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Science & Futurist Science & Art: Does the Process of the Discovery of the DNA Contradict Kuhn's *Structure of Scientific Revolutions*?

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ABSTRACT: Thomas Kuhn, in his influential and classic work, *The Structure of Scientific Revolutions*, claims that revolutionary change in science is change in the "paradigm" of a particular scientific field, that is, change in the larger conceptual framework and even underlying philosophical framework that guides a scientific field. In Kuhn's view, paradigms are essential: Paradigms constitute and determine scientific change; further, major innovators in science do not merely contribute new theories and discoveries but new paradigms which constitute and determine the nature of particular theories, ideas, the design of experiments, and also the use of scientific instruments in any particular scientific field. I seek to investigate whether Watson and Crick's discovery of the DNA as the genetic material challenges Kuhn's model of discovery and revolutionary change in science. I seek to show that Watson and Crick employed Gregor Mendel's conception of the particulate nature of genetic information (instead of Aristotle's early conception of blending inheritance); Watson and Crick stated that they employed Erwin Schrodinger's speculative conception from his book *What is Life?*, that the genetic material would likely be a complex aperiodic crystal; Watson and Crick employed Linus Pauling's framework of modeling complex molecules using indirect evidence (such as by X-ray crystallography by other researchers); unlike Pauling and other chemists and biochemists that still thought the genetic material would be a protein, Watson and Crick recognized that the genetic material could be the DNA, and that the structure and function of DNA could provide information for the building blocks of cells and cellular differentiation. Thus, Watson and Crick's scientific revolution employed multiple frameworks from related branches and sub-branches of science. Kuhn suggests that paradigm changes in physics and other branches of science are analogous to singular framework changes in the nature of perspective in the history of art and architecture. By contrast, Watson and Crick's scientific revolution involves multiple frameworks, and is thus more comparable to futurism and futuristic art. (The Futuristic art of Boccioni, Picasso, and Malevich is said to involve multiple perspectives and frameworks).

KEYWORDS: scientific revolutions, paradigms; Einstein, J.D. Watson, futurist.

INTRODUCTION

Thomas Kuhn, in his influential and classic work, *The Structure of Scientific Revolutions*, claims that revolutionary change in science is change in the "paradigm" of a particular scientific field, that is, change in the larger conceptual framework and even underlying philosophical framework that guides a scientific field. (1-2) In Kuhn's view, paradigms are essential: Paradigms constitute and determine scientific change; further, major innovators in science do not merely contribute new theories and discoveries but new paradigms which constitute and determine the nature of particular theories, ideas, the design of experiments, and also the use of scientific instruments in any particular scientific field.

Kuhn discusses how paradigms are essential by contrasting the success of empirical science and empirical astronomy in China and the West before and after Copernicus: "Western astronomers first saw change in the previously immutable heavens during the half-century after Copernicus' new paradigm was first proposed . . . The Chinese, whose cosmological beliefs did not preclude celestial change, had recorded the appearance of many new stars in the heavens at a much earlier date." In this regard, Kuhn follows historian of science Joseph Needham in recognizing the achievements of world importance of early Chinese astronomy and science. Kuhn continues: "without even the aid of a telescope, the Chinese had systematically recorded the appearance of sunspots centuries before these were seen by Galileo and his contemporaries." Thus, Kuhn seeks to show that paradigms are essential: Western astronomers were behind
Chinese until they had access to the framework or paradigm of Copernicus that allowed them to literally "see" the celestial heavens in new ways and observe previously unobservable celestial bodies.

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Does the Process of the Discovery of the DNA Empirically Contradict Kuhn's Model?

The process of the discovery of the DNA or the model of the genetic material may be a case that challenges Kuhn's famous model in ways that have not been previously appreciated: Co-discoverers James Watson and Francis Crick employed Linus Pauling's framework or paradigm for developing models of molecules, a fact explicitly recognized by Watson and Crick as well as others (discussed in greater detail below); however, it was Watson and Crick that made the revolutionary contribution to science by discovering the structure and function of DNA, not Pauling. Linus Pauling created the framework for modeling molecules, including the strategy of using children's building blocks for modeling molecules that Watson and Crick emulated, and was himself working on a model of the DNA at the same time as Watson and Crick. (3-6) Francis Crick himself explains that, "what Pauling did show us was that exact and careful model building could embody constraints that the final answer had in any case to satisfy. Sometimes this could lead to the correct structure, using only a minimum of the direct experimental evidence." (This is discussed further, below).

