**The Cell Theory**

The CELL THEORY, or cell doctrine, states that all organisms are composed of similar units of organization, called cells. The concept was formally articulated in 1839 by Schleiden & Schwann and has remained as the foundation of modern biology. The idea predates other great paradigms of biology including . (1859), (1865), and the establishment of (1940). Ultrastructural research and modern molecular biology have added many tenets to the cell theory, but it remains as the preeminent theory of biology. The Cell Theory is to as Atomic Theory is to Physics. Formulation of the Cell Theory In 1838, Theodor Schwann and Matthias Schleiden were enjoying after dinner coffee and talking about their studies on cells. It has been suggested that when Schwann heard Schleiden describe plant cells with nuclei, he was struck by the similarity of these plant cells to cells he had observed in animal tissues. The two scientists went immediately to Schwann's lab to look at his slides. Schwann published his book on animal and plant cells (Schwann 1839) the next year, a treatise devoid of acknowledgments of anyone else's contribution, including that of Schleiden (1838). He summarized his observations into three conclusions about cells:

* The cell is the unit of structure, physiology, and organization in living things.
* The cell retains a dual existence as a distinct entity and a building block in the construction of organisms.
* Cells form by free-cell formation, similar to the formation of crystals (spontaneous generation).

We know today that the first two tenets are correct, but the third is clearly wrong. The correct interpretation of cell formation by division was finally promoted by others and formally enunciated in Rudolph Virchow's powerful dictum, "Omn~s cellula e cellula" ... " I, The of the Cell Theory include:

* all known living things are made up of cells. the cell is structural & functional unit of all living things.
* all cells come from pre-existing cells by division. (Spontaneous Generation does not occur).
* cells contains hereditary information which is passed from cell to cell during cell division.

All cells are basically the same in chemical composition. all energy flow (metabolism & biochemistry) of life occurs within cells. As with any theory, its tenets are based upon previous observations and facts, which are synthesized into a coherent whole via the scientific method. The Cell Theory is no different being founded upon the observations of many. (Landmarks in the Study of Cells) Credit for the first compound (more than one lens) microscope is usually given to Zacharias Jansen, of Middleburg, Holland, around the year 1595. Since Jansen was very young at that time, it's possible that his father Hans made the first one, but young Jansen perfected the production. Details about the first Jansen microscopes are not clear, but there is some evidence which allows us to make some guesses about them (Jansen microscopes). In 1663 an English scientist, Robert Hooke, discovered cells in a piece of cork, which he examined under his primitive microscope (fiqures). Actually, Hooke only observed cell walls because cork cells are dead and without cytoplasmic contents. Hooke drew the cells he saw and also coined the word CELL. The word cell is derived from the Latin word 'cellula' which means small compartment. Hooke published his findings in his famous work, Microqraphia: Physiological Descriptions of Minute Bodies made by Magnifying Glasses (1665).

Ten years later Anton van Leeuwenhoek (1632-1723), a Dutch businessman and a contemporary of Hooke used his own (single lens) monocular microscopes and was the first person to observe bacteria and protozoa. Leeuwenhoek is known to have made over 500 "microscopes," of which fewer than ten have survived to the present day. In basic design, probably all of Leeuwenhoek's instruments were simply powerful magnifying glasses, not compound microscopes of the type used today. Leeuwenhoek's skill at grinding lenses, together with his naturally acute eyesight and great care in adjusting the lighting where he worked, enabled him to build microscopes that magnified over 200 times, with clearer and brighter images than any of his colleagues at that time. In 1673, Leeuwenhoek began writing letters to the newly formed Royal Society of London, describing what he had seen with his lenses.

