Chapter 16 – Chromosomes

Objectives

Given the synopsis in this chapter, competence in each objective will be demonstrated by responding to multiple choices or matching questions, completing fill-in questions, or writing short answers, at the level of 75% or greater proficiency for each student.

A. To name and describe the phases of the cell cycle.
B. To describe the structure of chromosomes.
C. To name and describe the phases of mitosis.
D. To name and describe the phases of meiosis.
E. To explain the role of meiosis in gamete production.

The cells of our body have specific functions. During most of a cell's life they are carrying out those functions. Chromosomes are central to the functioning of cells and for the reproduction of cells. In this chapter we are focusing on the life cycle of cells and on chromosomes.

Cell Life Cycle - Interphase

A cell spends most of its time in interphase, as shown in Figures 16.1.

- G1 Phase – the cell carries out its functions in the body.
- S Phase – DNA replicates and forms sister chromatids.
- G2 Phase –proteins are synthesized as needed later for mitosis.

A cell spends only a small amount of its time in mitosis.

- M Phase – the cell carries out mitosis (cell reproduction).

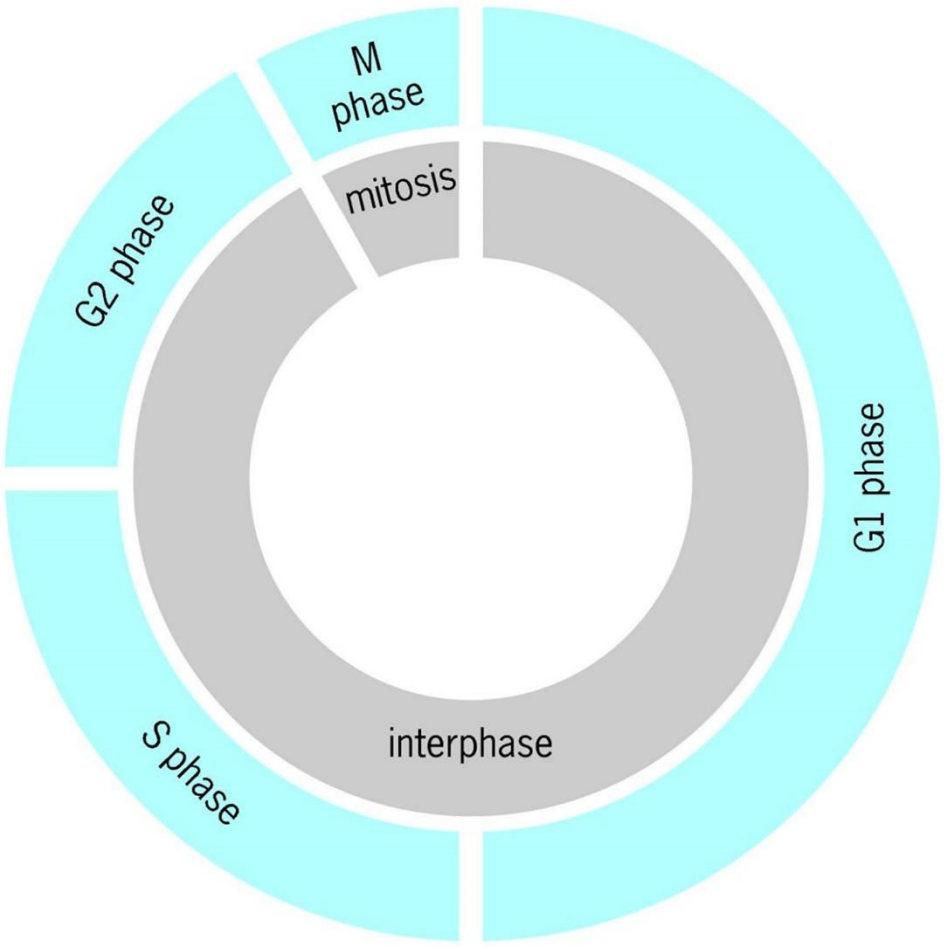

Figure 16.1 © 2014 David G. Ward, Ph.D., Synopsis of Physiology for Allied Health, 3rd Ed.

