

# BIOLOGY 163 LABORATORY

## The Cell Cycle and Mitosis in *Allium* and *Coregonus*

(Revised Fall 2007)

To understand genetics, we must understand how cells pass information (in the form of DNA) from cell to cell and from parent to offspring. When a cell divides, each of the two new cells must receive information identical to that of the parental cell that produced them. Mitosis is the mechanism that guarantees the transmission of balanced sets of genetic information from one cell to another.

Cell division is an orderly series of events in which a cytoplasmic division (cytokinesis) follows a nuclear division (karyokinesis) called **mitosis**. The duplication and distribution of chromosomes during mitosis are so precise that the chromosomal content of the resulting offspring cells is **identical** to each other and to the parent cell. Although the entire cell division process is often spoken of as mitosis, the term technically refers to only the nuclear division.

Tissue characterized by rapid cell division is ideal material for observing the various stages of mitosis. You will study prepared slides of sectioned onion (*Allium*) root tips, and whitefish (*Coregonus*) blastulae (an early stage in animal development). These slides have been stained to enhance the visibility of chromosomes and other cellular structures.

Keep in mind that slides represent very thin (about 10  $\mu\text{m}$ ) sections of cells that are three-dimensional. (An average plant or animal cell is about 40 - 60  $\mu\text{m}$  thick and a typical nucleus is about 3 - 10  $\mu\text{m}$  thick.) If a thin section does not pass through the nucleus or condensed chromosomes, those structures will not be visible on the slide. You are more likely to notice this in the *Coregonus* blastulae, as the cells are aligned more randomly than in the *Allium* root tip.

The cell cycle consists of interphase plus the four phases of mitosis: prophase, metaphase, anaphase, and telophase. Cytokinesis (division of the non-nuclear material) will usually occur in conjunction with late telophase. The following descriptions should help guide your observations--be sure to note the typical differences between plant and animal cells.

### INTERPHASE

The **nucleus** (and possibly **nucleolus**) are visible. At this stage the chromosomes are in an unwound form called **chromatin**. Individual strands of chromatin are too thin to be seen with the light microscope, but you may observe conspicuous chromatin granules within the nucleus. In a cell that is about to divide each chromosome is duplicated during interphase and the resulting identical strands remain together until anaphase of mitosis. In an animal cell, a **centrosome**, containing an apparently single centriole, may be seen lying near the nucleus. Plant cells lack centrioles.

### PROPHASE

Early in this stage the nuclear envelope and nucleolus begin to disappear and the **chromosomes**, thickened as a result of coiling, become visible. (Remember that each apparently single chromosome at this stage is really a pair of **chromatids** connected to each other at one point called a **centromere**.) In animal cells two **centrioles** resulting from self-duplication begin to move apart from each other. **Spindle fibers** between the centrioles and **astral rays** radiating out from the centrioles gradually become visible. In plant cells **spindle fibers** begin to appear. During late prophase the nucleolus and nuclear envelope are no longer visible, while the chromosomes and spindle fibers have become more conspicuous.

### METAPHASE

Individual chromosomes line up randomly at the cell's equator, forming the **metaphase plate**. You may be able to see that each chromosome is really a pair of chromatids. The spindle is obvious and, in animal cells, you may also see centrioles and astral rays at opposite ends of the cell.

**ANAPHASE**

Anaphase begins when the chromatids first separate. Once the chromatids have separated they are called chromosomes. Offspring chromosomes move away from each other, oriented toward opposite poles of the cell. Spindle fibers in the equatorial region may become less distinct.

**TELOPHASE**

Offspring chromosomes reach the two poles, become less tightly coiled and, therefore, less distinct. A nuclear envelope appears surrounding each set, and a new nucleolus may become visible. Spindle fibers and astral rays become less distinct.

**CYTOKINESIS**

In plant cells cytokinesis occurs by the formation of the **cell plate**, a partition that appears first at the center of the spindle apparatus and develops until it meets the cell walls, thus dividing the cytoplasm. In animal cells this stage is marked by the cleavage furrow, a cytoplasmic constriction that eventually pinches the cell completely in two. Each offspring cell now returns to interphase and begins a new cell cycle.

**EXERCISES**

The following exercises are designed to enhance your knowledge of the cell cycle, and to test your skill at identifying the different cell cycle phases through observations of actual specimens.

***Illustrations***

Create a series of figures illustrating each of the cell cycle phases for both *Allium* and *Coregonus*. Be sure to label the relevant structures associated with each phase. Organize your figures according to cycle chronology, not in the order in which you find them.

***Posters, Models, and Beads***

Compare the characteristics of the stages you have observed with the photographs and models available in the laboratory. Use pop-it beads to work through the stages of mitosis. (Your instructor may ask you to demonstrate your knowledge.)

Make sure that you understand that, from a genetic point of view, the two nuclei resulting from mitosis have identical chromosomal complements. Mitosis is a process that ensures continuity of identical genetic material from one nuclear division to the next. Barring abnormalities, no new combinations of genetic factors result from this process.

**ANALYSIS**

Use your observations to discuss and answer the following questions:

- Did you sometimes find it difficult to decide which phase a mitotic cell was in? Why might this pose a challenge?
- Why are you not always able to see all the chromosomes in any given cell?
- Which phase of the *cell cycle* do you observe most frequently? What does this suggest about the relative amount of time the cell spends in that phase? (HINT: consider that any given group of cells was "fixed" at a single point in time.)
- Which phase of *mitosis* do you observe most frequently? What does this suggest about the relative amount of time the cell spends in that phase?
- Propose biologically valid explanations for your answers to the previous two questions.
- What types of cells divide by mitosis? What types of cells would NOT divide by mitosis? Why? What process would they use, and how does it differ from mitosis?