**The** [**history of cell theory**](http://www.britannica.com/EBchecked/topic/148932/cytology)

The [history of cell theory](http://www.britannica.com/EBchecked/topic/148932/cytology" \o "history of cell theory) is a history of the actual observation of cells, because early prediction and speculation about the nature of the cell were generally unsuccessful.

The decisive event that allowed the observation of cells was the invention of the [microscope](http://www.britannica.com/EBchecked/topic/380582/microscope) in the 17th century, after which interest in the “invisible” world was stimulated. English physicist [Robert Hooke](http://www.britannica.com/EBchecked/topic/271280/Robert-Hooke" \o "Robert Hooke), who described [*cork*](http://www.britannica.com/EBchecked/topic/137676/cork)and other plant tissues in 1665, introduced the term *cell* because the [cellulose](http://www.britannica.com/EBchecked/topic/101633/cellulose) walls of dead cork cells reminded him of the blocks of cells occupied by [monks](http://www.britannica.com/EBchecked/topic/389542/monk).

Even after the publication in 1672 of excellent pictures of plant tissues, no significance was attached to the contents within the cell walls. The [magnifying powers](http://www.britannica.com/EBchecked/topic/357539/magnifying-power) of the microscope and the inadequacy of techniques for preparing cells for observation precluded a study of the intimate details of the cell contents.

The inspired Dutch microscopist [Antonie van Leeuwenhoek](http://www.britannica.com/EBchecked/topic/334699/Antonie-van-Leeuwenhoek), beginning in 1673, discovered [blood cells](http://www.britannica.com/EBchecked/topic/69685/blood), spermatozoa, and a *lively* world of “animalcules.” A new world of [unicellular organisms](http://www.britannica.com/EBchecked/topic/480085/protist) was opened up. Such discoveries extended the known variety of [living things](http://www.britannica.com/EBchecked/topic/344848/living-things) but did not bring insight into their basic uniformity. Moreover, when Leeuwenhoek observed the *swarming* of his animalcules but *failed* to observe their division, he could only reinforce the idea that they arose spontaneously.

Cell theory was not formulated for nearly 200 years after the introduction of microscopy. Explanations for this *delay* range from the poor quality of the microscopes to the persistence of ancient ideas concerning the definition of a fundamental living unit. Many observations of cells were made, but apparently none of the observers was able to *assert* forcefully that cells are the units of biological structure and function.

Three critical discoveries made during the 1830s, when improved microscopes with suitable lenses, higher powers of *magnification* without [aberration](http://www.britannica.com/EBchecked/topic/1183/aberration), and more satisfactory illumination became available, were decisive events in the early development of cell theory. First, the [nucleus](http://www.britannica.com/EBchecked/topic/422009/nucleus) was observed by Scottish botanist [Robert Brown](http://www.britannica.com/EBchecked/topic/81618/Robert-Brown) in 1833 as a constant component of [plant cells](http://www.britannica.com/EBchecked/topic/463311/plant-cell). Next, nuclei were also observed and recognized as such in some animal cells. Finally, a living substance called protoplasm was recognized within cells, its vitality made evident by its active [streaming](http://www.britannica.com/EBchecked/topic/148976/cytoplasmic-streaming), or flowing, movements, especially in plant cells. After these three discoveries, cells, previously considered as mere pores in [plant tissue](http://www.britannica.com/EBchecked/topic/720109/plant-tissue), could no longer be thought of as empty, because they contained living material.

German physiologist [Theodor Schwann](http://www.britannica.com/EBchecked/topic/528563/Theodor-Schwann" \o "Theodor Schwann) and German biologist [Matthias Schleiden](http://www.britannica.com/EBchecked/topic/527571/Mathias-Jacob-Schleiden" \o "Matthias Schleiden) clearly stated in 1839 that cells are the “elementary particles of organisms” in both plants and animals and recognized that some organisms are unicellular and others multicellular. This statement was made in Schwann’s (*Microscopical Researches into the Accordance in the Structure and Growth of Animals and Plants,* 1839). Schleiden’s contributions on plants were *acknowledged* by Schwann as the basis for his comparison of animal and plant structure.

