Day 3: Paradigms and Scientific Revolutions

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HOT Handout One Martello Paradigms Summary

"Thomas Kuhn's Scientific Revolutions"

(a summary by Rob Martello)

In 1962, Thomas Kuhn first published *The Structure of Scientific Revolutions*.[1] This groundbreaking book introduced concepts such as **paradigms**, **paradigm shifts**, **scientific revolutions**, and **normal versus extraordinary science**. This document will provide an oversimplification of this theory to help us start our discussion. Read it with a critical eye, and think of ways that it might relate to technology.

Paradigms

Kuhn's theory begins with the proposition that individuals and societies create and define **paradigms** that shape their thinking. A paradigm is a way of thinking, a mindset, a world view, a philosophy. Kuhn often uses the term broadly, as a conceptual framework that describes the universe. For example, you might say we operated in a "Newtonian" paradigm until this was replaced by a "Relativity" centered paradigm, to be replaced eventually by a "Lady Gaga" paradigm.[2]

We can also apply paradigm theory to non-scientific endeavors. For example, some artistic paradigms place a high value upon realistic portrayals of people and objects, the use of perspective and vanishing points, three dimensional texture, and so on. Picasso introduced the cubism paradigm in 1908, in which he shattered perspective and portrayed all aspects of an item at the same time.

A paradigm is more than a set of rules or collection of facts. Instead, it is a way of thinking that defines the type of questions one is allowed to ask. If our paradigm indicates that the universe is infinitely large and forever expanding, for example, one would not attempt to measure its length – this question holds no meaning. If we believe in a flat earth paradigm, you might ask (or investigate) what happens when you reach the edge, because this is a valid topic that extends the coverage of our understanding of the world. Therefore, a paradigm defines the questions we ask, the way we structure our investigations, and the framework we use to contextualize and validate the answers to these questions.

Without paradigms, Kuhn contends that we would not have science. We require shared beliefs, axioms, and so on to form a starting point for discussions and experimentation.

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[1] Thomas S. Kuhn, *The Structure of Scientific Revolutions* (London: University of Chicago Press, 1962 and 1970). All quotations and page citations are taken from this source.

[2] The third paradigm in this example is, in fact, a joke.

WORKING WITHIN A PARADIGM

When scientific practitioners agree upon a paradigm, they practice what Kuhn calls **normal science**. Normal science is the process of better defining and elaborating upon a paradigm. A paradigm might be limited (especially at first) and leave open questions for scientists to answer through observation, theoretical speculation, and experimentation. In Kuhn's words, "Normal science does and must continually strive to bring theory and fact into closer agreement." (page 80) This sort of clarification and explanation (described as "puzzle solving") constitutes the majority of all science. A practitioner of "normal science" uses the paradigm as described in the prior section, as a guide to the questions worthy of investigation and a framework aiding the interpretation of the answers to these questions.

With the passage of time, scientists often uncover **anomalies** – inconsistencies, errors, or gaps – in a paradigm. Many anomalies are downplayed or ignored when they first appear because it is easier to discard the anomaly than challenge the paradigm. Anomalies might be disproved, or addressed and explained by further research or even an expansion of the paradigm.

For example, Ptolemaic astronomy contends that all heavenly bodies revolve around the Earth except for the "fixed stars," so titled because they are fixed to a rotating sphere. This system explains many astronomical facts to a great deal of precision and provides a framework for asking and answering new questions. However, how can one explain the retrograde motion exhibited by certain planets, when they move back and forth across the sky (with respect to the stars) instead of linearly?[3] This anomaly can be addressed by adding complexity to the paradigm … i.e., by stating that the planets move in epicycles, or smaller orbits around points that themselves orbit the earth.

WHEN PARADIGMS COLLIDE

The accumulation of anomalies causes a paradigm to stretch as it increases in complexity. A sufficient number of anomalies might cause the unthinkable to happen, and shed doubt upon the validity of the paradigm (in part, this is caused by the widespread preference for simple and elegant solutions). Paradigms usually possess a huge amount of inertia and the scientific community often invests a lot of research in defining and supporting a mature paradigm. A challenge to a paradigm is a major event, referred to as a **Scientific Revolution**. Now we're getting to the good stuff, so tighten your seat belts!

Scientific revolutions inaugurate a period of tremendous uncertainty and even crisis. Scientists who believe the paradigm has been discredited (or stretched beyond plausibility) begin the development of new paradigms, and are unconstrained by most or all of the assumptions that previously guided their work. This process is referred to as **extraordinary science**, because it lends itself to great leaps of imagination and unfettered creativity. All bets are off and all hypotheses are fair game during this period of paradigm construction.

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[3] The word "planet" comes from a Greek term for "wanderer." Thank you so much.

The magnitude of paradigms makes scientific revolutions even more interesting. Many scientists are unable to conceive of a new paradigm after spending a lifetime following the guidelines of the old one, and respond to the revolution by defending their own world-view to the death (perhaps not literally). Others might find the new idea persuasive enough to cause them to joyously add their support to its development and refinement. If the new paradigm gains ascendancy, the revolution itself appears increasingly invisible because the new paradigm is viewed as a universal truth that was always in existence: the new paradigm becomes a new reality that successfully displaced and corrected an earlier error. In fact, the term "science" is often reserved for people who carry out their work in accordance with the current paradigm – holdovers from previous modes of thought or objectors who propose a new paradigm are often marginalized as practitioners of pseudo-science.

Optional Thought Questions:

The following questions are posed for your philosophical edification. Go on, give them some thought and even discuss them with your friends… but please do not write up answers to them!

- Is paradigm theory a way of saying that truth is relative, a matter of popularity among qualified practitioners? Is truth always in the eye of the beholder? Does objective truth exist?
- Is there such a thing as scientific progress?
- Is knowledge developed in a linear method?
- Do paradigms serve a useful function in scientific research?
- What are the consequences of multiple paradigms existing at the same time?
- What paradigms impact your life?

This summary was written by Rob Martello. Feel free to contact him with any comments or questions at robert.martello@olin.edu.