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ELEMENTS IN THE PROCESS OF DISCOVERY

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ABSTRACT

This paper reviews the elements that have to be present in the process of discovery either in the sciences or the arts. Discoveries, which generally make apparent something that was already in existence, are generally made by individuals and not by committees. One of the explanations for the possibility of discovery is that bits of information are found that do not fit into known or accepted patterns. Someone who is not ready to make the new discovery may continue to try to fit the bits of information into the old pattern, and the information may even appear to fit. Then comes one of these people, the scout, who are ready to break camp and find higher ground, and he introduces the new paradigm. Secondly, a particular individual forges ahead and makes a discovery, not because he is a genius or is creative. Creativity is largely an incremental process, the result of a per son adding something to what he already knows rather than the role of the unconscious; sudden shafts of light that have no explainable source; the role of brainstorming, and divergent thinking. In addition to incremental view of creativity, the person has a high level of motivation and total absorption in his work.

KEY WORDS: Discovery, paradigm, creativity, motivation, commitment, reality.

INTRODUCTION

The concept of discovery is that it makes apparent something that was already in existence. Some of the discoveries are those in the areas of the physical environment, and modern technologies that have sprung from basic scientific discoveries. Examples of discovery abound. Christopher Columbus discovered the West Indies. Albert Einstein developed the mathematical formula that became the theory of general relativity. The relationships he described had been there all the time, but his enquiring mind was the first to uncover them. The objective of this paper is to explain what elements need to be present for the process of discovery to work, and why some individuals happen to forge ahead as discoverers. Elements of discovery may be categorised as individual, boldness to create new paradigm, incremental steps in creativity, motivation and total commitment.

DISCOVERY AND THE INDIVIDUAL

Bergland (1985) makes the point that discoveries are almost made by individuals and not by committees. In describing the process of discovery, he says:

> "Along each path intellectual base camps have been constructed by teams of climbers who decided it was a propitious time to break camp and move to a higher place. Few if any of these new base camps were found by teams of scouts; most of the upward steps were taken first by people acting alone...The dents in the frontiers of science, the new paradigms, have almost been made by lone scouts."

BOLDNESS TO CREATE NEW MODELS - NEW PARADIGM

A paradigm or model is the pattern of organising knowledge (Chinwah, 2003). Knowledge fits into categories; bits are related. One partial explanation for the possibility of discovery is that bits of information are found that do not fit into the known or accepted patterns. Someone who is not "ready" to depart from the old paradigm may continue to try to fit the bits of information into the old pattern, and it may even appear to fit. Then comes a bold person, one of these people who are the scouts, ready to break camp and find higher ground – a new paradigm – and he introduces the new paradigm.

One example of breaking camp and introducing a new paradigm is found in the case of the mysterious "ether," which was regarded as a physical medium which filled all of space. The role of the speed of light in electromagnetic theory gives evidence to the apparent irreconcilability of the theory with the Principle of Relativity (a principle which, simply put, means seeing phenomena in different ways – disagreement). Electromagnetic waves propagate at a speed, $c = 1/\sqrt{\varepsilon_o \mu_o}$, where ε_o and μ_o are constants, permittivity and permeability respectively, of free space. A consequence of the Galilean Transformation, which predicts variable speed of light – is that ε_o and μ_o are variable. Such a variation, if accepted, would make Coulomb's law of electric force depend on the state of motion of the observer. Whereas the laws of mechanics are invariant under the Galilean Transformation, the laws of electromagnetism are not. This difference may be viewed in several alternative ways, (1) The Principle of Relativity happens coincidentally to be satisfied by mechanics but it is not a general principle of nature and is not important, (2) The Theory of Electromagnetism is incorrect and must be changed to conform to the Principle of Relativity, and (3) The Principle of Relativity is correct, but the Galilean Transformation must be discarded and a new transformation found that will permit the laws of electromagnetism to be invariant.

Even though early Maxwell (a leading Scientist of his day) and other architects of electromagnetic theory in the later part of the nineteenth century in effect took to the first point of view. To them it was an article of faith that there exists in the cosmos a preferred frame of reference, for they imagined the existence of a physical medium – the ether – filling all of space. One would expect the laws of nature to take on their simplest forms in other frames and therefore would not need - in an ether-filled universe – the principle of relativity, adopted

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the third, and perhaps radical, view. This view formed a foundation on which was built a new mechanics, a new view of the world, and even a deeper new insight into electromagnetism. A case of a new paradigm.