Schleiden and Schwann’s descriptive statements concerning the cellular basis of biologic structure are *straightforward* and acceptable to modern thought. They recognized the common *features* of cells to be the membrane, nucleus, and cell body and described them in comparisons of various animal and plant tissues. A statement by Schleiden pointed toward the future direction of cell studies:

Each cell leads a double life: an independent one, pertaining to its own development alone; and another incidental, *insofar* as it has become an integral part of a plant. It is, however, easy to perceive that the vital process of the individual cells must form the first, absolutely indispensable fundamental basis, both as regards vegetable physiology and comparative physiology in general.

[*cork*](http://www.britannica.com/EBchecked/topic/137676/cork)*: sughero*

*lively: vivace*

*arose: (arise, arose, arisen) sollevarsi, sorgere. Qui: sorgevano, nascevano*

*insight: comprensione*

*to swarm: affollarsi,*

*failed to: non riuscì*

*delay: ritardo*

*To assert: asserire*

*Magnification: ingrandimento*

[*streaming*](http://www.britannica.com/EBchecked/topic/148976/cytoplasmic-streaming)*, or flowing: scorrimento o flusso; cytoplasmic streaming =flusso citoplasmatico*

*empty: vuoto*

*straightforward: diretto, immediate*

*acknowledged: riconosciuto*

*insofar: in quanto, nella misura in cui*

*features: aspetti, caratteristiche*

*1 What was the most important invention in the development of the theory cell in the 17th century?*

*2 Who coined the term cell ? And Why*

*3 What did* [*Antonie van Leeuwenhoek*](http://www.britannica.com/EBchecked/topic/334699/Antonie-van-Leeuwenhoek) *discover?*

*4 Why was there no development in the study of cells in the 18th century?*

*5 What did* [*Robert Brown*](http://www.britannica.com/EBchecked/topic/81618/Robert-Brown) *find out?*

[*6 What are Schwann*](http://www.britannica.com/EBchecked/topic/528563/Theodor-Schwann)*’s and*  [*Schleiden*](http://www.britannica.com/EBchecked/topic/527571/Mathias-Jacob-Schleiden)*’s contribution to the cell theory?*

*7 Which are the common features of cells?*

**The problem of the origin of cells**

Schwann and Schleiden were not alone in contributing to this great generalization of natural science, for strong *intimations* of the cell theory occur in the work of their predecessors. Recognizing that the basic problem was the origin of cells, these early investigators invented a hypothesis of “free cell formation,” according to which cells developed de novo out of an unformed substance, a “cytoblastema,” by a sequence of events in which first the nucleolus develops, followed by the [nucleus](http://www.britannica.com/EBchecked/topic/422009/nucleus), the cell body, and finally the cell [membrane](http://www.britannica.com/EBchecked/topic/374264/membrane). The best physical model of the generation of formed bodies then available was crystallization, and their theory was inspired by that model. In retrospect, the hypothesis of free cell formation would not seem to have been justified, however, since [cell division](http://www.britannica.com/EBchecked/topic/101484/cell-division), a feature not characteristic of crystallization processes, had frequently been observed by earlier microscopists, especially among single-celled organisms. Even though cell division was observed repeatedly in the following decades, the theory of free cell formation *lingered* throughout most of the 19th century; however, it came to be thought *of more and more* as a possible exception to the general principle of the reproduction of cells by division. The correct general principle was affirmed in 1855 by a German pathologist and statesman, [Rudolph Virchow](http://www.britannica.com/EBchecked/topic/629797/Rudolf-Carl-Virchow), who asserted that “omnis cellula e cellula” (“all cells come from cells”).

The *inherently* complex events of cell division prevented a quick resolution of the complete sequence of changes that occur during the process. First, it was noted that a cell with a nucleus divides into two cells, each having a nucleus; hence, it was concluded that the nucleus must divide, and direct division of nuclei was described by some. Better techniques served to create perplexity, because it was found that during cell division the nucleus disappears. Moreover, at the time of division, *dimly* discerned masses, now recognized as [chromosomes](http://www.britannica.com/EBchecked/topic/116055/chromosome), were seen to appear temporarily. Observations in the 1870s culminated in the highly accurate description and interpretation of cell division by German anatomist [Walther Flemming](http://www.britannica.com/EBchecked/topic/210024/Walther-Flemming) in 1882. His advanced techniques of fixing and *staining* cells enabled him to see that [cell reproduction](http://www.britannica.com/EBchecked/topic/101484/cell-division) involves the transmission of chromosomes from the parent to [daughter cells](http://www.britannica.com/EBchecked/topic/152352/daughter-cell) by the process of [mitosis](http://www.britannica.com/EBchecked/topic/386154/mitosis) and that the division of the cell body is the terminal event of that reproduction.

