The Cell in Development and Inheritance (1900), by Edmund Beecher Wilson [1]

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The Cell in Development and Inheritance [3], by Edmund Beecher Wilson [4], provided a textbook introduction to cell biology for generations of biologists in the twentieth century. In his book, Wilson integrated information about development, inheritance, chromosomes, organelles, and the structure and functions of cells. First published in 1896, the book started with 371 pages, grew to 483 pages in the second edition that appeared in 1900, and expanded to 1,231 pages by the third and final edition in 1925. Wilson dedicated the book to the cell biologist Theodor Boveri [5], whose work established the roles of chromosomes in cell division. With its explanations and many illustrations and diagrams, *The Cell in Development and Inheritance* [3] enabled embryologists to better understand development in terms of cell structure and function.

Wilson held academic positions across several institutions of higher education that provided the basis for *The Cell in Development and Inheritance* [3] (hereafter called *The Cell*). Wilson received his PhD from Johns Hopkins University [6] in Baltimore, Maryland, in 1881, where he had studied with morphologist William Keith Brooks [7]. Wilson then taught at Williams College [8] in Williamstown, Massachusetts, from 1883 to 1884. While at Williams College [8], he joined William T. Sedgwick to write the textbook *General Biology*, which appeared in 1886 and introduced biology to beginning students. Wilson then accepted a teaching position at the Massachusetts Institute for Technology in Cambridge, Massachusetts, from 1884 to 1885, before he moved to Bryn Mawr College [9] in Bryn Mawr, Pennsylvania, to teach biology from 1885 to 1891.

Wilson then moved to Columbia University [10], in New York, New York, to help establish an experimental biology department, and while there he wrote the successive iterations of *The Cell*. At Columbia, as Wilson explains in the introduction of *The Cell*, he had taught students that evolutionary biology reduces to cells. He had offered a series of lectures for general university students to teach them about cellular biology. Those lectures led to Wilson writing *The Cell*, which provided an overview of the biological problems of the day and introduced the work of hundreds of then prominent researchers.

All editions of *The Cell* have nine chapters devoted to the cell's structures and processes, and Wilson discussed different kinds of cells to illuminate the features he wanted to explain. Rather than describing in detail many different kinds of cells, throughout the book Wilson works to describe the prototypical cell. Starting in chapter one, "General Sketch of the Cell," Wilson documents the cell and all organelles that researchers could observe at the time using the best available microscopic techniques. He describes the nucleus [11], vacuoles, passive body, centrosomes, and the cytoplasm within the cell. Wilson then explains the roles of each structure during development of the cell and describes some of the chemistry within the cell. For instance, he discusses the cell as having polarity [12], an axis along which chemical signals flow, and how that polarity [12] affects the function of different cells.

While chapter one outlines the general shape of the cell, chapter two "Cell Division," examines how cells proliferate. Wilson describes each step of cell division, including the movements and divisions of chromosomes. Wilson outlines the stages of cell division, called mitosis [13], and provides descriptions and illustrations for each phase. In chapter two, Wilson denies the claim of Robert Remak [14], who lived in Germany and studied cells, that cellular division is simple and involves only a few steps. Instead, throughout the chapter, Wilson shows the complex and intricate movements of the cell as it divides again and again. Wilson could not describe the causes behind his observations, and he instead provided scientists with illustrations to see what he saw under the microscope [15] and make their own interpretations.

Wilson then distinguishes two types of cells in chapter three, "The Germ Cells." He distinguishes between somatic cells and germ cells [16], using terminology from August Weismann [17], who studied animals an inheritance in Germany. Somatic cells perform functions for body maintenance, while germ cells [16] are sex cells made in the ovaries and spermaries, later called testes [18]. Two germ cells [16] fuse together to produce a fertilized egg [19], which then starts the process of cell lineage [20] that eventually leads to an offspring. Wilson acknowledges that there remained many questions about how heredity related to the processes of development.

Wilson continues discussing germ cells [16] and fertilization [21] in chapter four, "Fertilization of the Ovum." He says there are two ways fertilization [21] can occur. Either germs cells can fuse together, or nuclear material can come together from two different cells in a process called conjugation. In addition, Wilson notes that each offspring has an equal amount of chromatic material

from each parent, and he describes chromosomes as the carriers of inheritance, even though in the first two editions of *The Cell*, he could not say how they did so. He also includes diagrams in chapter four that draw on his 1895 book *Atlas of Fertilization and Karyokinesis of the Ovum*, and that illustrate the processes and details of fertilization [21].

In chapter five, "Oogenesis and Spermatogenesis, Reduction of the Chromosomes," Wilson continues to describe chromosomes in germ cells [16]. He notes that germ cells [16] have half the number of chromosomes as somatic cells. He calls the reduction [22] phases, in which the number of chromosomes is halved, oogenesis in females and spermatogenesis in males. During oogenesis, the initial egg [23] separates into four germ cells [16], but only one of those cells becomes the primary oocyte [24] that contains chromosomes and later divides. The other oocyte [24] cells are called polar bodies, and they cannot fuse with sperm [25] or develop further. During spermatogenesis, all four of the sperm [25] cells have chromosomes and can fertilize a primary oocyte [24].

Wilson concedes in chapter six, titled "Some Problems of Cell-Organization," that researchers still had much to study about cell organization [26]. He says that cells are complex, and that he and his contemporaries did not yet understand all the parts, some of which were called organelles, nor what each organelle does in the cell and how the parts function together to make the whole cell work. Even worse, he says, some organelles seem to be permanent while others may be only temporary.

In chapter seven, "Some Aspects of Cell-Chemistry and Cell-Physiology," Wilson discusses the functions of cells. Wilson describes how the cell nucleus [11] seems to dictate how the cell reacts in different circumstances, even though the reactions themselves take place in the cytoplasm. The cytoplasm constitutes most of the substance of the cell, with the nucleus [11] in the center, and both play some role in cell division and subsequent cell functions. Yet Wilson could not say how the nucleus [11] and cytoplasm work together.

Chapter eight, titled "Cell-Division and Development," describes the relationship between cell division and growth. Wilson describes how the number of cells in an organism's body limits that organism's capacity for growth, even while cells may be about the same size in large and in small organisms. Wilson theorizes that a heredity factor limits the size.

The final chapter, "Theories of Inheritance and Development," builds on the previous chapters to introduce theories about the interrelation of inheritance and development. Wilson discusses the different inheritance theories of his period, including discussions about the relative role of the nucleus [11] in guiding differentiation [27] as development progresses.

In 1896 and 1900, Wilson did not yet understand the role of chromosomes as carriers of genetic information. After early twentieth century researchers rediscovered Gregor Mendel's 1865 theory of heredity, Wilson revised and expanded *The Cell*, adding five chapters. In the 1925 edition, Wilson discusses Mendelian and chromosomal theories of heredity and how they relate to cells. Wilson titled the final 1925 edition of the book *The Cell in Development and Heredity* [28], as heredity had by then become a central topic in biology. Even though Wilson acknowledged in all editions of *The Cell* that there was still much to learn about cells, the book received positive reviews from Wilson's contemporaries and from later researchers.

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Topic

Publications [56]

Publisher

Arizona State University. School of Life Sciences. Center for Biology and Society. Embryo Project Encyclopedia.

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Last Modified

Wednesday, July 4, 2018 - 04:40

DC Date Accessioned

Thursday, June 18, 2015 - 22:33

DC Date Available

Thursday, June 18, 2015 - 22:33

DC Date Created

2015-06-18

DC Date Created Standard

Thursday, June 18, 2015 - 07:00

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