Kuhn (1962) writes:

> "Men whose research is based on shared paradigms are committed to the same rules and standards for scientific practice...scientific revolutions are inaugurated by a growing sense that an existing paradigm has ceased to function adequately in the exploration of an aspect of nature."

Davies (1995), the Mathematician and Physicist, says, in support of paradigm shift, that hidden orders would not be revealed if thinking were limited to old paradigms. He further says that if layer upon layer, and deeper layers of order is seen, it is a proof that these orders are not man-made, or merely data being misconstrued by scientists for their own purposes. Rather, such layers suggest that these orders truly exist as orders in reality, which reveal themselves as existing of true life-experience and explain themselves through science.

If thinking in any field accepts a false paradigm, or model, all the work done in that field will continue to be flawed to some extent until a better – or even a correct –paradigm is discovered. For example, Sir William Harvey discovered in 1628 that blood circulates and that the heart is the organ that controls this circulation. Yet, a Greek physician, Galen, was working with some false paradigm. To the ancient Greek, everything in the universe was composed of only four elements – fire, air, water, and earth. At the time of Galen, the concept of humours was regarded as sources of diseases and had become widely accepted. (The word *humour* started out in the Middle Ages meaning any of the four liquids believed to determine the state of a person's body and health. Humour today refers to a person's mood or state of mind. You can be in a good humour or a bad humour, but we no longer attribute these moods to the four liquids in our body, Scholastic Children's Dictionary, 1996). Galen developed a theory of different humours in a person, each of which supposedly had a discrete effect. The theory coincided neatly with the Greek concept of four elements. To describe the action of these humours, it was necessary for him to invent several anatomical myths, which, Gergland (1985) says, as a doctor Galen must have known were not true. Gerland puts it succinctly thus:

> "Galen wrote 22,000 pages of descriptive anatomy; he was no amateur anatomist. Yet to serve his paradigm he literally poked the body full of holes that didn't exist."

His mistake pleased the chemists, philosophers, theologians, astrologers, and physicians of his day. It did not ruffle any of the paradigms in their respective fields. Galen, through his dissection of bodies, had come within earshot of hearing that the blood circulates in the body. Instead, by bending what he had observed to make it fit the existing paradigm, he delayed medical knowledge in that area for 1500 years. Both the Christian and the Islamic religions helped to ensure the passage of Galen's mistake for seventy generations. Both religions maintained that Galen had given the world the "truth" about the body; it was written in his words, and pictures were not needed (Bergland, 1985).

Someone hearing in the twenty-first century for the first time about blood circulation as a discovery might be sceptical as to why it was discovered so late. The reality about the pace of change is that it has so quickened that we have little concept at all of how difficult it once was to dislodge any entrenched idea. Before the age of printing with movable typewriter, only a very few people were able to read books in very few libraries. One had to be extremely rich to have a personal library. Almost all knowledge was passed down orally. One knew only what he could remember. We are probably unable to conceive of the mental patterns that existed for all but a very small elite before the beginning of the sixteenth century.

Now, the patterns existing in one discipline differ from those in another. Lack of medical instrumentation, along with a disinclination to look for more answers in the human body itself, delayed the advance of medicine during the Middle Ages. In the case of religion and philosophy, the dominance of the Roman Catholic Church as both a religious and a temporal power exercised a kind of thought control over religious matters for about the same 1500 years that Galen's theories prevailed in medicine. Even the Protestants Reformation did not question the basic tenets of Christianity as they had existed since about A. D. 300. Most of the Reformation dealt with the authority of the Church over the individual, including the role of the Church as an institution through which one gained salvation. Some of the Protestant denominations that began at the time of the Reformation in each country of Europe, besides breaking with the ecclesiastical monopoly claimed by Rome, did not see the nature of the Church as a mediatorial instrument of salvation in the same way Catholicism had defined it. None of the major denominations to come into being asked the key questions that the Gnostics had asked. The nature of reality was not disturbed. The divinity of Jesus was not questioned. One early Unitarian, Servetus, was burned at the stake in 1560 for rejecting the divinity of Jesus (Nenneman, 1992). Satisfaction with an existing paradigm is not, it seems, a phenomenon only for the physical scientists.