The discovery that the number of chromosomes remains constant from one generation to the next resulted in the full description of the process of [meiosis](http://www.britannica.com/EBchecked/topic/373408/meiosis). The description of meiosis, combined with the observation that [fertilization](http://www.britannica.com/EBchecked/topic/205305/fertilization) is fundamentally the union of maternal and paternal sets of chromosomes, culminated in the understanding of the physical basis of reproduction and [heredity](http://www.britannica.com/EBchecked/topic/262934/heredity). Meiosis and fertilization therefore came to be understood as the [complementary events](http://www.britannica.com/EBchecked/topic/129886/complementary-event) in the life cycle of organisms: meiosis halves the number of chromosomes in the formation of [spores](http://www.britannica.com/EBchecked/topic/560952/spore) (plants) or [gametes](http://www.britannica.com/EBchecked/topic/224938/gamete) (animals), while fertilization restores the number through the union of gametes. By the 1890s “life” in all of its manifestations could be thought of as an expression of cells.

*Intimation: Preannuncio*

*Lingered: Aggirarsi*

*more and more: sempre di più*

*inherently: inerentemente; “di per sè”*

*dimly : in maniera oscura, confuse*

*staining: macchiare, colorare*

What was the “free cell formation” theory?

What was this theory inspired from?

What is the mitosis process?

How does the number of chromosomes change from one generation to the next?

**The** **[protoplasm](http://www.britannica.com/EBchecked/topic/480430/protoplasm" \o "protoplasm) concept**

As the concept of the cell as the elementary particle of life developed during the 19th century, it was paralleled by the “[protoplasm](http://www.britannica.com/EBchecked/topic/480430/protoplasm)” concept—the idea that the protoplasm *within* the cell is responsible for life. Protoplasm had been defined in 1835 as the [*ground substance*](http://www.britannica.com/EBchecked/topic/246981/ground-substance) of living material and *hence* responsible for all living processes. *That\** life is an activity of an elementary particle, the cell, can be contrasted with the view that it is the expression of a living complex substance—even a supermolecule—called a protoplasm. The protoplasm concept was supported by observations of the [streaming](http://www.britannica.com/EBchecked/topic/148976/cytoplasmic-streaming) movements of the apparently *slimy* contents of living cells.

Advocates of the protoplasm concept implied that cells were either fragments or containers of protoplasm. Suspicious and often contemptuous of information obtained from dead and stained cells, such researchers discovered most of the basic information on the physical properties—mechanical, optical, electrical, and contractile—of the living cell.

An *assessment* of the usefulness of the concept of protoplasm is difficult. It was not *wholly* false; on the one hand, it encouraged the study of the chemical and mechanical properties of cell contents, but it also generated a resistance, evident as late as the 1930s, to the development of biochemical techniques for cell fractionation and to the realization that very large molecules (macromolecules) are important cellular constituents. As the cell has become fractionated into its component parts, protoplasm, as a term, no longer has meaning. The word protoplasm is still used, however, in describing the phenomenon of [protoplasmic streaming](http://www.britannica.com/EBchecked/topic/148976/cytoplasmic-streaming)—the phenomenon from which the concept of protoplasm originally emerged.

*Within: al’interno di*

[*ground substance*](http://www.britannica.com/EBchecked/topic/246981/ground-substance)*: sostanza base*

*hence: da qui, dunque*

*That\*: “il fatto che”*

*Slimy: viscose, viscido*

*Assessment: valutazione*

*Wholly: interamente*

What is the substance responsible for life within the protoplasm theory?

What is the main difference between the protoplasm theory and the cell theory?

What experimental evidence seemed to confirm the protoplasm concept?

What were the cells supposed to be, according to this theory?

Was the concept useful? And how?

How is the word still used today?