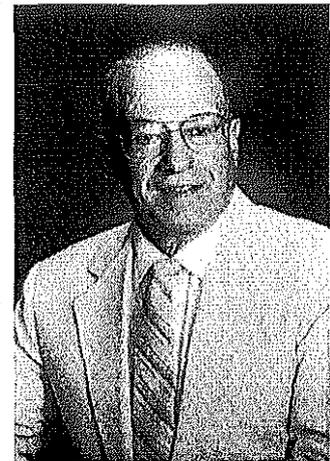


Kuhnian Discovery: Its Way-Stations and Choke-Points

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ABSTRACT: Thomas Kuhn differentiated normal scientific progression from the replacement of basic assumptions by a novel paradigm. With his recent death, it is time to sequence the innovation cycle, some of whose parts he had detailed. A Kuhnian discovery faces battle before it is can even be tried and evaluated. We enumerate over two dozen "way-stations," or phases, many heretofore vaguely differentiated in half a dozen academic disciplines. Each phase is illustrated with a vignette. Within that cycle, the mental awareness that one has found an anomaly is a distinct advantage, for which we propose the name of neocognition. Certain phases are especially vulnerable dead ends, choke-points, of the entire sequence. Particularly so are the 8th to 10th periods – the cultural reactions based on the perceived immediacy of benefit. Any requirement to obtain commercial support at this pre-development stage prevents the emergence of even farsighted latent support that could hurdle the remaining steps. The eventual acceptance of any Kuhnism activates forces that will likely evolve its own era of scientific / political correctness. – From a score of thumbnail histories, it becomes obvious that research organizations may accelerate basic discovery by pre-constituency dissemination.

1. Methodology Of Basic Discovery Offers Great Potential

1.1 *The Divergent Paths Of The Two Kinds Of Discovery Lie Unsynthesized.*

One of science-history's most stimulating discoveries in the past half-century is that there are at least two quite different kinds of discovery. The first simply fills a gap within the fabric of an existing theory-set, or paradigm. It is normal, incremental, or interpolative, discovery. But the other kind reveals a new paradigm altogether. Science-historian Thomas S. Kuhn (1962) called it revolutionary science. We shall term such innovation as "Kuhnian."

There have appeared many detailed case-studies, and, at the other extreme, many ultra-broad, philosophical conclusions. Yet a systematic utilization of Kuhn's finding would require the codification of the phases surrounding it in order to find where and how

they may be adapted to a particular discovery. We have been unable to locate such a technical synthesis.

The literary critic Jacques Barzun (1986, p.495) has declared that the Western World's codification of particularities is "today ... one of the largest dimensions [of scholarly activity since 3rd-century B.C.] in Alexandria itself." Therefore, let us make an early attempt to codify Kuhnism. If we try to fit the concept into a cycle, we can find surprisingly clear way-stations.

1.2 *Social Science & General Systems Suggest Comprehensive Theories.*

The reason for the intellectual scatter may be that many disciplines are potentially involved, within both the natural sciences, the individualistic human sciences, and the social human sciences. General Systems Theory is one such. It has been defined as the search for analogies between different levels of organism (e.g., between viruses and plants). And anthropology is the study of principles differentiating the

human from other species. It has a long tradition of concern with the zeitgeist factors in innovation. For example, there is the entire subfield of acculturation studies, whether "spontaneous" or planned (e.g., Arsenberg and Niehoff 1964).

As for inventions of the interpolative kind, there is a vast literature (e.g., Rogers, 1971) on diffusion of ideas. There are many other impinging subdisciplines, such as the popular culture of the Great Man, or hero; the psychology of apperception; the sociology of diffusion; etc. And historian Kuhn himself (e. g., 1962 and 1970) brilliantly detailed the battles facing many paradigms (especially of the 18th and 19th centuries). His history-of-science method was usually to detail the repartee between technical coteries, especially in the natural rather than the social, sciences.

The present author has, however, argued (e.g., 1984) that the under-studied element is *process*. We believe that the processual analysis reveals striking similarities in the broad strokes whereby a new paradigm battles its way to possible acceptance.

Alas, we know of no university Department of Inventiveness. Instead, we must search many disciplines. Each discipline tends to emphasize only one part of the cycle of development through application. Many commingle normal and paradigmatic change. The time frame of major innovation covers thousands of years, and the archives are scattered.

For all these reasons, we cannot begin with the statistical sort of analysis that enlightens research in well-defined areas. Rather, we must select as tentative exemplars, the provocative cases noted over the years. Because of this paper's wide scope, we cannot pretend that it is comprehensive. We offer it as a provisional skeleton on which reader revisions may slowly take their places.

Perhaps our crude method should be called Select-and-Sequence: That is really the obvious method in early codification of any phenomenon. For example, current research methodology suggests that the understanding and possible engineering of DNA will come from the ongoing Genome project to record all experimental findings in the sequencing of genes. Again, the significance of the human adulthood initiation was clarified by Arnold van Gennep's (1909) analysis into a three-part cycle of separation, transition, and incorporation. Likewise, our method will be to attempt to specify and sequence the phases of a Kuhnian paradigm acceptance of a phenomenon. In Kuhnism too, we find some phases well-recognized, while others seem quite unremarked. And so our discussion will offer disproportionately rectifying treatment, rather than equal treatment, for each phase.

