History of the Cell Theory

All living organisms are composed of cells, and all cells arise from other cells. These simple and powerful statements form the basis of the cell theory, first formulated by a group of European biologists in the mid-1800s. So fundamental are these ideas to biology that it is easy to forget they were not always thought to be true.

Robert Hooke's microscope. Hooke first described cells in 1665.

Early Observations

The invention of the microscope allowed the first view of cells. English physicist and microscopist Robert Hooke (1635–1702) first described cells in 1665. He made thin slices of cork and likened the boxy partitions he observed to the cells (small rooms) in a monastery. The open spaces Hooke observed were empty, but he and others suggested these spaces might be used for fluid transport in living plants. He did not propose, and gave no indication that he believed, that these structures represented the basic unit of living organisms.

Marcello Malpighi (1628–1694), and Hooke's colleague, Nehemiah Grew (1641–1712), made detailed studies of plant cells and established the presence of cellular structures throughout the plant body. Grew likened the cellular spaces to the gas bubbles in rising bread and suggested they may have formed through a similar process. The presence of cells in animal tissue was demonstrated later than in plants because the thin sections needed for viewing under the microscope are more difficult to prepare for animal tissues. The prevalent view of Hooke's contemporaries was that animals were composed of several types of fibers, the various properties of which accounted for the differences among tissues.

At the time, virtually all biologists were convinced that organisms were composed of some type of fundamental unit, and it was these "atomistic" preconceptions that drove them to look for such units. While improvements in microscopy made their observations better, it was the underlying belief that there was some fundamental substructure that made the microscope the instrument of choice in the study of life.

In 1676 the Dutch microscopist Antony van Leeuwenhoek (1632–1723) published his observations of single-cell organisms, or "little animalcules" as he called them. It is likely that Leeuwenhoek was the first person to observe a red blood cell and a sperm cell. Leeuwenhoek made numerous and detailed observations on his microorganisms, but more than one hundred years passed before a connection was made between the obviously cellular structure of these creatures and the existence of cells in animals or plants.

The Development of the Cell Theory

In 1824 Frenchman Henri Milne-Edwards suggested that the basic structure of all animal tissues was an array of "globules," though his insistence on uniform size for these globules puts into question the accuracy of his observations. Henri Dutrochet (1776–1847) made the connection between plant cells and animal cells explicit, and he proposed that the cell was not just a structural but also a physiological unit: "It is clear that it constitutes the basic unit of the organized state; indeed, everything is ultimately derived from the cell" (Harris 1999, p. 29). Dutrochet proposed that new cells arise from within old ones, a view that was echoed by his contemporary François Raspail (1794–1878). Raspail was the first to state one of the two major tenets of cell theory: *Omnis cellula e cellula,* which means "Every cell is derived from another cell." However, despite this ringing and famous phrase, his proposed mechanism of cell generation was incorrect. Raspail was also the founder of cell biochemistry, making experiments on the chemical composition of the cell and their response to changing chemical environments.

In 1832 Barthelemy Dumortier (1797–1878) of France described "binary fission" (cell division) in plants. He observed the formation of a mid-line partition between the original cell and the new cell, which, Dumortier noted, "seems to us to provide a perfectly clear explanation of the origin and development of cells, which has hitherto remained unexplained" (Harris 1999, p. 66) These observations led him to reject the idea that new cells arise from within old ones, or that they form spontaneously from noncellular material. The discovery of cell division is usually attributed to Hugo von Mohl (1805–1872), but Dumortier proceeded him in this regard. Von Mohl did coin the word "protoplasm" for the material contained in the cell.

The first unequivocal description of the cell nucleus was made by a Czech, Franz Bauer, in 1802 and was given its name in 1831 by Robert Brown (1773–1858) of Scotland, who is best remembered for discovering the random "Brownian" motion of molecules. The first accurate description of the nucleolus was made in 1835.

Schleiden and Schwann, who are usually given credit for elucidating the cell theory, made their marks in 1838 and 1839. In 1838 Matthais Schleiden (1804–1881) proposed that every structural element of plants is composed of cells or the products of cells. However, Schleiden insisted on priority for several ideas that were not his and clung to the idea that cells arise by a crystallization-like process either within other cells or from outside, which Dumortier had dispensed with some years earlier. (In Schleiden's defense, it should be remembered that drawing incorrect conclusions from limited observations is a risk inherent in science, especially when working on the frontier of a new field.)

