ROSEDALE ACADEMY

Biology Journal Group Activity

Read the following article. Once you are finished, get together into groups of 2 and work together to discuss and answer the questions given.

The Elucidation of the Structure of DNA

Abstract

Watson and Crick required a great deal of background analysis and insight to develop their model of the double helix structure of DNA. All the information they required came from an ongoing collaboration among scientists. At the same time as the scientists were collaborating, however, they were competing to be the first to publish the exciting discovery of the structure of DNA. Scientific research is always a balance between cooperation and competition. The analysis and insights of Pauling and Corey, Chargaff, and Franklin and Wilkins played an indispensable role in helping Watson and Crick develop their model, which, in itself, was no small accomplishment.

Introduction

The scientific community comprises not only the scientists themselves, but also their collective knowledge and discoveries. One of the defining features of scientific progress is openness. Scientists from around the world continually share their data, insights, and techniques to push the frontiers of human knowledge.

James Watson and Francis Crick's elucidation of the double helix structure of DNA is a class example of this process. While working on their DNA model, they exchanged ideas and data with many other scientists who were also hoping to be the first to work out the structure of DNA. In this atmosphere of collaboration and competition, Watson and Crick came to their discovery.

Ideas from Pauling and Corey

Nobel Prize-winning chemist Linus Pauling and biochemist Robert Corey were modelling the structure of DNA at the same time as Watson and Crick. Pauling and Corey's model featured three strands intertwined around each other. Before they sent their article to publication, however, they shared their ideas with Watson and Crick. Pauling was also kind enough to review Watson and Crick's research and offer his own critique and ideas. Watson and Crick mention this collaboration in the opening sentences of their landmark 1953 paper in the prestigious journal *Nature*:

> *We wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features, which are of considerable biological interest. A structure for nucleic acid has already been proposed by Pauling and Corey. They kindly made their manuscript available to us in advance of publication. Their model consists of three intertwined chains, with the phosphates near the fibre axis, and the bases on the outside.*

Chargaff's Results

Another unsolved question was how to account for the ratios of the nitrogenous bases. Char gaff published his findings in 1950, showing that the ratios of adenine:thymine: and cytosine:guanine were always 1:1. Like all members of the scientific community, Watson and Crick had access to this information through peer-reviewed journals. After they became aware of the inner location of the bases, they incorporated Chargaff's results into their model:

> *The novel feature of the structure is the manner in which the two chains are held together by the purine and pyrimidine bases ... They are joined together in pairs ... One of the pairs must be a purine and the other a pyrimidine for bonding to occur ...*

Franklin and Wilkins's Crystallography

In 1952, Rosalind Franklin and Maurice Wilkins produced the first high-resolution crystallography of DNA. Watson had the opportunity to view the crystallography because both he and Wilkins were working at Cavendish Laboratory at Cambridge, England. With guidance from Franklin, Watson and Crick realized that Pauling and Corey had the structure inside out. The only solution was to place the phosphates on the outside and have the nitrogenous bases meet in the middle. The problem with Pauling and Corey's model was that the phosphate groups were electrically negative. IF they were packing together into the centre of the molecule, they would repel each other, making DNA highly unstable.

Watson and Crick now knew that the sugar-phosphate backbone was on the exterior of the DNA molecule and the bases were joined together in pairs in the interior. The only problem left to solve was the overall shape of the molecule.

There was much debate as to the correct interpretation of the crystallography produced by Franklin and Wilkins. Franklin initially disagreed with Crick's (ultimately correct) view that the structure of DNA was a double helix. Crick saw in Franklin's crystallography not only the structure of the molecule, but also the one piece of information that brought everything else together. Understanding their minority opinion, they made clear the uniqueness of their model:

> *We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis ... Both chains follow right-handed helices ... the two chains run in opposite directions ... the bases are on the inside of the helix and the phosphates on the outside.*

In the end, Franklin agreed with the double helix model. Watson and Crick took care to give collaborative credit where it was due, specifically citing Franklin and Wilkins in the acknowledgements in their article:

> *We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M.H.F. Wilkins, Dr. R. E. Franklin and their co-workers at King's College, London.*

The scientific community understood the importance of this collaboration: Wilkins shared the 1962 Nobel Prize with Watson and Crick. Sadly, Franklin died of cancer in 1958, at the age of 38, and Nobel Prizes are not awarded posthumously. Her cancer may have been caused by exposure to X-rays from her groundbreaking work.

Watson later wrote that Crick had announced their discovery by walking into a nearby pub and blurting out that they had "found the secret of life!" Their keen insight into the importance of their discovery is also found in a sentence near the end of their publication:

> *It has not escaped our notice that the specific pairing we have postulated immediately suggests a possibly copying mechanism for the genetic material.*

This note clearly anticipated the research to delineate the process of DNA replication.

Conclusion

Science grows through the interplay of experimentation, interpretation, and rigorous debate. Often, a simple reordering or reinterpreting of existing data offers a key insight. It is not only the pieces of the puzzle that matter, but also how they fit together. Ultimately a human endeavour, science incorporates our collaborative yet competitive natures to attain the goal of knowledge for everyone.

Further Reading

If you are interested in reading the scientific papers mentioned in this article, look online for the following:

Crick, F.H.C., & Watson, J.D. (1953). A structure for deoxyribose nucleic acid. *Nature*, 171, 737-738.

Watson, J.D. (1969). *The double helix*: *A personal account of the discovery of the structure of DNA*. Kolkata, India: Signet Press.

Questions

1. Scientific advances are often heavily dependent on technological advances. How is this illustrated in Watson and Crick's 1953 paper?

2. Using Watson and Crick's work as an example, explain how science s both collaborative and competitive.

3. Do you think both competitiveness and collaboration are essential to success in scientific research, or is one more essential than the other? Explain your thinking.