1.3 Scope & Definitions

A few definitions are in order.

scope of applicability: The way-stations to be described involve such institutional matters as grant-awarding. For such reasons, the discussion will not apply to developing nations, and will concern only those cultures which have the so-called Western criterion of falsifiable science.

world-view, paradigm: A set of usually unconscious, interlocking beliefs that define or guide one's perception.

interpolative or incremental search or discovery (Kuhn's "Normal Science"): Research or discovery of one variable or one gap within an already accepted structure. Herein lies most of what is popularly termed INVENTION.

bean-counting: Emphasis on measurement at the expense of its significance, technique exceeding purpose.

gimcrackery: Cheap, contrived, shoddy expedients in general. The word could well be applied to interpolative research and organization seeking quick commercial application, often contracted for development at otherwise prestigious institutions. Particularly suitable are auto-suggestive, self-fulfilling solutions: Many physical conditions, such as headache or acidulous stomach, can be induced by a culture's constantly discussing them. Such iatrogenicity can generate an endlessness of symptoms and a "rathole" of consumption. Therefore those studies are often funded by pharmaceutical corporations producing popular but scientifically trivial merchandise, like anti-gas antacids.

Kuhnian discovery, Kuhnism, etc.: Discovery, codification, or similar output that importantly changes a basic viewpoint about causality in some science. This article will focus on Kuhnian, not normal, discoveries.

2. Scientific Disarray Engenders Kuhnism

2.1 Oddity Accumulation Breeds Kuhnian Discovery

2.1.1 Interpolative Discoveries Fill Small Gaps, Reveal Others

It has well been argued that each developmental phase of a culture, each spirit-of-the-times, or zeitgeist, itself quite determines where most of its creative spirits will cluster. A ranked society tolerates elitists' recondite activities, as in astronomy rather than applied sociology. This is a most important "climatic" matter. Therefore we defer further discussion of zeitgeist until considering what elite reception occurs after a discovery is announced, around our phases 8 and 9.

Clearly, however, most intellectual projects operate within the existing paradigm of a given discipline, such as traditional chemical experiments within the Table of Elements. They essentially fill gaps, like predicting the properties of a proposed compound by comparing some already known compounds.

But any existing theory or paradigm is, after all, merely an abbreviated model or algebra of reality. Hence, some findings gradually appear which misfit the most comprehensive extant theory-system. For example, when Ptolemaic astronomers charted the planets, they could not explain why the predictable grand sweep of the Sun and of each planet "around the Earth" should be producing wobbly sky paths.

2.1.2 *Misfitting Data Are Found & Reported* (=Kuhnian Phases 1-2)

In the earliest phase of a Kuhnism, an acute observer makes measurements that reveal the misfit of his existing world-view. (To standardize reference to these Kuhnian-acceptance milestones, let us number each, with this becoming Phase-1.) Thereby he generates "cognitive dissonance" (Festinger, 1962).

But humans dislike anomaly. And so the trouble area is papered over by some concept, however quackish, rather than being recognized as abnormal. The Establishment must quickly rationalize some intervening gimmick (=Phase 2). Thus, the Earth-centered astronomers explained the grievous backtracking that Earthlings saw in planetary sweeps by presupposing intricate "epicycles." The masses see no paradox. Even today, when several parts of Newtonianism have been shown erroneous, most earthly activities appear consonant with Newtonian physics, not requiring Einsteinism. Chaos may be, after all, merely the confluence of several small or unnoticed factors.

2.1.3 *A Researcher with Overlapping Backgrounds Enters the Arena* (=Phase.3)

As a consequence, the few chaos-busters are often of that special personality which enjoys gaming. According to R. S. Root-Bernstein (discussed in Garfield, 1989, p.315-316), they tend to think holistically, as for pattern recognition.

Such researchers become dissatisfied at what they feel is mere convolution. Investigation attracts a person who understands not only the obviously involved discipline, but also straddles another field. The Kuhnian's mental tapestry accommodates more variables, leading to his broader viewpoint. Hence he has avoided being 'perceptualized' in a single mold (cf. R. W. Girard in Ghiselin 1952, p.249). The multiple disciplines may be academic. Thus, Thomas Malthus (1766-1834), of population-explosion fame, brought

both clergyman and economist experience to bear. – Or, since ethnicity may be considered a kind of mental discipline, the perceiver may well come from one ethnicity into another. One obvious example is the widely European group of World War II refugees who made contributions to the U. S. development of atomic fission.

And, in this day of large organization, the contrastive backgrounds may appear as one hierarch examines the work of a subordinate. Thus, an outside committee oversaw the current, researcher-specific work of the Medical Research Council (U.K.). Finding an insightful chapter by a stereochemical-configuration researcher, one committeeman emphasized it to his colleague, James Watson (1968, p.174-182). Noticing an x-ray of a strong meridional reflection, Watson was able to concentrate his effort on the two-chain model that proved the correct structure of DNA.

The polymath seeking a new paradigm begins by assembling the existing misfits. He tries to algebraize them in a novel way. As the Nobel physicist Paul Dirac once commented, "The really good ideas are had by only one person."

2.2 *Paradigm Incubation Requires Mental Rearrangement & Tolerance*

2.2.1 *The Reporter Perceives a Misfit in the Compilation* (=Phase.4)

The true discoverer may or may not be the gatherer of the misfitting data. In that way, one Kuhnian attacked as erroneous, the extensibility of James Clerk-Maxwell's fixed magnetism: "Maxwell's electrodynamics ... when applied to moving bodies, leads to [unnatural] asymmetries" (Albert Einstein 1905).

Two separable activities must occur: compilation (phase 4) and insight (phase 5). Perhaps the classic case of the combination in one person is Darwin's (especially South American) naturalist gatherings, and his London meditations.

The combination of talents is particularly useful where there is a back-and-forth of micro-changes. In that way, the plant geneticist Barbara McClintock noticed that adjacent tissues in maize were sometimes inverse in their streak coloration. This anomaly suggested that the mitotic development time must have been early. There must be chromosomal breakage and transposition, controlled by what she would call a Dissociator. The gene is thus not a fixed hereditary unit, but somewhat regulated by an organism itself. Her gapped theory was not made "seamless" until six years after her first reports (Keller, 1983, p.123-144).