Some cells are permanently arrested in G_1 interphase once they are created by mitosis. Most nerve cells fit this category. Actually when cells are "stuck" in G_1, we call this G_0 (subscript zero). All cells sit in G_1 until given the Go signal by a transcription factor or hormone, or some other cell signal. These are specific for the type of cell and where it is in the body. For example, squamous epithelial cells in the cheek have a very rapid cell cycle because they need to be replaced constantly. However, nerve cells don't get the Go signal again once they have been produced. Therefore, if they are lost, they don't get replaced.

Most often we would see cells in interphase, as shown in Figure 16.2.

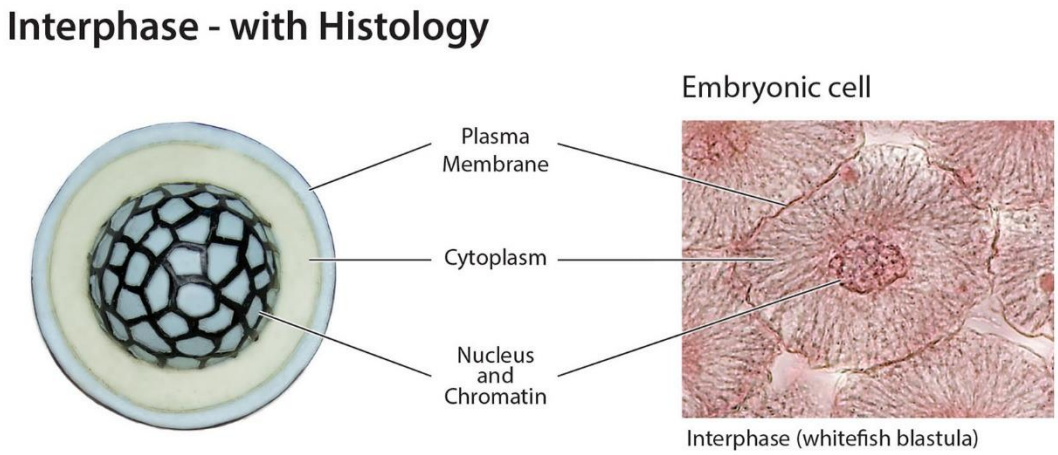

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Figure 16.2 © 2014 David G. Ward, Ph.D., Atlas of Anatomy for Allied Health, 3rd Ed.

- During the G_1 phase of a cell, each chromosome consists of a single chromatid, usually in an uncoiled form.
- During the S phase of a cell, the chromatid replicates and forms two “sister” chromatids.

Structure of Chromosomes

Chromosomes are composed of DNA (deoxyribonucleic acid) and various proteins. Chromosomes cannot be readily seen during interphase, especially during the G_1 phase of a cell. Figure 16.3 shows the general structure of chromosomes; before DNA replication and after DNA replication. Remember that before DNA replication, each chromosome consists of a single chromatid. After DNA replication, each chromosome consists of two “sister” chromatids.

