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Science to de Laeter: What now comes later

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Abstract

Selected episodes of history illustrate developments in science and philosophy by which we try to grasp the realities of immense ranges of scales for time, distances, temperature, mass, and substance. In this epoch of isotope awakening, John de Laeter is a principal contributor, worthy of celebration and institutional pride for Curtin University of Technology. New knowledge and understanding is changing problems and opportunities in physics, chemistry, astronomy, geology, and the biological sciences, including agriculture, the environment and medicine. We can not accurately foresee consequential developments in sciences and technologies. Let our hope rest on reestablishing meaningful communications between science and religions leading to moral codes consistent with modesty in human self perception. Thus alone - but with unforetellable cost from stresses imposed on individuals and societies - we can secure a desirable destiny for humanity.

A salute to John de Laeter and Curtin University of Technology

The de Laeter Symposium is a delightful occasion for celebration. An occasion to praise his achievements, to proclaim the significance of his discoveries, and extol the science in his country. For many of us, overseas visitors, a cordial salute to Australia is very appropriate. Particularly in measurement science, we have recently witnessed this nation's image change from one with dispersed scientific talents to one that houses institutions equal to the foremost centers of scientific excellence.

A trait of Australians is to be fine team players. Driven by press and Nobel prizes, we tend to overestimate the individual scientist. Good science thrives on good team work, such as we have come to expect at Curtin, where in our field stands John de Laeter, the head of a productive group. In the happy memories of those who served the International Commission for Atomic Weights and Isotopic Abundances remain the years of de Laeter's innovative and effective leadership towards quantified reliability of data (Peiser *et al.* 1984, 1996). We know he has exerted similar influences in Australia. Generally speaking, we all wish for a great future for science in Australia supported by its universities. Just as the ancient pyramids in Egypt, the temples of Greece and Rome, and the medieval cathedrals of Europe, so the technical universities today give evidence to posterity of the cultural pinnacles exalting their respective periods of history.

Foundations for Today's Achievements in Science were Laid in the Past

I am neither historian nor philosopher and realize that, even for experts, there exist undecipherable complexities in every past epoch. Nevertheless, I dare to focus on a few developments in history that happen to have struck my attention (Tanton 1958).

We all know of the wealth of ideas that were developed in classical Greek and Roman times. By comparison, the Western European Middle Ages are faulted. Yet, in Bartholomew's 13th century *De Proprietatibus Rerum* we are given a catalogue of observations pertaining to "heaven and earth, beasts, birds, stones, metals, and other substances". The forward momentum in arts and sciences during the renaissance period was initially due to the rediscovery of Greek ideas. The playful Muses are superlative models for originators in the arts and sciences. These ideas themselves, however, were based on sparse observation of nature. By detailed observations begun during the 'dark ages', some of Aristotle's and other Greek postulates were successfully challenged.

Allow me here to anticipate three of my impressions:

– Progress in science is made in very small steps. As Sir Lawrence Bragg used to tell us; "scientists ask only simple questions". Answers, if any, can only come in tiny steps (Thomas & Phillips 1960).

– My second theme is this: knowledge coupled with intuition leads to descriptions of nature. Careful measurement, however, often fails to fit exactly with that description. A forced small modification of our understanding then brings a slightly better description of nature. It is surprising that these modifications are often anticipated by eccentric scholars (De Laeter *et al.* 1992). No better example is that of Democritus' atomic theory; its reality remained an unsubstantiated speculation for many centuries.

– My third concern is that religion and science have great difficulty in engaging in a constructive dialogue aiming at mutual understanding. Religions ask complicated general questions, often answered by trusted divine revelation and accepted, though not without difficulty, by a believing public (Luycxx 1991). Let us recognize that highest achievements of mankind in the fine arts, literature, music, education, philosophies, psychology, as well as

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in architecture have come in association with religion.