An example of the other approach, separation of data gathering from data analysis, is the utilization by Johann Kepler (1571-1630) of the planetary measure-

ments made by Tycho Brahe (1546-1601). Kepler concluded that the planets travel in ellipses, not circles.

2.2.2 *Curiosity Teases Researcher(s) toward a Novel Solution (= Phase-5)*

The insight requires the basic instruments of logic. Typically these are pencil and paper and (in recent years) simple computer-running time of modest amounts. This work is labor-intensive, not capital-intensive. "It is genius that leaps ahead of the facts," declared Kuhn (1961; 1977, p. 194), "leaving the rather different talent of the experimentalist and instrumentalist to catch up." Fieldwork or laboratory was needed to evoke the raw data, but in this stage of fitting the "jigsaw pieces," a laboratory is usually not needed.

Consider the Michelson-Morley experiments (1881 onward) which had cast doubt on Newtonian light-velocity theory. Solution came not with ever more expensive equipment, but from Einstein's (1905) thought-experiment (Gedankenexperiment) that time is an extension, rather than an isolate, of space. Rather likewise, the discovery of the structure of the basic life stuff, DNA: Its final decipherment required a minimum of special equipment, merely things like microphotographs of the atom (James Watson, 1968).

A phase-5 product is essentially a scholarly publication: article (e.g., Einstein, 1905) or book (e.g., Darwin, 1859). Its great originality requires a stability of surroundings. Thus, the aforementioned creative burst in Einstein's life came while he drudged in the Swiss Patent Office as a salaried examiner, Technical Expert Third Class. Indeed, it could be argued that the Kuhnian is not an "active" scientist but a codifier.

Finally, some pioneer dares to propose a grossly novel paradigm that fits most of his folder-full of exceptions. The present author would differentiate two kinds of compatibility. In the first, the discovery unifies an unprincipled (Kuhn's "pre-paradigmatic") mass of activity, aiding it toward attaining initial disciplinary status. An example might be the Cybernetics structured by mathematician Prof. Norbert Wiener (1948).

The culturologists' current trend toward self-searching (hashed and reshaped in Anthropology Newsletter of the mid-1990's) suggests that many consider anthropology to be pre-paradigmatic, despite the emergence of multiple coteries within that discipline. More probably, each coterie will eventually succeed to full-discipline status in its own right, rather as the discipline of Philosophy has historically birthed many now-separate activities.

A second kind of Kuhnism appears in a set of activities that *had* already been linked into a discipline. But data "violating" the overarching theory have now

accumulated. The Kuhnian proposes a broader system. For example, when the heavenly bodies kept stubbornly appearing in the places not allowed by Ptolemaic calculations, Copernicus radically supposed that the Earth circled the Sun.

2.2.3 *A Radical Perception ("Neocognition") Finally Unifies the Unprincipled Activity (=Phase-6)*

Yet merely observing a phenomenon is not the complete act of discovery. Also crucial is the cognition that it is phenomenal and not merely (say) a dubious or trivial measurement. "Discovering a new sort of phenomenon," argued Kuhn (1977, p.171), is necessarily a complex process which involves both *that* and discovering *what* occur together and in an instant."

Kuhn seemed to consider that situation as an original observation on his part. But we find traces of it in many predecessors. The idealist Schopenhauer noted (1851; 1974, p.208) that "he alone is the author of a truth who has recognized it from its grounds and has thought it out to its consequents.... Columbus is the discoverer of America, not the first shipwrecked sailor [earlier] cast up by the waves." Likewise, the mathematical idealist Alfred North Whitehead remarked (1917; 1991, p.252) that "to come very near to a true theory, and to grasp its precise application, are two very different things...."

Kuhn (1977, p.171) concluded that "we need a new vocabulary and new concepts for analyzing events like the discovery of oxygen", which was encountered for at least two decades before being perceived as an element. But Dr. Kuhn was a science-historian, not a lexicographer. In fact, his belief that existing terminology should be extended to more situations, proved obscure when he tried to redefine the established term, *paradigm*.

If, then, this consciousness (phase-6) is not to be continually relost and refound, it requires a distinctive name. There is no need to lament its absence when it may be coined. Cognition as a novelty is similar to, yet nuanced from, such terms as *subceiving*, *pre-cognizing*, *cognitizing*, etc. The present writer suggests that such a discovery consciousness be termed the *neocognizing* of the phenomenon.

2.3 *Dissemination Seeks Possible Constituencies*

2.3.1 *The Kuhnian Whispers His Hunch (=Phase-7)*

The phase-6 perception was purely internal. But the Kuhnian is a human, not a machine, and so he also needs social support: "Because every creative act overpasses the established order ..., it is likely to appear eccentric to most men. An inventor must begin in isolation and draw the group to himself only as it

is discovered ... that he has invented some part of what they are in need of" (Ghiselin, 1952, p.13). Now the percept is to be tested socially, at least by the braver innovators.

And so "trial balloons" constitute a seventh phase. Sociologists have termed the effectual unit of an advanced (though not necessarily Kuhnian) scheme as an "invisible college" or "Special-Interest Group." The methods range from face-to-face conferences and, in the days before international reproduction of tables-of-content, publication of the hunch in a local journal, as Mendel did. (Today the "whispering" might include computer Chat Rooms.) Their relative low cost is often termed "seed money."