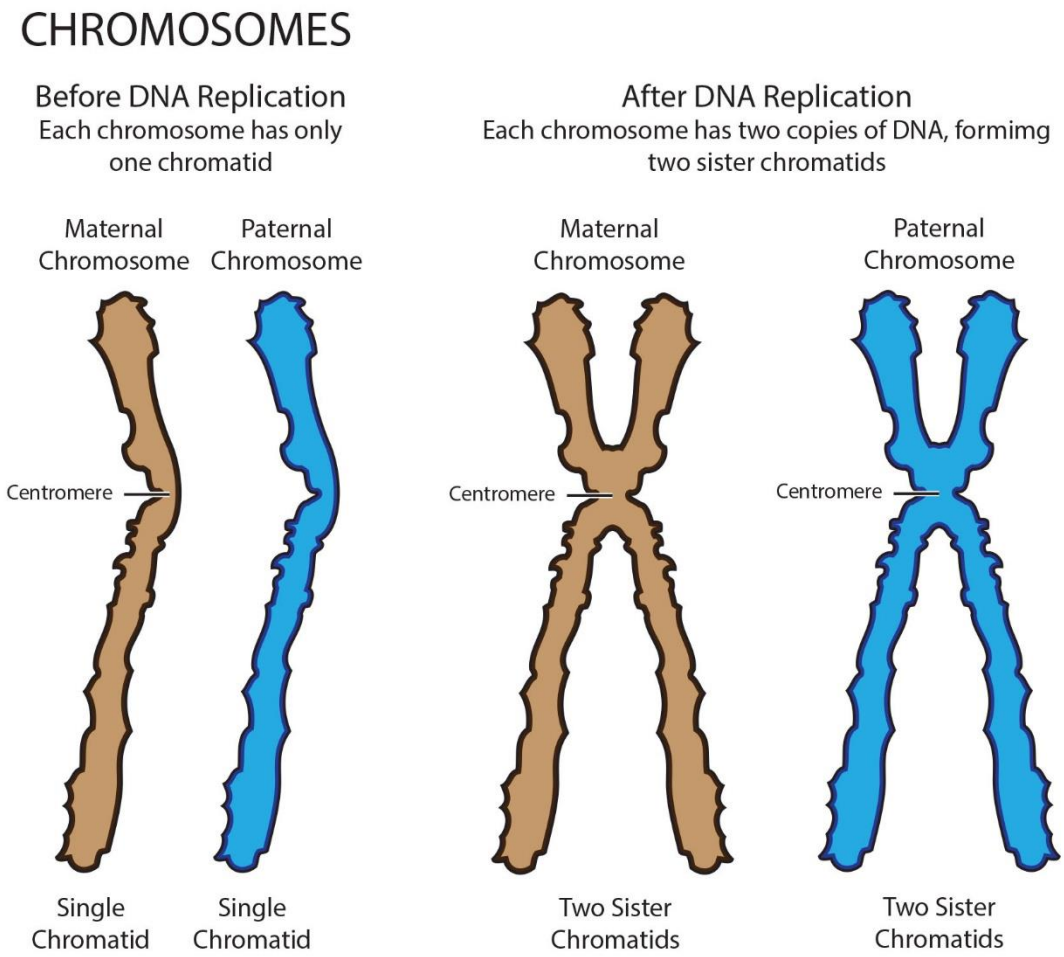

Figure 16.3© 2014 David G. Ward, Ph.D.

Number of chromosomes

In humans each somatic cell contains 23 groups of chromosomes, as shown in Figure 16.4. Each group normally contains two chromosomes. One chromosome of each group comes from the person's mother (maternal chromosome). The other chromosome of each group comes the person's father (paternal chromosome). Together, each somatic cell has 46 chromosomes.

Chromosomes have either one or two chromatids, depending on the phase of the cell cycle. Remember that before DNA replication, each chromosome consists of a single chromatid. After DNA replication, each chromosome consists of two "sister" chromatids. Figure 16.4 shows chromosomes after DNA replication, when each chromosome consists of two "sister" chromatids.