In the historic past, deeply religious people have also been the principal contributors to science. The well known controversy between the geocentric versus heliocentric doctrines was carried on both sides by Christian leaders. In the 15th century Nicholas of Cusa, a bishop, was by time and concept well in advance of Copernicus in proclaiming “the earth is a sphere, like many celestial bodies, in a cosmos of which the center is everywhere and the circumference nowhere.” Established religion did not oppose him, at least not for that speculative philosophy. The first serious conflict with science came when Copernicus showed with inescapable logic that a heliocentric universe must have a radius much larger than demanded by Aristotle’s model. Was there fear that a large universe devalued the importance of the human race?

De Laeter’s group and other astronomers have in recent years enormously further enlarged the universe that fits very detailed evidence and ties astronomy closely into terrestrial chemistry (De Laeter 1990). Other scientists in this century elucidated the wonderful atomic-scale structures a million times smaller than is open to the unaided human eye or imagination. The earliest experimental investigation into the relationship between the atomic and macroscopic scales was by Johannes Kepler in the 17th century book on snowflakes with the title *De Nive Sexangula* (Senechal 1990).

De Laeter’s group, again, and other geologists have given overwhelming evidence by experimentation with radioisotopes that the earth’s creation exceeds by a large factor any time span one can piece together from the Bible’s pages (Faure 1977). It would be heresy - as Albert Einstein implied - to suggest that our Creator might have planted evidence to deceive us into deducing an erroneous age of our world!

Biology, since the middle ages, has been a beautiful descriptive science. In that mode, especially with the aid of microscopes, it continues to thrill us and bonds our wonderment of nature to that of our children. Biology added new vistas by the genius of Pasteur whose 100th anniversary we observe right now. He showed the idea of spontaneous creation to be false and physiological processes to be chemical reactions. In a recent speech, Arthur Kornberg told how biologists then became microbe hunters (Kornberg 1995), later virus hunters, recently enzyme hunters and now gene hunters. All objects of these hunts aim at chemical entities. Let us thus declare biology now open to de Laeter’s experimentation with isotopes.

Allow me just to enumerate some dazzling new scientific insights gained in this century. A million times shorter intervals than we can intuitively grasp are shown to dominate the changes within our cells. We see beauty principally in patterns of audible sounds and visible light. Intuition or divine revelation might lead us to their appreciation, but hardly to patterns of other radiations with far smaller and far larger energy quanta than those of light. Scientists have shown that the earth’s biosphere is narrowly limited also in temperature and pressure compared with the enormous ranges of those quantities experienced in our universe. All physical entities are found to be ‘grainy’ by nature. Even more bizarre to intuition appear some descriptions of subatomic- and galactic-scale phenomena that nevertheless ring true by their precise fit with observations and the power of successful predictions.

All that leaves individual humans within the real wonders and opportunities of creation with a place that is exceedingly modest, probably not even unique. Religions the while hold on to an instinctively attractive view of preeminence in creation with rewards of Heaven and threat of Hell to assure moral behavior of mankind. From earliest times, the defense of traditional religious views turned beautiful legends and practical rules into dogmas, litmus tests for the faithful.

In a world governed by uncertainty, is the long-term survival of features of our DNA inscribed inheritance not miraculous and adequate comfort to our souls? Do we not see in the trillions of individually living, predominantly cooperating cells in our bodies, a clue that association of human populations could lead to a higher being more worthy of the spirit creation? Are we not ready to concede of the possibility that the evolution of galaxies, isotopes, and all objects in-between are perhaps step by tiny step in principle explainable by the laws of physics and chemistry? We expect to fail in explaining the infinite detail.

Let me take one more look back into the 18th century, when Joseph Priestley is remembered for discovering oxygen. For many historians he was even the founder of modern chemistry. Perhaps he would have described himself primarily as a philosopher, who in Fruchtman’s words (Gibbs 1965) “believed [science] was a vehicle, a conduit, by which human beings may best understand the universe as God had originally intended and created it. The more people learned of the fundamental nature of matter, the better informed they would be about the direction of human life.”