Example: In 1954, Eugene Garfield used the magazine *Science* to argue that there should be a system to trace the fate of every alleged discovery forward in time. Hence the publications critiqued ("references cited") appearing at the end of academic articles should also be arranged by the name of the earlier (targeted) author. One reader, Nobelist Joshua Lederberg, advised Garfield to apply for a National Science Foundation grant under a certain category in which Lederberg had some influence. There Garfield began to succeed in bankrolling his "citation indexing" (1977:passim).

2.3.2 *A Kuhnian Discovery Begins Gapped & Flawed*

The author of a revolutionary-science proposal cannot at first hope to marshal full logic and detail. For example, the Darwinian hypothesis lacked the proto-human skeletons that would prove anthropoid evolution in each intermediate era. Darwin likewise erred in imagining migratory "gemmules" instead of what we would call (relatively stationary) chromosomes. And yet, his theory of evolution would withstand time.

The early hypothesis is inherently partial. It must be bruited for complete feedback, and yet it is inherently incomplete. This paradox produces collegial skepticism, as documented for many schemes by Downs (1956). Democritus's Fifth-century B.C. hypothesis of microorganisms, for example, could not be "proved" without the much later microscope.

3. Plebeian Presentism Inhibits Kuhnism

3.1 *Democracy Favors Apparent Advantages, Not Eventual Significance*

3.1.1 *Are Zeitgeists Themselves Cyclic?*

The lengthy battles of proposed paradigms blight them from popular arenas. Many scholars have argued that humankind suffers inherently systemic devolution from its heroic founders of any culture. The 14th century Berber historian Ibn-Khaldun said as

much, as did the French penologist Alexis de Tocqueville, the British historian Arnold J. Toynbee, etc. In the 18th century, the Scottish historian Alexander Tyler principled the problem thus: "A democracy cannot exist as a permanent form of government. It can only exist until a majority of voters discover that they can vote themselves largess[e] out of the public treasury." And the version of the political scientist Northcote Parkinson is that any power structure faces a cyclic spiral downward toward populism: "Monarchy arises, to be superseded by aristocracy, which is replaced by democracy, which ends in dictatorship, which may well be the prelude to monarchy again" (Parkinson, 1958, p.305).

The coteries that Kuhn discussed are mainly those trained in natural science. But social science equally emphasizes the importance of *zeitgeist*, the spirit of a given ethnicity in a given venue. To that variable within phase-6, we must digress before moving on.

The tolerance for statesmanship seems to parallel the degree of political separation between grantors and the masses. Those that are remote, such as entrenched monarchies, will have little concern for immediate payback. Thus, Antoine Lavoisier (1743-1794), was as a nobleman able to defeat the phlogiston theory with a combustion theory - but later the French Revolutionaries beheaded him.

The argument implies that an early monarch will desire to leave a legacy, and therefore practice true statesmanship. But if the polity evolves into republicanism, egalitarian momentum is likely to accelerate into democracy. The masses may install demagogues to distribute quick returns.

This dilemma of excessive short-term gratification ("presentism") in popularity-based politics haunts its scholarly institutions. Of course, not every polity attains the democratic phase that allegedly triggers a collapse.

3.1.2 *Democratic Devolution Pressures Presentism*

Observers have long remarked the Yankees' presentism and their attendant neglect of long-range enhancement. "They are more apt to complete a number of undertakings with rapidity, than to raise lasting monuments of their achievements," lamented Tocqueville (1835-1840, vol.II, p.xix); "and they care much more for success than for fame." For example, the 1986 (U. S.) Tax Reform Act eliminated incentive for long-range risk-taking investment ("capital gains") by taxing it at the same rate as short-term benefits. Such presentism must be perceived as a byproduct of "The Democratic Disease."

3.1.3 Profit Comparability Forces Measurement of Intangibles (=Phase-8)

Response to such incomplete trial balloons may be considered Phase-8 of the Kuhnian curriculum. The thought-experiment was, after all, really a plea for financing, as summarized in the working-class adage, "If you're so smart, why ain't you rich?" But resource investment in any scheme must, especially in a representative government, consider cost-benefit. How long, administrators ask, between investment and payback?

Rewarding the immediately visible, presentism forces interpolative discoveries to fit extant niches in the economy. Their siting requires measurement and machinery. Indeed, industrialism has long suffered a fascination with making precise even that which is inherently fuzzy, such as human relations. Such sham use of mathematics was termed "quantophobia" by Sorokin (1956, p.102). It was personified by the U.S. Defense Secretariat during the Vietnam War (ca. 1964 - 1973): Robert McNamara assured us that 'by every quantitative measure, we are winning the war.' (Even today, many deny that the U. S. lost.)

Excessive or misfocused precision, also termed "bean-counting," aids shortsightedness by demanding quick, trivial Gimcrackery-type work. The present writer constantly observed this intolerance for long-range analysis of ethnic specialization when serving as the only anthropologist among the 1,000 staffers (mostly psychologists) in the U. S. "Regional Educational Laboratories" scheme (Burger, 1970).

In nondemocratic industrial systems, the criteria would be somewhat different. U.S.S.R. socialism, for instance, was ambivalent about paradigm discovery. Its alleged faith in pure science was, in fact, belied by its deeply politicized situation. Thus, a U. S. laboratory scientist could requisition a slightly irregular piece of tungsten for next-day delivery. But in the Soviet Union, even if the scientist obtained the many necessary approvals for experimental work, his request would at best be entered into the next Five-Year Plan for coal and iron (Ramo, 1983, p.252).