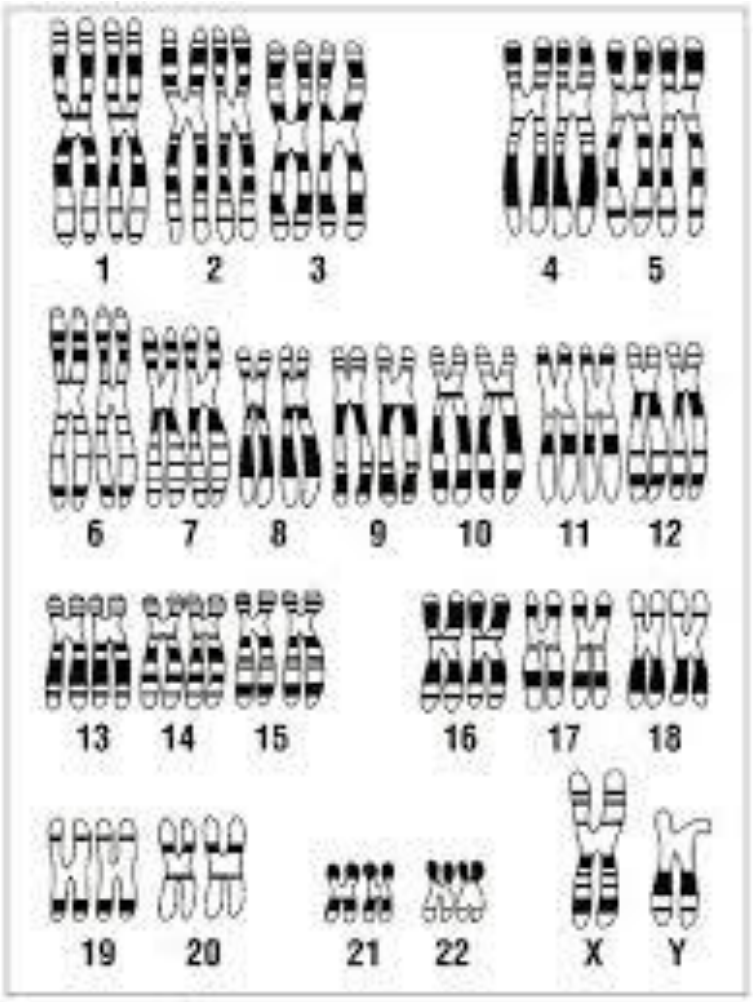

Figure 16.4 © Getty Images

Cell Life Cycle - Mitosis

A cell spends only a small amount of its time in mitosis, which involves the process of cell duplication. Mitosis is divided into four major phases, as shown in Figure 16.5.

- Prophase – chromosomes with sister chromatids are visible.
- Metaphase – chromosomes line up at center of cell
- Anaphase – sister chromatids are pulled apart by spindle fiber
- Telophase – chromosomes arrive at poles (centrioles)