His first letter contained some observations on the stings of bees. For the next fifty years he corresponded with the Royal Society. His observations, written in Dutch, were translated into English or Latin and printed in the Philosophical Transacfions of the Royal Society. Leeuwenhoek looked at animal and plant tissues, at mineral crystals, and at fossils. He was the first to see microscopic single celled protists with shells, the foraminifera, which he described as "little cockles. . . no bigger than a coarse sand-grain." He discovered blood cells, and was the first to see living sperm cells of animals. He discovered microscopic animals such as nematodes (round worms) and rotifers. The list of his discoveries is long. Leeuwenhoek soon became famous as his letters were published and translated. In 1680 he was elected a full member of the Royal Society. After his death on August 30,1723, a member of the Royal Society wrote ... "Antony van Leeuwenhoek considered that what is true in natural philosophy can be most fruitfully investigated by the experimental method, supported by the evidence of the senses; for which reason, by diligence and tireless labour he made with his own hand certain most excellent lenses, with the aid of which he discovered many secrets of Nature, now famous throughout the whole philosophical World". No truer definition of the scientific method may be found.

Between 1680 and the early 1800's it appears that not much was accomplished in the study of cell structure. This may be due to the lack of quality lens for microscopes and the dedication to spend long hours of detailed observation over what microscopes existed at that time. Leeuwenhoek did not record his methodology for grinding quality lenses and thus microscopy suffered for over 100 years. German natur-philosopher and microscopist, Lorenz Oken had been trained in medicine at Freiburg University. He went on to become a renown philosopher and thinker of the 29th century. It is reported that in 1805 Oken stated that "All living organisms originate from and consist of cells" ... which may have been the first statement of a cell theory. Around 1833 Robert Brown reported the discovery of the nucleus. Brown was a naturalist who visited the "colonies of Australia" from 1801 through 1805, where he cataloged and described over 1,700 new species of plants. Brown was an accomplished technician and an extraordinarily gifted observer of microscopic phenomena. It was Brown who identified the naked ovule in the gymnospermae. This is a difficult observation to make even with a modern instrument and the benefit of hindsight. But it was with the observation of the incessant agitation of minute suspended particles that Brown's name became inextricably linked. The effect, since described as Brownian Movement, was first noticed by him in 1827. Having worked on the ovum, it was natural to direct attention to the structure of pollen and its Brown interrelationship with the pistil. In the course of his microscopic studies of the epidermis of orchids, discovered in these cells "an opaque spot," which he named the nucleus. Doubtless the same "spot" had been seen often enough before by other observers, but Brown was the first to recognize it as a component part of the vegetable cell and to give it a name.

This nucleus (or areola as he called it) of the cell, was not confined to the epidermis, being also found, in the pubescence of the surface and in the parenchyma or internal cells of the tissue. This nucleus of the cell was not confined to only orchids, but was equally manifest in many other monocotyledonous families and in the epidermis of dicotyledonous plants, and even in the early stages of development of the pollen. In some plants, as Tradascantia virginica, it was uncommonly distinct, especially in the tissue of the stigma, in the cells of the ovum, even before impregnation, and in all the stages of formation of the grains of pollen. It is upon the works of Hooke, Leeuwenhoek, Oken, and Brown that Schleiden and Schwann built their Cell Theory. It was the German professor of botany at the University of Jena, br. M. J. Schleiden, who brought the nucleus to popular attention, and to asserted its all-importance in the function of a cell. Schleiden freely acknowledged his indebtedness to Brown for first knowledge of the nucleus, but he soon carried out his own observations of the nucleus, far beyond those of Brown. He came to believe that the nucleus is really the most important portion of the cell, in that it is the original structure from which the remainder of the cell is developed. He called it the , He outlined his views in an epochal paper published in Muller's Archives in 1838, under title of "Beitrage zur Phytogenesis."

This paper is in itself of value, yet the most important outgrowth of Schleiden's observations of the nucleus did not spring from his own labors, but from those of a friend to whom he mentioned his discoveries the year previous to their publication. This friend was Dr. Theodor Schwann, professor of physiology in the University of Louvain. Schwann was puzzling over certain details of animal histology which he could not clearly explain. He had noted a strange resemblance of embryonic cord material, from which the spinal column develops, to vegetable cells. Schwann recognized a cell-like character of certain animal tissues. Schwann felt that this similarity could not be mere coincidence, and it seemed to fit when Schleiden called his attention to the nucleus. Then at once he reasoned that if there really is the correspondence between vegetable and animal tissues that he suspected, and if the nucleus is so important in the vegetable cell as Schleiden believed, the nucleus should also be found in the ultimate particles of animal tissues.