3.2 Departmentalism Generates Standardization

3.2.1 Funders Unconsciously Inhibit Major Discoveries

Kuhn found (1962) that the acceptance of a worldview, such as Newtonian physics, gradually generates its own organizations and textbooks. "The ruling ideas of each age," Karl Marx's *Manifesto* had likewise argued in 1848 (Bartlett, 1968, p.687) "have ever been the ideas of its ruling class." A consequence is that leaders of mainstream paradigms have little incentive to disavow those foundations. (One recalls the adage that "Dukes don't emigrate.") Hence a granting insti-

tution will be staffed and committed by office-holders who have already been imperceptibly indoctrinated against other systems. Major discoverers must be insiders rather than accountants, if they are to break the circular logic: "Once ... a theory has been adopted by the profession - no theory is recognized to be testable by any quantitative tests that it has not already passed," cautioned Kuhn (1977, p.186) That chilling comment casts doubt on Karl Popper's axiom that to be science, a theory must be disprovable.

Logic suggests further that the wider the membership of a funding committee, the lower must be the common denominator of any successful proposal. "The larger the informal group, ...the less exploratory and adventurous the group's discussions...", as Berelson and Steiner reminded social scientists (1964, p.358). This jury-like system is thus a method appearing rational but actually as political as it is scientific (cf. Cohen, 1983, p.1). Thereby Peer-Review favors modest projects.

The net result is the politicalization (perhaps preceded by Political Correctness?) of research. Its archetype is Trofim Lysenko as President of the U.S.S.R. Academy of Agricultural Sciences. His office decreed that crops must 're-geneticize' themselves to fit Marxist predictions. Alas, his violation of Mendelian genetics produced widespread famine.

Now, a private enterprise is faced with yearly profit-and-loss announcements that determine its stock-market position. But governmental grants importantly fund all universities. How, then, can they bankroll their long-range research? - Commercialists in several occupations, such as pharmaceuticals, stand ready, even eager, to transfer their research chores to the untaxed universities. By the end of the federal expansion, the leading universities of the U.S. already received about 9% of their research budgets from corporations, according to Holmes (1986, p.44).

Hence a researcher finds it easy to obtain funding on the superficial, especially "rat-hole" activities such as bibblers' stomach acidity, or self-induceable headache. Thus a potential geologist may be diverted from millennial erosion problems to the landscaping of a luxury golf course.

3.2.2 Tax Laws & Expense-Plus Further Deter Kuhnian Constituency

Taxation rules likewise discourage broad-range research. Thus, U.S. Internal Revenue Service regulations on research bonuses declare: "The credit applies only...in the experimental or laboratory sense... You cannot take the credit for ... social sciences or humanities...." (U.S., 1985, p.5). It is considered more real to work with tiny Outer-Space particles that live only a nanosecond, than with humans. Even then, fi-

nancial wizards can overrule senior scientists. Research itself becomes "accountantized."

4. Tortuous, Phase-Predictable Probations Confront Kuhnism

4.1 *As Theory, The Kuhnism Fits Nowhere*

4.1.1 *Publication Evokes No Reaction (=Phase 9)*

The Kuhnian must use cheap instruments. He tries to voice his hunch for discussion by his 'invisible college.' The "voicing" normally occurs in academic conferences and journals.

Now a Kuhnism at this early stage is a mere idea, an unpatented system, and not a three-dimensional, usable thing. The reaction to its bare announcement usually consists of a great yawn on the part of the "normal" (interpolative) scientists and corporations. This behavior constitutes phase-8.

Example: Einstein's theory of relativity appeared in 1905. (Exact day is unclear.) To imagine the reactive climate, the present author randomly selected a date within that era. What was the tenor of the world's leaders, as expressed in the then-leading newspaper, the *Times of London*? – No mention whatever was found of Einstein's revolutionary investigations. In fact, the principal headline was political: "...Nomadic Laplanders Are to Be Allowed to Graze ... in Each Country" (*Times*, 26 September 1905).

(In very recent years, those very Laplanders have become imperiled by the recent nuclear mis-release from the Cherynobl power plant – which derived directly from Einstein's slighted discovery.)

The result is that period-9 sees no supportive action concerning this "nowhere" announcement. In a similar fashion, London's Linnaean Society heard the original speciation announcements of Charles Darwin and of Alfred Russel Wallace in 1858, and yet officially concluded that "the year ... has not been marked by any of those striking discoveries which at once revolutionize...." (Clark, 1984; 1986, p.118).

The Establishmentarian may well try to defeat the new paradigm by quibbling some triviality in the micro-area where he feels secure. Plate Tectonics, for instance, was scorned by geologists because 'by now, the oceans would have drained between the margins.' Other examples of how today's classics were misjudged upon publication fill the pages of Downs (1956, mostly science), Henderson (1987, mostly literature), and books with sarcastic title like *The Experts Speak*.

4.1.2 *The Discovery Awaits a Zeitgeist (=Phases 10-11)*

Therefore the discovery becomes a "sleeper" to await need. This period may be designated as phase-10. "The Zeitgeist, ... the climate of opinion, ...

pushes one idea into bloom but nips another in the bud," explained Edwin G. Boring. The coming of the zeitgeist is not mystical but, ultimately, economic and Darwinian. The dream may mismatch the state-of-the-art, as when Leonardo da Vinci's 15th-16th Century helicopter drawings lacked the metallic moldability they would need for construction. Likewise, "why classical Greece was so sterile in useful inventions ... is to be sought in the predominant ideology, which exalted speculation over utilitarian application," explained Robert Lowie (1963, in Murphy, 1972, p.172). "Furthermore, the [Greek] social scheme allocated manual work to slaves, of which there was an ample supply. Those [patricians] who were mechanically gifted accordingly lavished their ingenuity upon clever but useless toys...."