Interphase, mitosis, and cytokinesis are summarized in Figure 16.6

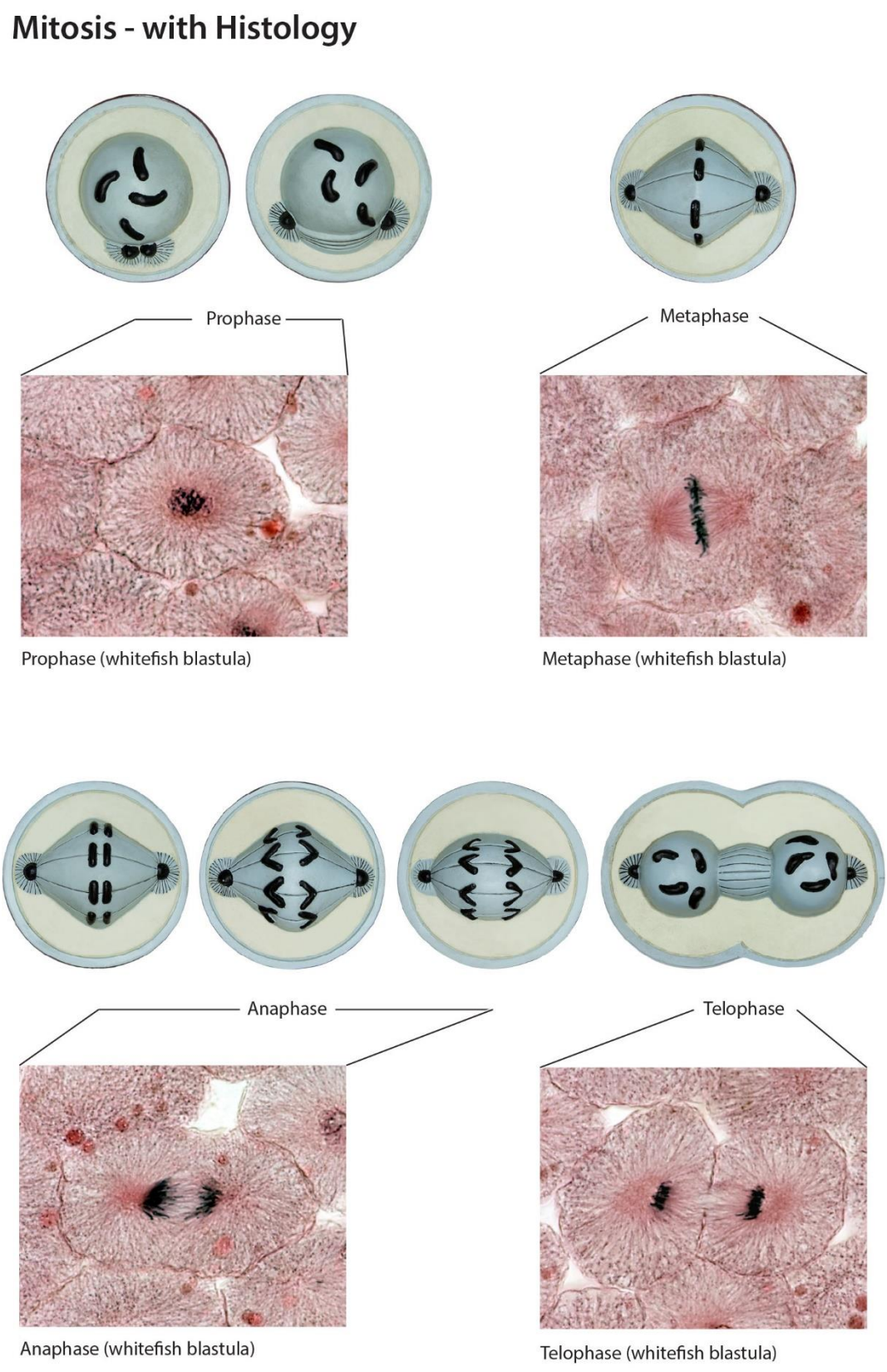

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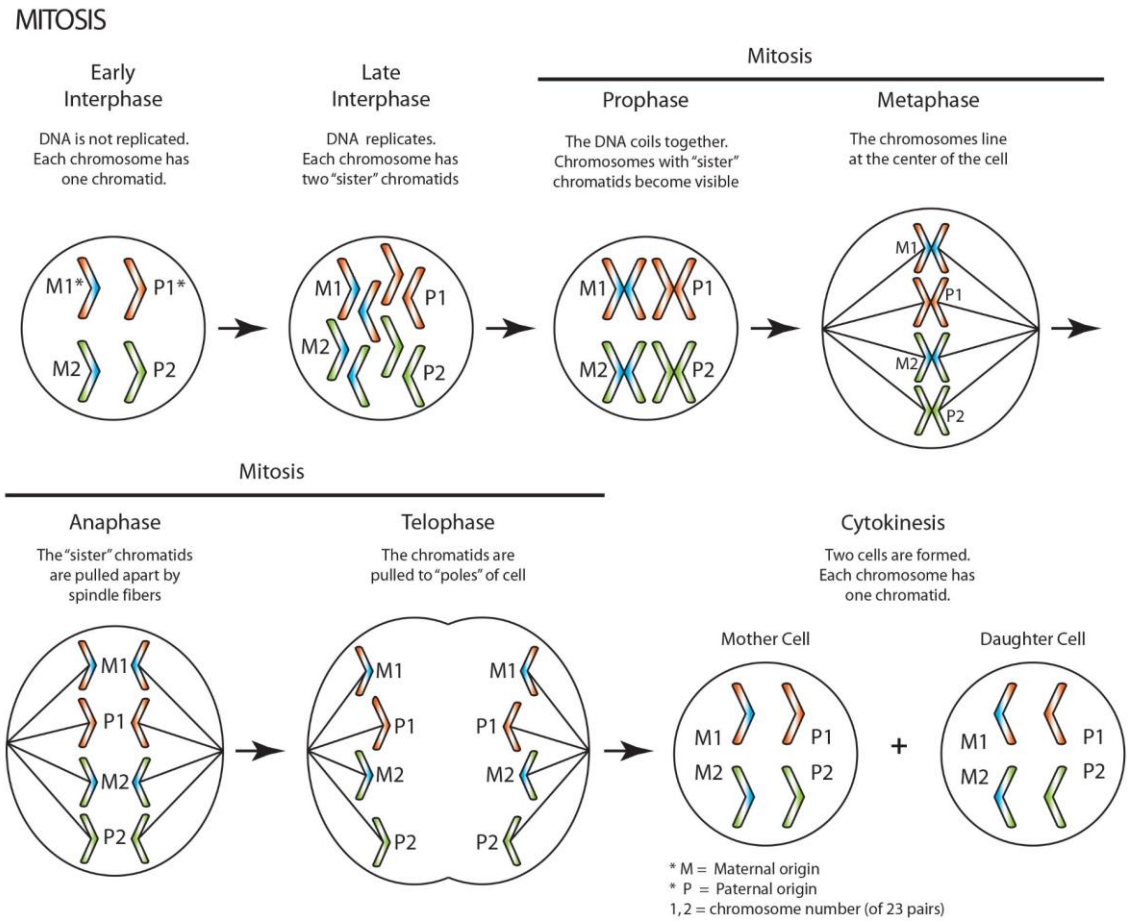
Figure 16.5 © 2014 David G. Ward, Ph.D., Atlas of Anatomy for Allied Health, 3rd Ed.



