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A Kuhnian Analysis of Paradigm Shift in Recent Biological Taxonomy

In his 1962 book *The Structure of Scientific Revolutions*, Thomas Kuhn challenged the previously held notion that scientific progress is a gradual continuum. Kuhn instead suggested that scientific progress is based on a structure of a shared set of beliefs assumed to be true in specific scientific field, known as a paradigm, and the manner in which these paradigms are formed, built upon, or overturned for the creation of new paradigms. Sherrie Lyon's article "Thomas Kuhn Is Alive and Well: the evolutionary relationships of simple life forms—a paradigm under siege?" explores how Kuhn's ideas of paradigms can be applied to the recent dilemma in biology about whether there are two or three primary types of life forms (prokaryotes, eukaryotes, and possibly archaebacteria). Kuhn's structure of scientific process can be used to examine this controversy by looking at how the formerly held paradigm that there are two fundamental life forms is being overturned and replaced by the new paradigm that archaebacteria is also a fundamental life form, and the implications this may have for the scientific community.

Lyons describes Kuhn's idea of a paradigm as a "set of shared beliefs and achievements by a specific group of scientific practitioners." In The Structure of Scientific Revolutions, Thomas Kuhn argues that before scientific discoveries become significant, they have to be related and in agreement with a preconceived notion. Scientists want to solve an old paradigm, not start a new one. There is first

a “pre-paradigmatic” stage, which is basically random fact gathering, in which scientists are unsure of what information and discoveries are significant and which should be disregarded. Then, once enough information is assembled and accepted as true by the scientific community, the paradigm is established. Fundamental principles of a field becomes fixed, and scientists focus on problems in which they know have a definite solution. If enough anomalies are found, the current paradigm is challenged, what Kuhn calls revolutionary science, and it is either flexible enough to survive or a new paradigm is established in its place.

Sherrie Lyons applies Kuhn’s idea of paradigms to the modern debate over whether there are two or three fundamental groups of living organisms. She describes a scientific paradigm that originated by the beginning of the twentieth century: that the every living organism could be divided into two fundamentally different groups, eukaryotes and prokaryotes. Eukaryotes were defined as such by the fact that they possessed a distinct membrane bound nucleus. Rather than being defined by shared qualities, prokaryotes were defined by their lack of certain characteristics. The relationship between different prokaryotes and their shared qualities were not yet known, and until the late 1950s and 1960s, when the field of molecular evolution was born, the classification of prokaryotes was still in a “pre-paradigmatic stage.”

By the 1980s, Carl Woese and his coworkers suggested another fundamental division of organisms: archaebacteria. They discovered that this group of “archaebacteria” were no more closely related to prokaryotes than eukaryotes, and they established several fundamental differences between archaebacteria and

prokaryotes, such as the environments they are found in, their evolution rates, and metabolisms. Woese argued that since archaebacteria are a distinct group with a separate, individual line of descent from their ancestors, they should be classified as a distinct fundamental group. This became the prevailing paradigm, overturning the past paradigm that there were only two fundamental groups.

In the 1990s, however, Radney S. Gupta, a biochemist, came up with significant evidence to challenge Woese's paradigm, and suggest a reversion to the previously held notion of two basic divisions among organisms. Gupta discovered a deletion in a sequence of gram-positive bacteria that did not hold with Woese's findings. Gupta upheld Woese's finding that archaebacteria and eubacteria are different, but found a close evolutionary relationship between archaebacteria and gram-positive bacteria. This led Gupta to suggest a new classification: there is a great distinction between prokaryotes and eukaryotes so they are still the basic building blocks of taxonomy. Within the prokaryotes there are two subdivisions based on the relationships between the prokaryotes and their environment: "monoderms"(archaebacteria and gram-positive bacteria, which only have one membrane), and "diderms" (gram-negative bacteria, which has two different membranes). Gupta's findings suggest that the old paradigm might not necessarily be overturned but that it may be flexible enough to survive to fit new found data.

Sherrie Lyons asserts that "if one accepts Gupta's interpretation, then the three-domain hypothesis cannot be correct." She says that the findings of Gupta and Woese cannot coexist and that one paradigm or another must be overturned. But has any paradigm necessarily been overturned? The original paradigm established

at the advent of microscopy simply defined eukaryotes, and left the group of prokaryotes still in the "pre-paradigmatic" stage. If this group was still in the pre-paradigmatic stage, can a paradigm truly be overturned? Much of Gupta's research drew upon or elaborated on Woese's work, and confirmed that archaebacteria was fundamentally different from other types of prokaryotes. Lyons says that "to return to a classification that only recognizes two domains would be a major setback in the understanding of both the prokaryotic world and the role that microorganisms play in the history of life," but at the moment it is inconclusive how many fundamentally different types of prokaryotes there are, but they still can be grouped together by the fact that they are not eukaryotes. Modern scientists are still in the process of classifying and defining them, but putting them under an umbrella term does not dampen our understanding of them or their fundamental differences and roles in evolution and the environment.

Bibliography:

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