And so a major factor in fitting the zeitgeist is the matter of immediate economic "progress" that the discovery will bring. At this early stage, humans are sometimes as short-sighted as organisms. "It is one of the best attested generalities of [organismic] evolution that its rate is exceptionally fast when an evolving group takes on some hitherto unexploited way of life or adaptive zone" (Simpson, 1961, p.20). Similarly in human affairs: A gene-based paradigm leading to (let us say) increased food supply would course through the Kuhnian curriculum far more quickly than a discovery dealing with the deep sea. The nutritional improvement would lead to the rapid efficiency leap and then a new leveling off – the "J-Shaped Growth Curve." Yet if a specific zeitgeist found the food-gene threatening a powerful group's patent, and if the deep sea concerns protection from submarined missiles, the priorities may be reversed. And so here is where the particular skills of the ethnographer are needed. The relationship between benefit and zeitgeist is probably inherently co-influential.

As a large nation industrializes, it needs to coordinate and accelerate its transportation and communication. By the 1870's, burgeoning U. S. capitalism was stimulating (multi-party) inventiveness in practical mechanisms. The ethnic-wide pressures toward simultaneous invention are one of the classical but recurring topics of ethnology (e.g., Kroeber, 1917). And so, patent descriptions of what is now the telephone were independently made by Alexander Graham Bell and Elisha Gray within hours of one another.

Or consider Gregor Mendel's genetic-dominance publication of 1865-66. It lay unused until heredity became topical at the turn of the century. At that time, it was rediscovered by three independent groups – within mere weeks (Barnouw, 1987, p.371). But Mendel's 35-year delayed recognition is not the extreme. Democritus's atomic systemization had to wait 2,500 years.

Discovery coming before its zeitgeist is "premature." Zuckerman and Lederberg (1986; 1991, p.19) offer as major reasons that they are "conceptually misconnected with 'canonical knowledge,' are made by an obscure discoverer, are published in an obscure place, or are incompatible with prevailing religious and political doctrine. Barriers between disciplines imposed by specialization of inquiry also contribute to neglect or resistance." But Oxford Unabridged defines canon as "... a standard of judgement or authority...." Hence their "canonical knowledge" is the very definition of a new paradigm.

Despite the oblivion, a playful genius (French, *bel esprit*) may occasionally mention the discovery. It may gradually win some small technical respect, some critical acclaim. The French equivalent, succès d'estime, may cynically be translated as "A Commercial Impossibility." In sum, blame it on the zeitgeist.

But the Kuhnian discovery refuses to be buried. It surfaces sporadically in this Phase-11. Hence, a good measure of the merit of such a discovery might be the accruing columnar inches that are devoted to critiquing the proposal, however severely, during this era.

4.2 Elsewhere, A Traditionally Insoluble Problem Justifies Speculation.

4.2.1 Recurrent Mentions Are Finally Challenged (=Applicatory Phases 12-13)

A few futurists and generalists, dissatisfied with the conventional paradigm, occasionally encounter these casual references to the naggingly radical proposal. Finally, a researcher in a different field who has desperately faced some quandary, perceives an analogy. In this phase-12, he skeptically applies it. To his delighted surprise, it solves most of the problem.

He publishes the curious success story in a phase-13. Thus, 14 years after Einstein's physics publication, a forthcoming solar eclipse would remind astronomers of some vexatious astrophysical questions. Arthur S. Eddington decided to try applying Relativity. His experiment revealed a radiational bending concordant only with Einstein's 1905 argument.

4.2.2 The Surprising Matchup is Experimentalized (=Phase 14)

The paradigm is now advancing from hypothesis to theory. At this juncture, some reader finds a potentially serious use, no longer a mere experiment, for the now more practical idea. Only at this time does it begin a "laboratory phase," the 14th Kuhnian hurdle.

Again we may illustrate from Relativity. After Eddington, 20 years were to pass before a utilization-prompting situation would occur: A most fierce enemy, Naziism, was rumored to be entering atomic

fractionation. Only then did the U.S. government very skeptically fund a Manhattan Project, with laboratories remotored to New Mexico.

4.2.3 Early Uneconomic Effectuation Is Slowly Optimized (=Phase-15)

The Kuhnism may now prove itself in such practice, as by the atom-bombings of Hiroshima and Nagasaki. We term the engineered success as the 15th milestone. Yet research and development hurdles still dwarf output-payback. The primary contractors become interested, but cannot yet justify the gamble. So they seek more riskless experience, more insider knowledge – in other words, more governmental or bureaucratic monies. The scheme becomes a "cost-plus" system. Such an approach avoids originality, and lends itself to misuse. In one recent extremity, a tool kit, assemblable from merely \$92 of hardware-store purchases, was sold to the U.S. Navy for fully \$10,169 (Garfinkle, 1986, p.142). – This early replication may be termed a 16th Kuhnian phase.

4.2.4 Idea-Incubation Must Not Be Red-Taped (Phase-16)

Suppose a samaritan were not available to fund it; would a Kuhnian project continue? – Only if the breakthrough is producing obvious benefits. And in that instance, a different demon arises: the commercial plagiarist. His organization's superior capitalization ("deep pockets") probably far exceeds those of an independent discoverer. And so he can muddle ownership through costly legal maneuvers. Thus, Radio Corporation of America initiated complex lawsuits when Major Edwin H. Armstrong's frequency modulation was shown obviously more static-free than the corporation's prevailing amplitude modulation (Erickson, 1973).

But rarely will a paradigm provide such clear evidence of superiority. Then a project would seldom continue. Case studies may be seen in the U. S. governmental bankrolling of general academic research from the late 1960's to the early 1980's. At the end of that era, various budgetary and political reasons caused the hitherto almost unbridled federal expansion of universities quite suddenly began to reverse. Details appear in Sharff and Lessinger (1994).