DISCOVERY BY INCREMENTAL STEPS

Weisberg (1986) takes the view that creativity is not the work of geniuses; it is society that later on attaches the label genius to someone for what he has created in either the sciences or the arts. It may also take away the label, as was the case with Joann Sebastian Bach for the century after his death, until his rediscovery by a new generation. Weisberg looks at the various psychological explanations of creativity and rather convincingly debunks them all: the role of the unconscious; sudden shafts of light that have no explainable source; the role of brainstorming, and divergent thinking. Rather, he makes a strong case that creativity is largely an incremental process. It is the result of a person adding something to what he already knows. Weisberg said:

> "...an incremental view of creativity leads to the expectation that even impressive creative products are rooted firmly in the experience of the creative individual and are developed gradually from his or her past work, and the work of others. Small steps, in this view, rather than great leaps, are the rule. Furthermore, the thought processes involved in great acts of creativity are like those found in more ordinary activities."

Consider the case of the discovery of atomic structure, which could underscore the incremental steps in discovery. In 1815, Prout suggested that the elements were made up of hydrogen – using as evidence the fact that the atomic weights of many elements are nearly integral multiples of that of hydrogen. J. J. Thomson discovered the electron in 1897 and with this discovery a high level of research commenced. Thomson proposed the 'plum pudding' model where positive charges of the atom was thought to be spread out through the whole atom (a sphere of about 10^{-10}m) with the electrons located here and there like plums in pudding. In 1911, Earnest Rutherford showed the inconsistency between the α-particle scattering experiments of Geiger and Marsden and Thomson's model of the atom. Rutherford then proposed the nuclear model of the atom – a model which confirmed the positive charge to a small sphere of radius about 10^{-15}m called the nucleus. In this model, the electrons circulate about the nucleus in a volume of the same order of magnitude as Thomson's sphere. This is a definite incremental step in the search for the 'real' model, for it formed the basis of modern theories about the atom.

Investigation of the hydrogen spectrum led Neils Bohr to push further the frontiers of knowledge about the atom by postulating that the circular orbits of the electrons were quantized, which meant that the orbits were discrete or separate and definite and were not continuous (Evwaraye *et al.*, 2006).

Models of the atom (nucleus), while retaining the basic assumptions of Rutherford, have been highly refined and now assume the presence of sub-nuclear particles, e.g. protons, neutrons, which themselves move within and make up the nucleus. A case of incremental steps in the process of discovery – precepts upon precepts.

DISCOVERY, MOTIVATION AND TOTAL COMMITMENT

Incremental view of creativity does not play down the role of the individual in discovering something new. In fact, the tenor of Weisberg's argument is entirely in line with Bergland's (1985) assertion, that new paths are generally charted by lone individuals. But why does a particular individual happen to forge ahead? It is not because he is a genius or has some particular grouping of talents that explains creativity, there must be some general explanation. Weisberg finds it in two rather simple, related factors, in addition to his incremental view of creativity, the person must have high level of motivation and total absorption in his work, when he said:

> "...the creative genius is totally committed to work. The most influential scientists and artists in modern Western culture have had long careers characterized by very high productivity. Freud, for example, produced 330 publications in a forty-five-year career. Picasso produced several thousand works in seventy-five years; Einstein, 248 publications in fifty-three years, and Darwin, 119 in fifty-one years."

Creative people are often so devoted to their work that they become virtually unaware of anything going outside their own consciousness. This kind of absorption is one reason they succeed at what they are doing, since some discoveries happen only after many combinations of ideas have been tried. There is also a greater likelihood of those chance occurrences that contribute to their discoveries happening, since the problems they are trying to solve are constantly on their minds. This can be applied to virtually every person who contributed to the emancipation and growth of science in the post-Renaissance centuries. In looking at these peoples' discoveries with the instruments now available, much of what they discovered seem common sense. Yet for the most part they forged ahead on hunches that came out of long observation and cognition over what the observations meant.