A closer study of animal tissues under the microscope showed, in particular in embryonic tissues, that the "opaque spots" that Schleiden described were found in abundance. The location of these nuclei at comparatively regular intervals suggested that they are found in definite compartments of the tissue, as Schleiden had shown to be the case with vegetables; indeed, the walls that separated such cell-like compartments one from another were in some cases visible. Soon Schwann was convinced that his original premise was right, and that all animal tissues are composed of cells not unlike the cells of vegetables. Adopting the same designation, Schwann propounded what soon became famous as the CELL THEORY. So expeditious was his observations that he published a book early in 1839, only a few months after the appearance of Schleiden's paper. The main theme of his book was to unify vegetable and animal tissues. Accepting cell-structure as the basis of all vegetable tissues, he sought to show that the same is true of animal tissues. And by cell Schwann meant, as did Schleiden also, what the word ordinarily implies--a cavity walled in on all sides. He knew that the cell might be filled with fluid contents, but he regarded these as relatively subordinate in importance to the nucleus and cell wall. Their main thesis, the similarity of development of vegetable and animal tissues and the cellular nature of life, was supported almost immediately by a mass of carefully gathered evidence which a multitude of microscopists confirmed. So Schwann's work became a classic almost from the moment of its publication. Various other workers disputed Schwann's claim to priority of discovery, in particular an English microscopist, Valentin, who asserted that he was working closely along the same lines. So did many others, such as Henle, Turpin, Du-mortier, Purkinje, and Muller, all of whom Schwann himself had quoted in his work. Many physiologists had, earlier than any of the above, foreshadowed the cell theory, including Kaspar Friedrich Wolff around the close of the previous century, and Treviranus in 1807. But, as we have seen in the scientific method, it is one thing to foreshadow a discovery, it is quite another to give it full expression and make it the cornerstone of future discoveries. And when Schwann put forward the explicit claim that "there is one universal principle of development for the elementary parts, of organisms, however different, and this principle is the formation of cells," he enunciated a doctrine which was for all practical purposes absolutely new and opened up a novel field for the microscopist to enter.

A most important era in Cell Biology dates from the publication of his book in 1839. Landmarks in Study of Cell Biology 1856 IN. Pringsheim observed how a sperm cell penetrated an egg cell. I liRudolf Virchow (physician, pathologist and anthropologist) expounds his famous conclusion: omnls cellula e cellula, that is cells develop onl). from exlstlng cells [cells come from preexisting cells] 1857 11879 ~lemmin~ described chromosome behavior during m~tos~s. 17, Kolliker described mitochondria. 1869 I/ Miescher isolated DNA for the first time. 1883 7 Germ cells are haploid, chromosome theory of heredity. 11898 I/ 11941 I~oons used fluorescent labeled antibod~es to detect cellular antigens. iii Golgi described the qolqi apparatus. /1926 11952 l~e~ and co-workers established a continuous human cell line. Svedberg developed the first analytical ultracentrifuge. Behrens used dlfferentlal centrlfuqatlon to separate nuclei from cytoplasm. Siemens produced the first commercial transmlsslon electron mlcroscope. 11953 /Crick, Wilkins and Watson proposed structure of DNA double-helix. Eagle systematically defined the nutritional needs of animal cells in culture. 1957 Meselson, Stahl and Vinograd developed density gradient centrifugation in cesium chloride solutions for separating nucleic acids. Ham introduced a defined serum-f ree medium. Cambridge Instruments produced the first commercial scanninq electron microscope. Sato and colleagues publish papers showing that different cell lines 1976 require different mixtures of hormones and growth factors in serumfree media. 1981 Transgenic mice and fruit flies are produced. Mouse embryonic stem &line established. 1987 /~irst knockout mouse created. il /!1998 Mice are cloned from somatic cells. ii 2000 Human genome DNA sequence draft.