One instance of the blow-by-blow minutiae of changing the zeitgeist occurred at the University of Missouri. That was the 13th largest of the thousand institutions of higher learning on the continent. It particularly concerned the Kansas City campus (hereafter cited as UMKC).

At UMKC, funding for any reasonable research project or dissemination had always been easy to obtain, whether normal-science or Kuhnian. The amounts awarded were small, but served as institu-

tional encouragement. We may term such provision of basic support, whether verbal or fiscal, as the 16th era.

At that time, the present author was developing a broad paradigm in lexicography (cf. Burger, 1991). And so observation and documentation became possible. I single it out simply because I was routinely receiving the considerable innovation-evaluation documentation, and found its strategy expressed very openly. (No malfeasance is implied. In fact, similar procedural changes were widespread throughout the nation's campuses.)

4.2.5 *Requiring Private Investment Before Now, Would Choke a Discovery.*

In 1980, however, the aforementioned financial pressures caused UMKC to create a new post, Associate Vice Chancellor for Research. To it was appointed blood specialist John M. Mishler III. Regulations emerged quickly to enforce a massive re-prioritizing. It struck at the cradle of research – the traditionally internal encouragement of *idea-incubation*. The new bureau required that each professor's mere proposal be henceforth submitted to five external evaluators. They would be selected by – that same vice-chancellor.

Five outside panjandrums? – We remember the sociological principle that the more kinds of judgment, the greater their conventionality. The deputy director of the U.S. National Institutes of Health (William Raub, 1986, p.20) had conceded as much: "Bringing together contemporary experts tends to reinforce the contemporary dogma, and therefore, in some instances, the inability to distinguish between something that is truly silly and something that is the product of genius working a different paradigm."

Furthermore, the present paper has just argued that a Kuhnian proposal cannot expect to gain a constituency until after Phase-16, long after such events as the now-micromanaged Phase-7 trial-balloon chats with friends about an often error-bearing idea. Yet this UMKC diktat required earliest consent of the skilled practitioners of the status quo.

4.2.6 *Discouragement of Kuhnism Trickles Down*

By 1987, follow-up regulations favoring grantsmanship success strictly determined priorities. All resources were rationed centrally: typist labor, teaching-time replacement, computer disk space, etc.

The provability of hard (subsocial) science easily overwhelmed that of the softer sciences. As time passed, the experimentalist scholars began to feel the resultant lockstep: "The Chancellor did not think that funds had dried up – except in the social sciences"(!) (UMKC Senate, 1985, p.2). In fact, those

physicalist subsocial disciplines, including virtually all the Gimcrackery-type projects, were by now receiving two and a half times as many internal UMKC research grants as all its social sciences AND humanities together (Mishler & Ellyson, 1987, table 1).

Thus, the same campus soon boasted (UMKC Inside, 1987, p.4) that two professors had been awarded \$10,000 by the Bristol-Myers toiletries corporation to evaluate its proprietary aspirin. Meanwhile, a different project produced a full-page, full-color magazine advertisement: "Interplak (trademark) from Dental Research Corp.:... Let the new technology keep your smile bright.... The University of Missouri study solemnly concluded [that the \$99] 'Interplak ... is superior to the manual [tooth] brush....'" (Sharper Image, 1987, p.8). Here, then, was the flower arising from snuffed basic research.

During an era of babbittry, a potential breakthrough simply cannot generate the seed money for earliest experimentation and perfective dialog so as to create the constituency for momentum. *To limit resources to projects attaining phase-level-16, means to squelch the breed-stock of phases 7 through 15.* It is as impossible as if a life-insurance firm paid death claims only on certification of the circumstances – to be signed by the decedent!

We are reminded of the so-called Vannevar Bush Law, that "applied science invariably drives out pure." Let some other organization do the basics? – Such parasitism resembles the behavior of the European cuckoo, which lays its eggs in other birds' nests for the labor of incubation (Darwin, 1859, ch. VII).

Science-history should accumulate comparative data of the effect of this increasingly important choke-point. The technique of computer searching recommends unique terminology for this procedure evaluation on probable payback speed. Should we perhaps say that such an institution will "Mishler" its project applications? The problem is how to predict the eventual profitability of a barely-tried idea. How can we change "bottom-line" immediacy thinking to "payback," or eventual accrual, thinking? Until it can be done, we will have "corporate raiders" reducing researcher payroll in favor of immediate dividends.

5. Slow Appreciation Greets The Survivors

5.1 *Engineering Brings Constituency*

5.1.1 *Kuhnism + Engineering Create a Constituency (=Phases 17-19)*

And what awaits those few Kuhnian projects which somehow hurdle this choke-point? – Only gradually does the grantee private producer (e.g., General Electric Company) perceive the magnitude of the potential that has survived. Practical ways are

found to bring its cost down to beneficial effectiveness in this 17th stage. Such economizing contrivance is the "essential cleverness" engineering stage that Agassi (1966, p.361) termed Hatfield's Law. It is the watershed that bridges theory into practice. For example, Heavy Water is – or is not – found to be the most cost-effective way to produce atomic reactors.

One historical figure who seems to have excelled in this praxis stage was Thomas A. Edison (1847-1931). He patiently tinkered such well-known substances as aluminum foil into a phonograph record, and carbonized fiber into a lamp bulb (Baldwin, 1995, *passim*). The opportunities for the novelty of electrical appliances was so great that the need arose for development, for entrepreneurship, not more theory. In fact, one legend has Edison "explaining" electricity by simply saying, "If you had a ... dachshund ... long enough to reach from Edinburgh to London, and you pulled his tail in Edinburgh, he would bark in London" (Webb & Morgan, 1930, p.207).