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Cell Life Cycle - Meiosis

Sex cells (gametes) undergo meiosis, which involves a process of cell halving (meiosis phase 1), as shown in Figure 16.7. Meiosis continues with a process of cell duplication (meiosis phase 2), as shown in Figure 16.8.

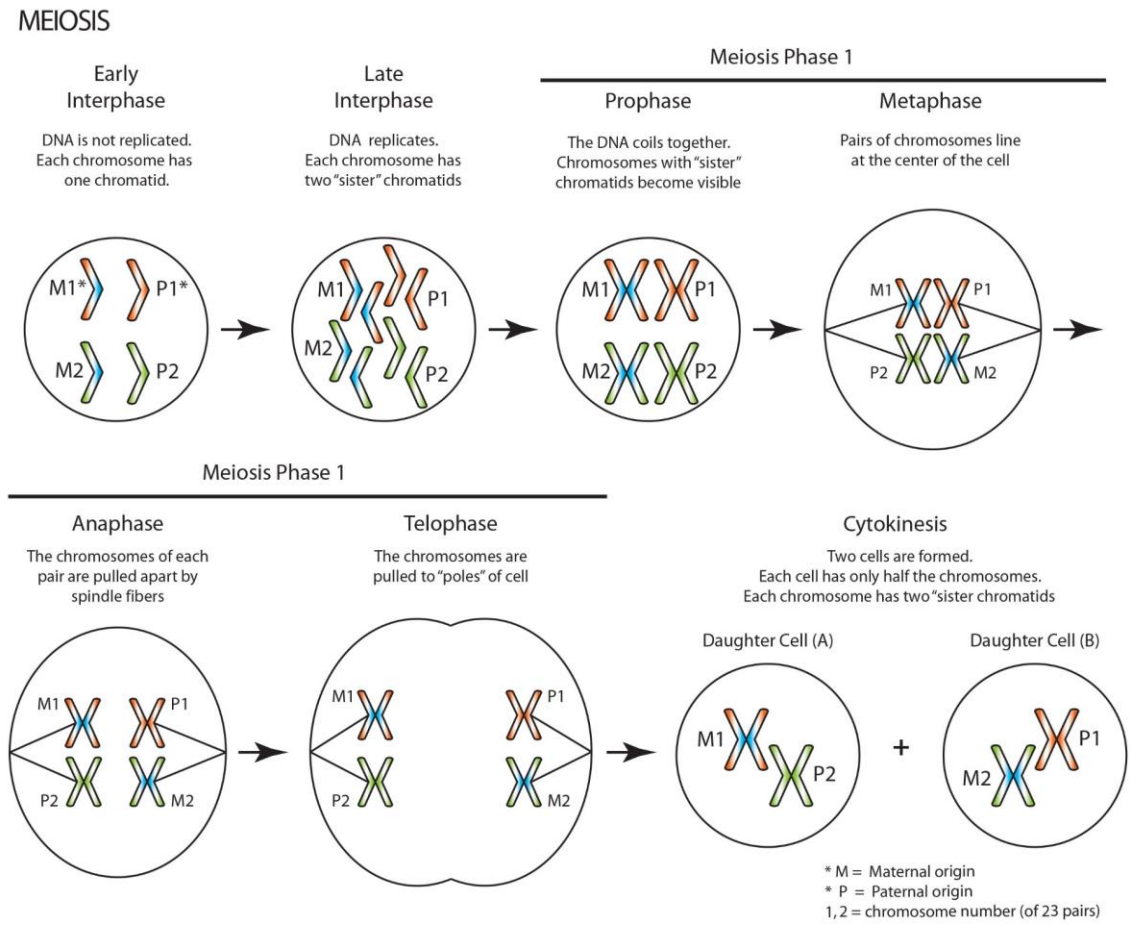

Figure 16.7 © 2014 David G. Ward, Ph.D., Synopsis of Physiology for Allied Health, 3rd Ed.

Meiosis Phase 1

- Prophase – chromosomes with sister chromatids are visible.
- Metaphase – maternal and paternal <u>pairs</u> of chromosomes line up at center of cell
- Anaphase – maternal chromosomes are pulled apart from paternal chromosomes by spindle fiber
- Telophase – maternal chromosomes or paternal chromosomes arrive at poles (centrioles)
- Cytokinesis – two cells are produced, each has only one-half of the chromosomes, but each chromosome retains two chromatids.

