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LEONARDO THINKS

Opinion: Something Has Doubled

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In memoriam Erwin Chargaff (1905-2002)

The double helix, discovered 50 years ago, has replaced the mushroom cloud of the atomic bomb as a symbol of modern science. On 25 April 1953, a one-page article appeared in *Nature* (London), entitled "Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid" [1]. In it, James Watson (b. 1928) and Francis Crick (b. 1916) suggested a double-helix structure for the substance of heredity, known also as DNA. A purely diagrammatic figure of elegant simplicity illustrated the article. It showed the two helices of the molecule, related by a twofold axis of rotation perpendicular to the common axis of the helices. This symmetry implied that the two helices ran in opposite directions, complementing each other. The paper described the two helices as held together by purine and pyrimidine bases, which were joined in pairs—a single base from one being hydrogen-bonded to a single base from the other. A by-now-famous sentence concluded the note: "It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material." A new era of science was begun. Many of the achievements of molecular biology today, including the Human Genome Project, can be traced back to the discovery of the double helix.

This discovery deservedly catapulted Watson and Crick to fame, but there were other players who should also be remembered. In 1944, Oswald Avery (1877-1955) and his two associates showed that DNA was the substance of heredity. In 1949, Sven Furberg (1920-1983) uncovered important features of the DNA structure, such as the bases and the sugar rings being perpendicular to one another. Erwin Chargaff (1905-2002) determined that, while the relative proportions of the different bases varied considerably in the DNA of different organisms, the relative amounts of the different bases followed strict regularities; between certain bases, there was a one-to-one correspondence. Rosalind Franklin



(1920-1958) produced X-ray diffraction photographs of DNA that proved its helical structure. While all these discoveries were crucial contributions that would have led in time to the discovery of the structure of DNA, Watson and Crick's discovery was a master stroke. They received the Nobel Prize in Physiology or Medicine in 1962, sharing it with Maurice Wilkins (b. 1916), who did a comprehensive X-ray crystallographic study of the DNA structure.

In addition to the enormous importance of the structure of DNA, various aspects of its discovery have been immortalized in literary creations, the most notable being Watson's *The Double Helix*, first published in 1968 and a best-seller ever since [2]. The double helix has also become a subject of artistic creation, especially in sculpture. Erwin Chargaff did not mean it kindly when he noted its popularity, but, sarcasm notwithstanding, he was not far off the mark when he said,

The outstanding charismatic symbol of our time—the spiral staircase leading, I hope, into heaven—has been advertised with a truly remarkable intensity. It has been used as an emblem, it has been put on neckties, it embellishes letterheads, it stands outside of buildings as what might be called commercial sculpture. It has even invaded the higher forms of mannerist art [3].

There is something breathtaking about the double-helix structure whether it is represented by a diagrammatic sketch or an elaborate design. On the campus of Cold Spring Harbor Laboratory, a recently unveiled sculpture is conspicuously simple: the two helices are connected with straight rods and at the top the two helices are turned back into the ground as they divide, an effect that may have symbolic significance for reproduction, but also serves as a stabilizing feature for the sculpture. Possibly the largest and most spectacular double-helix sculpture stands outside the Biomedical Center of Uppsala University (Fig. 1); the two helices ascend vertically as if from a cell and then split at the top, as if getting ready for reproduction. This is an ornate creation in which various elements of the DNA structure may be recognized, but closer scrutiny reveals an error in the arrangement. Some bases appear to be outside of the backbone rather than inside, as they are in the true structure of DNA [4].

Watson and Crick's discovery of the double helix uncovered one of life's most fundamental secrets. DNA research has led to improvements in the quality of life; it is a field whose potential appears to be boundless, although genetic engineering has a long way to go to develop appropriate guidelines for its use and to reach general acceptance. The figure of the double helix has also created a bridge between science and the arts.



Endnotes

[1] J.D. Watson and F.H.C. Crick, "Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid," *Nature* 171 (1953) pp. 737-738.

[2] . James D. Watson, *The Double Helix: A Personal Account of the Discovery of the Structure of DNA* (New York: Signet Books, 1969)

[3] Erwin Chargaff, Heraclitean *Fire: Sketches from a Life Before Nature* (New York: Rockefeller University Press, 1978) p. 106.

[4] Linus Pauling had published a structure before the Watson-Crick discovery that had this erroneous feature, so it may have been Pauling's influence on the sculptor or it may have been an expression of artistic freedom.

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