The criterion slights most or all theory, not merely Kuhnian hypothesis. It simply asks: Will it perform for the Establishment? Only now does a (usually large) company become a willing sponsor with its own resources, in a Phase-18. In the instance of Relativity, it becomes engineered away from government work and adapted for a few atomic power stations.

As the breakthrough proves itself publicly, organizations unrelated to the contractors become eager to fine-tune the now well-proved invention to their narrower needs, as this 19th step appears. In pharmaceutical development, this may be a Gimcrackery phase. The decision makers are not discoverers or even entrepreneurs; they are simply exploiters. We are reminded of the proverb heard in several foraging cultures: "When a hunter returns with bagged game, many mouths suddenly appear."

The observant Establishmentarians, of course, never convert. "A new scientific truth does not triumph by convincing its opponents ..., but rather because its opponents eventually die...." (Max Planck, quoted in Sills & Merton, 1991, p.186). Indeed, England is said even today to have a Flat Earth Society.

5.1.2 *The Achievement Is Finally Perceived* (=Phases 20-23)

Coincidentally with the discovery's exploitation, we may distinguish two phases of outward dissemination. The notoriety of the now proved principle (such as the laser) fills the semipopular science-technology (sci-tech) magazines, like today's *Discover* magazine, in a Phase-20. Then, in a 21st step, it is pidginized via the mass media, such as a gossipy *National Enquirer* ('Laser Burns Turned My Child into a Monster').

Somewhere around this time, in a 22nd phase, scholars ask why textbooks are still downplaying the phenomenon. In over-corrective haste, journalists connect it with some glamorous phenomenon already known to the masses, as if obeying the gospelist Matthew's sermon, "Unto everyone that hath [already,] shall be given, and he shall have abundance...." This halo constitutes a Matthew Effect, according to sociologist R. K. Merton (quoted in Sills & Merton, 1991, p.160). The public erroneously accredits its most recent developers. (Many of the public seem to believe that the telephone was invented by the actor Don Ameche, who played the role of Alexander Graham Bell in its cinematic version.) The true discoverer may still be a 'prophet, in his own country.' Only slowly will the thoughtful perceive the intellectual magnitude of the original insight.

A few of the more entrepreneurial foundations begin coming to the Kuhnian with proposals they want him to evaluate, in a 23rd phase. Thus Einstein failed to receive satisfactory employment, let alone a sinecure, until his 51st year (1940, at Princeton Institute of Advanced Studies)

5.1.3 *Kuhnian Work Accrues Prestige, Not Immediate Dollars* (=Phase 24)

As the original paradigmater becomes prominent, jockeying for prestige worsens. His often-subtle discovery ever so slowly elevates (apotheosizes) him as it is realized that most people overlooked the opportunity that he exploited. Followers of the interpolative and immediately-valuable work, like the 'more practical' technical colleges, begin to sense the value of the bold theory. The Kuhnian's "cradle-parent" institution begins to bask in the reflected glory. Example: The Swiss patent office, which had employed Einstein during his 1905 intellections. But this spreading kudos begins only at about this 24th part.

Such a paradox is nicely illustrated in the career of Cybernetics conceptualizer Norbert Wiener. In retrospect of his student days, he would report (1953:196-197) his own experience that "Harvard has always hated the eccentric and the individual." Consequently, Wiener had moved across the Charles River to the Massachusetts Institute of Technology, where he stayed. – But soon after he died, a Wiener Memorial was trumpeted at Harvard.

5.1.4 *The Accepted Kuhnism Itself Becomes Archaic* (=Phases 25-26)

Gradually the new heterodoxy establishes its committees and becomes a new orthodoxy, in a Phase-25. Its researchers slowly become smug. They disregard the accumulating oddities in their findings.

In such ways, structural perfection rigidifies, in a conservative 26th-phase.

Eventually the need will arise for a new Kuhnism to correct the new rigidity. The discovery cycle will have come full turn.

6. Conclusion: Some Of The Milestones Need Far More Care Than Others

"The greatest invention of the 19th Century," declared Whitehead (1925; 1995, p.48), "was the invention of the method of invention." But the present author would argue that much remains to make the method explicit. The current paper is one such attempt – to anchor a mass of Thomas Kuhn's brilliant descriptive findings into a referential and eventually harnessable system, a full cycle. We have tried to specify the way-stations and the choke-points that a Kuhnism must traverse before its acceptance. The attempt should help to harmonize concepts from half a dozen disciplines. Each cyclic step seems necessary but not sufficient, thus creating a (Louis) Guttman Scale. We have attempted to periodize them, and find two dozen identifiable phases. The readers of this journal are likely to find exceptions that will increase, not decrease, that composition.

Our method has been merely citation of significant examples, and their apparently logical arrangement. But fuller proof would require quantification and controlled comparisons. Furthermore, our stages have been delineated by historical facts from a limited quantity of events and in a very narrow part of the world. Yet the attempted sequencing may provide a scaffold for later pinpointing and acceleration.

The duration of most phases depends primarily on the zeitgeist, and secondarily on idiographic factors such as the discoverer's persistence. The slowest and most erratic part of the procedure seems to be Phase-10 – Awaiting a needer. "How many important scientific discoveries were just missed because work ceased too soon?" reproached the discoverer of the planet Pluto (Tombaugh, 1959).

Unimaginative treatment by bureaucracies there creates Mechanisms of Mediocrity. A future discoverer would consequently increase his chances of matching someone's need by publishing his finding widely, even if thinly, as via multidisciplinary newsletters. (The Internet may develop entirely new media.)

Fundamental discovery is the flimsiest flower of a complex culture. Group success will depend ever more heavily on research administrators who can be gardener-statesmen, and not mere croupiers.

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