meiosis, starting the cycle all over again (figure 6-22).



**FIGURE 6-22.** Coral polyp's life cycle and cell cycles

## APPENDIX: CHROMOSOME AND CELL TERMINOLOGY

Below is a review of some of the parts of a chromosome (figure 6-23) and a cell (figure 6-24).



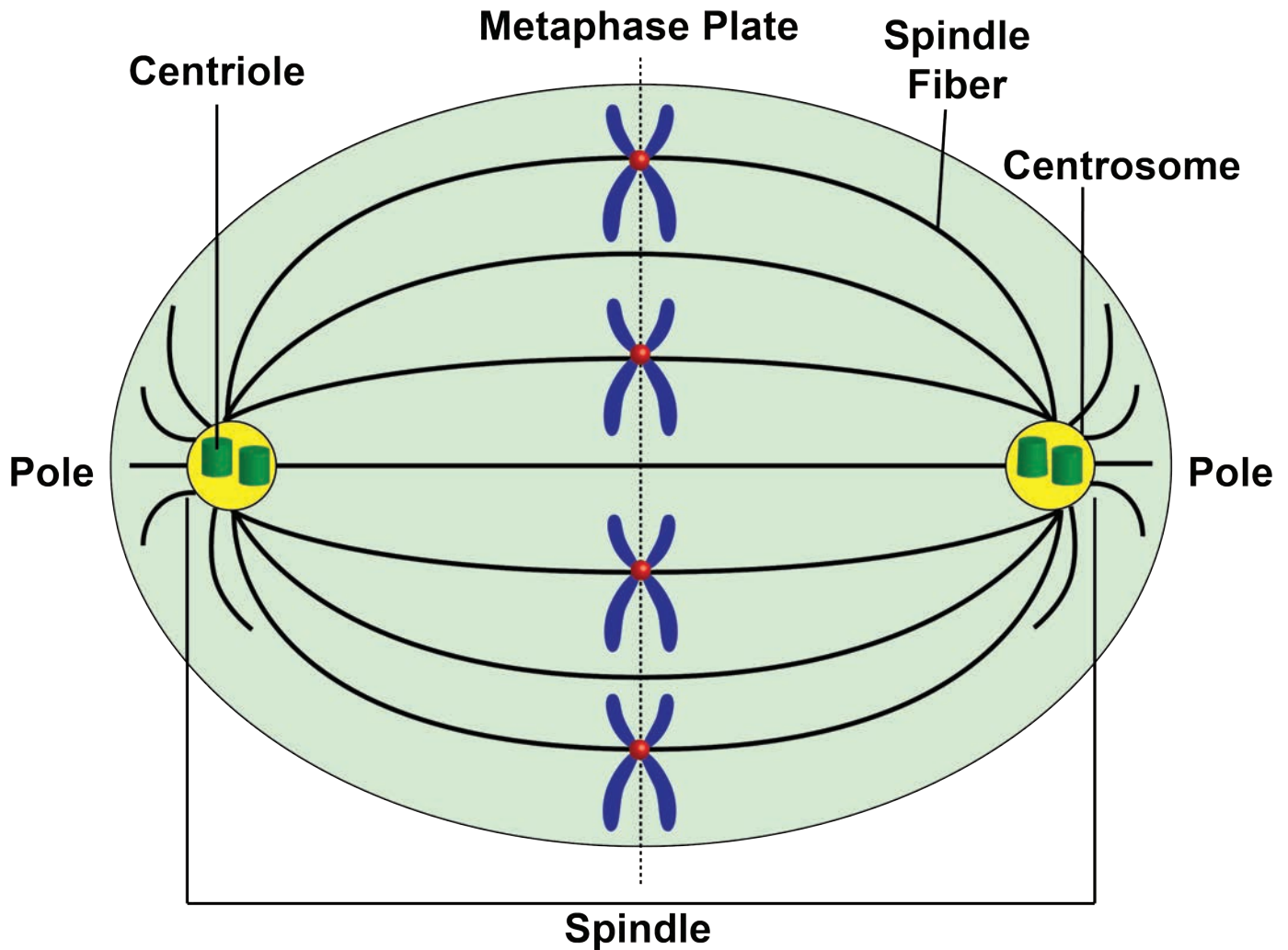
**Centromere:** The area on the chromosome where the kinetochores attach during cell division and that connects the chromatids together.

**Chromosomes:** Long strands of molecules called DNA.

**Chromatid:** When dividing the chromosome longitudinally, each half is considered a chromatid. They contain a double helix of DNA.

**Kinetochores:** A structure that forms on the centromere and is the point of attachment for microtubules during cell division.

**FIGURE 6-23.** The parts of a chromosome



© 2014 Khaled bin Sultan Living Oceans Foundation

**FIGURE 6-24.** The parts of a cell during cell division

**Centriole:** A cylindrical organelle that consists of microtubules. They help to anchor the spindle fibers during cell division.

**Centrosome:** Replicates during interphase. It is part of the spindle and contains two centrioles. During cell division, they migrate to opposite poles and aid in pulling apart the chromosomes.

**Metaphase plate:** An imaginary vertical plane that divides the cell into two halves.

**Microtubule:** Miniature tubes that help to support the structure of the cell. It is like our skeleton and how it functions to support our body. They form spindle fibers during cell division.

**Spindle fiber:** Clusters of microtubules that help to move chromosomes during cell division.

**Spindle:** The structure that separates chromosomes during cell division. It contains the spindle fibers and centrosomes.

# ATTRIBUTION

**Figure 6-22.** Adapted from *Alternation of generations.svg*: By Peter coxhead derivative work: Peter coxhead [Public domain], 20 February 2012 via Wikimedia Commons. [http://commons.wikimedia.org/wiki/File%3AAlternation\\_of\\_generations\\_simpler.svg](http://commons.wikimedia.org/wiki/File%3AAlternation_of_generations_simpler.svg).





# CORAL REEF ECOLOGY CURRICULUM

The Coral Reef Ecology Curriculum is a comprehensive educational resource designed to educate people about life on coral reefs. Developed by educators and scientists at the Khaled bin Sultan Living Oceans Foundation, this curriculum strives to increase ocean literacy by creating awareness about coral reefs, the threats they face, and how people can help to preserve these diverse ecosystems.



**Khaled bin Sultan  
Living Oceans  
Foundation**

The Khaled bin Sultan Living Oceans Foundation is a US-based nonprofit environmental science organization. The Foundation was established to protect and restore the world's oceans through scientific research, outreach, and education.