Moreover, it was Watson and Crick's revolutionary contribution, and not Pauling's framework, that gave birth to a tremendous amount of scientific growth, namely the new field and subfields applying molecular genetics to a range of research in biology and biological engineering. (see 3-4, 6) Kuhn's model of scientific change and discovery is usually criticized in philosophical terms, such as by philosophers of physics like Karl Popper, Carl Hempel, and others. However, if Kuhn's model of scientific change has empirical consequences (and it is widely recognized to have empirical content), then the case of the process of the discovery of the genetic material appears to contradict Kuhn's model.

In addition, empirically challenging Kuhn's model also may have larger philosophical and intellectual significance. Since Kuhn portrays new paradigms as the pinnacle of scientific achievement, with particular discoveries being mere "mop up work" once paradigms are established, the generally recognized importance of the discovery of the structure and function of the genetic material also suggests that Kuhn's view of what is most important in science is misplaced. That is, revolutionary change in science is a consequence of the development of new theories and discoveries, that may then have larger conceptual and even metaphysical significance in the worldview of a particular field of science or the world at large.

Revolutionary Change in Science as Change in Paradigms

In an interview 33 years after having published *The Structure of Scientific Revolutions*, Kuhn explicitly identified his work not as philosophy but as part of the history and social science of science. Thus, while Kuhn is sometimes identified as a philosopher, and has many times been criticized by philosophers and scientists as conflating his observations on the nature of scientific change with normative statements about how science should or should not operate (7-8), Kuhn identifies his work as part of empirical science. (cf. 9)

While Kuhn's revolutionary work has clearly had a great influence on philosophy, and is sometimes identified as part of the philosophy of science, his work is highly empirical in nature since his books and papers are histories of science, albeit novel histories of science that attempt to provide new models and images of the nature of science and scientific change. (These include *The Structure of Scientific Revolutions*, *The Copernican Revolution*, and *The Essential Tension*).

As Thomas Kuhn stressed in the famous opening of *The Structure of Scientific Revolutions*, "History, if viewed as a repository for more than anecdote or chronology, could produce a decisive transformation in the image of science by which we are now possessed." Alternatively, I seek to propose to investigate the process of the discovery of the structure and function of DNA that could produce an empirical challenge to the Kuhnian view of science of which many are now possessed.

Evaluating Kuhn's Theory

I seek to investigate whether Watson and Crick's discovery of the DNA as the genetic material challenges Kuhn's model of discovery and revolutionary change in science.

As alluded to above, Watson and Crick employed Linus Pauling's framework or paradigm to develop their model of the DNA, a fact that Watson, Crick, and their contemporaries admitted. This may be elaborated. Crick once recalled that he and Watson were unquestionably following Pauling's framework to approach the problem of developing a model of the DNA: "We . . . never wasted any time discussing whether we should think in the way Schrodinger did or the way Pauling did. It seemed quite obvious to us that we should follow Pauling." Why follow Pauling's framework? As Crick put it, Pauling demonstrated that, "exact and careful model building could embody constraints that the final answer had in any case to satisfy. Sometimes this could lead to the correct structure, using only a minimum of the direct experimental evidence." Watson recalls how other influential figures, such as physicist turned biologist Max Delbruck, "had ambivalent feelings about the ultimate value to biology of Pauling-like structural studies." Watson and Crick did not share this view.

Watson comments in his Nobel Prize lecture (10) that Crick and Watson "quickly discovered that we thought the same way about biology. The center of biology was the gene and its control of cellular metabolism. The main challenge in biology was to understand gene replication and the way in which genes control protein synthesis . . . these problems could be logically attacked only when the structure of the gene became known. This meant solving the structure of DNA. Then this objective seemed out of reach to the interested geneticists."