In 1839 a fellow German, Theodor Schwann (1810–1882), proposed that in animals too every structural element is composed of cells or cell products. Schwann's contribution might be regarded as the more groundbreaking, since the understanding of animal structure lagged behind that of plants. In addition, Schwann made the explicit claim that the fundamental laws governing cells were identical between plants and animals: "A common principle underlies the development of all the individual elementary subunits of all organisms" (Harris 1999, p. 102).

A special word should be said here about the Czech Jan Purkyňe (1787–1869), or Purkinje, as his name is usually given. Purkinje was the premiere cytologist of his day, and one of the most influential formulators of the cell theory. He gave his name to structures throughout the body, including the Purkinje cells of the cerebellum. Purkinje, in fact, deserves much of the credit that usually goes to Schwann, for in 1837 he proposed not only that animals were composed principally of cells and cell products (though he left room for fibers) but also that the "basic cellular tissue is again clearly analogous to that of plants" (Harris 1999, p. 92). Unfortunately, Schwann did not credit Purkinje in his influential publication.

Reproduction and Inheritance

Despite the work of Dumortier, the origins of new cells remained controversial and confused. In 1852 a German, Robert Remak (1852–1865), published his observations on cell division, stating categorically that the generation schemes proposed by Schleiden and Schwann were wrong. Based on his observations of embryos, Remak stated instead that binary fission was the means of reproduction of new animal cells. This view was widely publicized not by Remak but by Rudolf Virchow (1821–1902), unfortunately without crediting Remak. Virchow is also usually given the credit for the phrase *Omnis cellula e cellula,* indicating the importance of cell division in the creation of new cells.

The understanding of the central importance of chromosomes lagged well behind their discovery. In 1879 Walther Flemming (1843–1905) noted that the chromosomes split longitudinally during mitosis (a term he introduced). Wilhelm Roux (1850–1924) proposed that each chromosome carried a different set of hereditable elements and suggested that the longitudinal splitting observed by Flemming ensured the equal division of these elements. This scheme was confirmed in 1904 by Theodor Boveri (1862–1915). Combined with the rediscovery of Gregor Mendel's 1866 paper on heritable elements in peas, these results highlighted the central role of the chromosomes in carrying genetic material. The chemical nature of the gene was determined in a series of experiments over the next fifty years, culminating in the determination of the structure of deoxyribonucleic acid (DNA) in 1953 by James Watson and Francis Crick.

Modern Advances

The modern understanding of cellular substructure began with the use of the electron microscope. Keith Porter (1912–1997) was a pioneer in this field and was the first to identify the endoplasmic reticulum and many elements of the cytoskeleton . The explosion of knowledge brought about by improvements in microscopy, biochemistry, and genetics has led to a depth of understanding of cell structure and function undreamed of by the earliest cell biologists.

Bibliography

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Timeline of the Establishing the Cell Theory

Date	Event
1665	**Cell first observed** Robert Hooke, an English scientist, discovered a honeycomb-like structure in a cork slice using a primitive compound microscope. He only saw cell walls as this was dead tissue. He coined the term "cell" for these individual compartments he saw.
1670	**First living cells seen** Anton van Leeuwenhoek, a Dutch biologist, looks at pond water with a microscope he made lenses for.
1683	**Miniature animals** Anton van Leeuwenhoek made several more discoveries on a microscopic level, eventually publishing a letter to the Royal Society in which he included detailed drawings of what he saw. Among these was the first protozoa and bacteria discovered.
1833	**The center of the cell seen** Robert Brown, an English botanist, discovered the nucleus in plant cells.
1838	**Basic building blocks** Matthias Jakob Schleiden, a German botanist, proposes that all plant tissues are composed of cells, and that cells are the basic building blocks of all plants. This statement was the first generalized statement about cells.
1839	**Cell theory** Theodor Schwann, a German botanist reached the conclusion that not only plants, but animal tissue as well is composed of cells. This ended debates that plants and animals were fundamentally different in structure. He also pulled together and organized previous statement on cells into one theory, which states: 1 - Cells are organisms and all organisms consist of one or more cells 2 - The cell is the basic unit of structure for all organisms
1840	**Where does life come from** Albrecht von Roelliker discoveres that sperm and eggs are also cells.
1845	**Basic unit of life** Carl Heinrich Braun reworks the cell theory, calling cells the basic unit of life.
1855	**3rd part to the cell theory added** Rudolf Virchow, a German physiologist/physician/pathologist added the 3rd part to the cell theory. The original is Greek, and states Omnis cellula e cellula. This translates as all cells develop only from existing cells. Virchow was also the first to propose that diseased cells come from healthy cells.