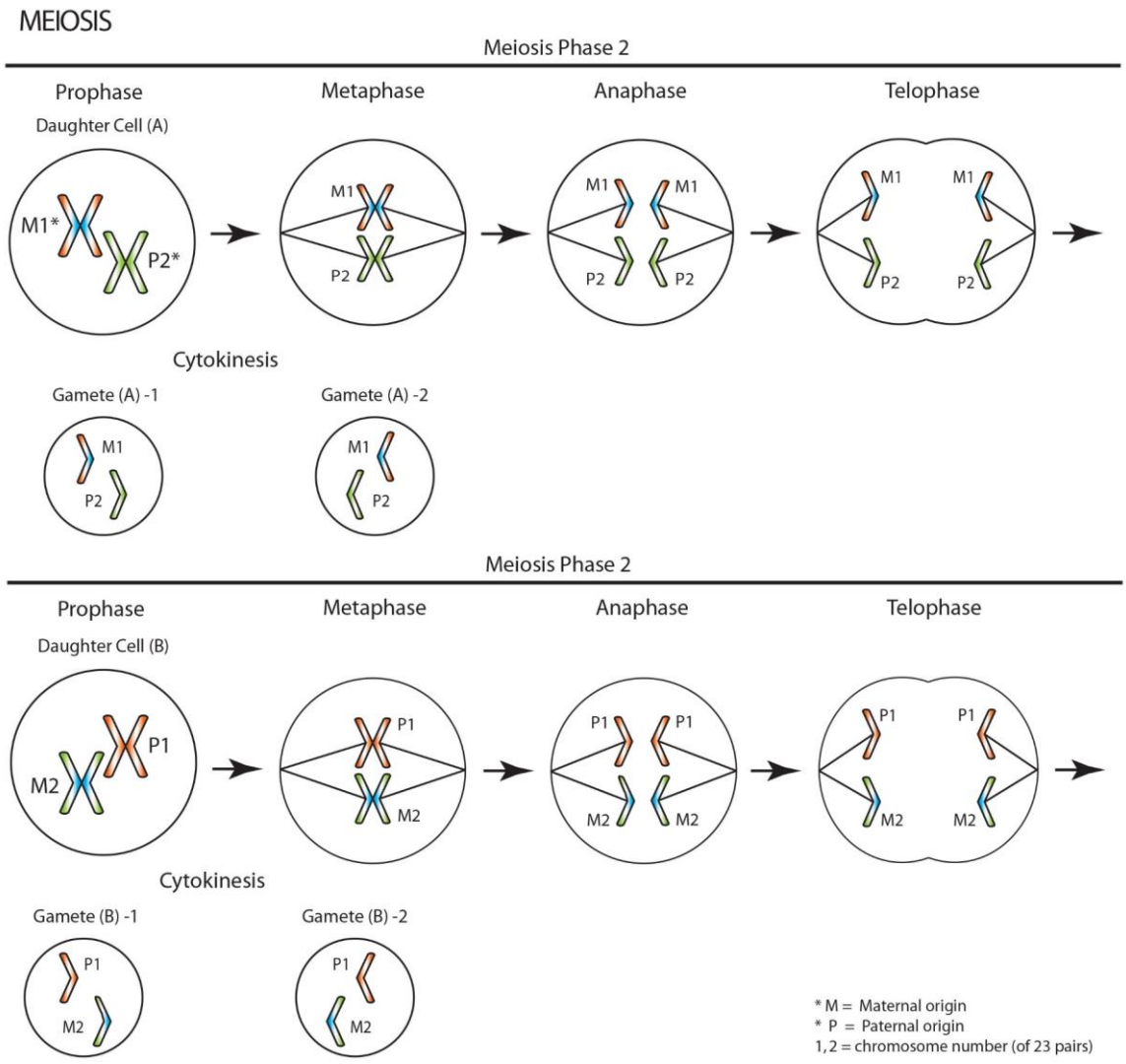

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Figure 16.8 © 2014 David G. Ward, Ph.D., Synopsis of Physiology for Allied Health, 3rd Ed.

Meiosis Phase 2

- Prophase – chromosomes with sister chromatids are visible.
- Metaphase – chromosomes line up at center of cell
- Anaphase – chromatids are pulled apart by spindle fiber
- Telophase – chromatids arrive at poles (centrioles)
- Cytokinesis – two cells are produced, each has only one-half of the chromosomes, but each chromosome has just one chromatid.