However, Watson and Crick sought to "imitate Linus Pauling and beat him at his own game." Watson and Crick used Pauling's framework, but, contra Kuhn, it was Watson and Crick that made the revolutionary contribution to science by discovering the structure and function of DNA. (Even though Pauling was also working on a model of the DNA, and it was Pauling that invented the techniques of modeling complex molecules by using macro-scale building blocks).

Framework or method?

If Watson and Crick were using Pauling's "framework," why did they discover the DNA model instead of Pauling? Observers such as Freeland Judson, in his magisterial history of molecular biology, *The Eight Day of Creation*, also recognize that Watson and Crick were using Pauling's framework: "[Watson and Crick] could get there first by borrowing Pauling's model-building method." Judson's use of the term "method" is misleading, however; Pauling, after all, was using the same "method." If he was using the same method, why did not Pauling develop a successful model of the DNA before Watson and Crick, since he obviously had access to the set of procedures, method, or paradigm for developing models of molecules that he himself had created. Thus, Pauling's framework was not a method in the sense that there were no set of procedures to follow to arrive at a solution. If so, then Pauling would have discovered the model of the DNA before Watson and Crick. Instead, as Kuhn himself would suggest, it was a framework for approaching and conceptualizing questions and problems in science; but, contra Kuhn, this is a case of a major paradigm being established before and independent of the revolutionary discovery and revolutionary change to which it was later attached. By a strict reading of Kuhn, Watson and Crick were doing little more than "mop up work" or "normal science" instead of highly innovative or revolutionary science since they were applying someone else's paradigmatic ideas or model or method for approaching problems.

As alluded to above, Kuhn was originally trained in physics, like most of the dominant major philosophers of science, such as Karl Popper, Carl Hempel, Imre Lakatos, and others, or historians of science such as George Sarton, Gerald Holton, or I.B. Cohen. Like Kuhn, all of these figures portray revolutionary change or revolutionary discoveries in physics and other branches of science as involving a single or major paradigm change. Watson and Crick's scientific revolution is futuristic in the sense that it involves the use of multiple frameworks for its revolutionary contribution. By contrast, Kuhn suggests that paradigm changes in physics and other branches of science are analogous to singular framework changes in the nature of perspective in the history of art and architecture.

On Watson and Crick's scientific revolution: Watson and Crick employed Gregor Mendel's conception of the particulate nature of genetic information (instead of Aristotle's early conception of blending inheritance); Watson and Crick stated that they employed Erwin
Schrodiner's speculative conception from his book *What is Life?*, that the genetic material would likely be a complex aperiodic crystal; Watson and Crick employed Linus Pauling's framework of modeling complex molecules using indirect evidence (such as by X-ray crystallography by other researchers); unlike Pauling and other chemists and biochemists that still thought the genetic material would be a protein, Watson and Crick recognized that the genetic material could be the DNA, and that the structure and function of DNA could provide information for the building blocks of cells and cellular differentiation. (The Futuristic art of Boccioni, Marinetti, Picasso, Georges Braque, Kazmir Malevich, Natalia Goncharova, and Olga V. Rozanova is said to involve multiple perspectives and frameworks).

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Note on Incommensurability

Since Watson and Crick used multiple frameworks or paradigms in their scientific revolution discovering the DNA as the genetic material, the different paradigms were not "incommensurable" as Kuhn alleges. The "incommensurability" claim is another controversial and debated aspect of T.S. Kuhn's model of scientific change and scientific revolutions. Different paradigms are "incommensurable" with one another: "the world of research will seem, here and there, incommensurable with the one that inhabited before. That is another reason why schools guided by different paradigms are always slightly at cross-purposes."

As suggested in the foregoing sections, paradigms are not necessarily incommensurable as Kuhn argues in this famous work. Instead, as the scientific revolution of Watson and Crick shows, different paradigms for theory and research may be complementary and potentially additive or multiplicative in their effects.

Thomas S. Kuhn focuses especially on the history of physics and astronomy in formulating and expressing his views on the nature of scientific change and discovery. This brief paper may have the added value of informing and challenging dominant models of the nature of science and scientific investigation that depend far more on models of physics and astronomy, and especially their histories in early modern science, compared to modern biology, genetics, biochemistry and the information sciences or computer science.

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