Priestley did not live to hear of the discovery of the full elemental set of 90 building stones of matter. To following generations each chemical element had just one kind of atom. As de Laeter has pointed out, it was lucky indeed that this simplification was approximately true. Had it not been so, the development of chemistry would have been delayed until the discovery and separation of isotopes. I believe this because, even after Theodore Richards convincingly proved that there are different leads, the majority of chemists into the latter half of this century regarded atomic weights as constants of nature. De Laeter not only corrected that fallacy, but also propounded the idea that time has now come to turn the problems of isotopes into great opportunities (De Bièvre *et al.* 1993). One of these is to make all chemical analyses much more accurate through isotope-dilution mass spectrometry. So, with others, de Laeter leads science, technology, and commerce to more comparable chemical measurements, firmly bonded to the international system of units.

Further simplification of our understanding of nature showed the elements, the 90 ‘building stones’ of all matter, all to have just three constituents. This simplifying step brought to light more beauties of nature as well as a multitude of deeper questions. Another example of a ‘simplification’ of our view of nature resides in our own complex inheritance. It is spelt in an atomic-scale code composed of just four molecular 'letters', and the vast multitude of enzymes are built from just twenty types of amino acids specified by sequences of these four 'letters'.

What now comes later?

At the start of this paper, I correctly described myself as neither historian nor philosopher; for the last portion, with even more justification, I disclaim prophetic talent. However, I take heart from the fact that science has always failed to predict its important consequences. Administrators and politicians, nevertheless, keep trying to predict. They are encouraged, though perhaps misled, by the fact that from scientific progress often emerge some 'certainties', especially for successful applications to industry. De Laeter's isotope work is rich in such potential benefits. Progress, however, remains delayed by expense of instruments and failure of industrial entrepreneurs to grasp the full potential for profitable production of a great variety of materials enriched in and preferably certified for specific isotopes. Eventually this work will surely lead to much more reliable chemical measurements of all kinds, more varied medical test programs and cures. Many of these developments come much more slowly than can reasonably be anticipated. Thirty years ago I would have derided a suggestion that in 1995 physicists would still have to persuade the US Congress that fusion research is a bargain, although it does not yet contribute to the availability of isotopes or to the world's vast power needs.

I marvel at the thermodynamic balances between the innumerable compounds, built up mainly from four types of atoms on a carbon skeleton and a water solvent. These compounds execute virtually all processes in living plants and animals without unduly disturbing the temperature and balance of these amazing systems. Might there be temperature ranges in which similar skeletons of, say, nitrogen (with ammonia as solvent), or of boron (perhaps with B_6H_{10} as solvent), or of silicon (with carbon disulfide as solvent) yield compounds of comparable diversity and catalytic activities? Might such systems produce a kind of 'life' found in other worlds? Even further removed from current research goals is a consideration of electron-orbital systems in which energy barriers to chemical reactions are lowered by substitution of extranuclear electrons by mesons. As far as we know, nature does not widely employ such systems. I would not dare to speculate further on applications for Bose-Einstein condensates or quantum teleportation. When the current 'spin crisis' is resolved, the new insight may well have every-day applications?

A wonderful legend, not unlike that of Adam and Eve, tells that despite Prometheus' warning, Epimetheus opened the box of the lovely Pandora (Mercatante 1985). That box contained all that is evil. All that evil escaped. Likewise - despite warnings of the scientific community - the evil of a nuclear bomb, a fallout of science, will surely be let off as a terrorist's weapon within some of our life times. We have again but hope, as hope alone was left in the box when Pandora herself replaced the lid.

Hope alone is left to us as we grieve over the history of devastating wars and bruising disagreements between theology and science, with the general public intuitively on the side of religions. As the weapons of war have become potentially lethal to entire populations, science has been widely blamed. Science also came to some bitterly contested conclusions that by logical reasoning have become inescapable. Among them is that not every seed designed for life can be given the environment or species-specific nurturing to mature. Mature individuals deserve and need support and comfort in the harsh competitive existence. Communities will thrive only by care for their individuals and their environment. Thus, to secure further evolution rather than disaster for our human destiny, scientists must join with leaders of religion, the guardians of moral codes of thinking men and women, to recognize, believe, seek, and praise nature as revealed by observation. Alas, this very hope, remains a heresy to the majority of fellow men and women. Yet, for a progressive destiny of human life on our earth, such philosophies are needed to connect with the insights of John de Laeter and other contemporary heros of science.

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