Until the time of Johannes Kepler (Ferris, 1989), the astronomers were still trying to see the heavens through the mistaken belief of Ptolemy that the planets moved in circular orbit. Kepler, building on the astronomical sightings of Tycho Brahe, "tested *seventy* circular orbits against Tycho's Mars data, all to no avail. At one point...he imagined himself on Mars, and sought to reconstruct the path the *earth's* motion would trace out across the skies of a Martian observatory; this effort consumed *nine hundred* pages of calculations, but still failed to solve the major problem." Finally, the answer hit him, "the orbit of the planet is a perfect ellipse."

Just as notable was Sir Isaac Newton's work in establishing the first general laws of physics. Ferris (1989). writes about Newton:

> "Newton's surviving drafts of the *Principia* support Thomas Edison's dictum that genius is one percent inspiration and ninety-nine perspiration. Like Beethoven's drafts of the opening bars of the Fifth Symphony, they are characterised less by sudden flashes of insight than by a constant, indefatigable hammering away at immediate, specific problems; when Newton was asked years later how he had discovered his laws of celestial dynamics, he replied, "By thinking about them without ceasing." Toil was transmuted into both substance and veneer, and the finished manuscript, delivered to Halley in April 1686, had the grace and easy assurance of a work of art. For the modern reader the *Principia* shares with a few other masterworks of science - Euclid's *Elements* among them, and Darwin's *Origin of Species* – a kind of inevitability, as if its conclusions were self-evident. But the more we put ourselves into the mind-set of a seventeenth-century reader, the more it takes on the force of revelation. Never before in the history of empirical thought had so wide a range of natural phenomena been accounted for so precisely, and with such economy."

In the early attempt to prove electric power could be put to practical use, Thomas Edison ran into many difficulties, many disappointments – literally "burning the midnight oil" in an attempt to unlock the secrets of the incandescent lamp. Demonstrating the belief, resilience, total commitment and determination that drive every pioneer, he ultimately succeeded in bringing light to the world. When interviewed several years later why he so persisted after 10,000 experiments without a solution to his problem, he said, "I've tried everything. I have not failed. I've just found 10,000 ways that won't work" (McGraw-Hill, 1986).

CONCLUSION

Discoveries are generally made by individuals who dared to be different rather than conform and not by committees. The explanation for the possibility of discovery is that bits of information are found that do not fit into the known or accepted patterns. Someone who is not "ready" to make the new discovery may continue to try to fit the bits of information into the old pattern, and it may even appear that they do fit. Then comes one of these people who are the scout, ready to break camp and find higher ground – a new paradigm – and he introduces the new paradigm. Creativity is not the work of geniuses; it is society that later on attaches the label genius to someone for what he has created in either the sciences or the arts. A particular individual forges ahead, not because he is a genius or has some particular grouping of talents that explains creativity, but there is some general explanation. In addition to his incremental view of creativity, the person has a high level of motivation (more of self motivation) and total absorption in his work. The incremental view of creativity does not negate the concept that an area of human knowledge occasionally needs a new paradigm.

REFERENCES

Bergland, R., 1985 The Fabric of Mind New York Viking Penguin 9p

Chinwah, Uriah Hukumere, 2003. The epic saga of the scientific method (from the paradigmatic revolution of Thomas Kuhn to the Coctic intuitions of the New Millennium and beyond). *Global Journal of Humanities*, 2, (1 & 2): 1 – 6.

Davies, P., 1995. Are we alone? New York Basic Books, 121 – 125.

Encyclopaedia of unified Science, Chicago: Univ. of Chicago Press, 11, 92p.

Evwaraye, A. O., Mgbenu, E. N. and Okeke, P. N., 2006. Electromagnetism and modern Physics, Nigerian University Physics Series, Spectrum Books Limited, Abuja, Nigeria.

Ferris, T., 1989. Coming of the Milky Way. New York: Anchor Books, 79p.

Kuhn, T. S., 1962. The Structure of Scientific Revolutions, 2, (2): International McGraw-Hill Publications, Graduating engineer, 1986, McGraw-Hill Publications, N. Y., 7p.

Nenneman, R. A., 1992. The New Birth of Christianity: why religion persists in a scientific age. Harper Collins Publishers, San Francisco, 83 – 96.

Weisberg, R., 1986. Creativity: Genius and other myths. New York: W. H. Freeman.

Scholastic, 1996. Scholastic Children's Dictionary. Usborne Publishing Ltd., USA.