Science and the Objectivity Myth

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Introduction

In 1904 the French Academy of Science awarded French physicist René-Prosper Blondlot a prestigious science medal for his discovery of N-Rays in the previous year. N-Rays emanated from many materials as well as from humans, especially during speech. These rays could only be detected by specially trained observers with adapted scientific instruments.

An American physicist, Robert W. Wood, was unable to replicate Blondlot's results and then, after tricking Blondlot into demonstrating with disabled equipment, questioned the very existence of N-Rays. Wood published the incident and his concerns, and then scientists outside of France abandoned the search for N-Rays. However French researchers continued to document observations for some years to come.

This episode in scientific history demonstrates the very best and the very worst of science – scepticism and self-delusion. Wood demonstrated the best with his critical assessment of N-Rays to show them to be a fiction. He was hopefully motivated by search for truth and not US-French science rivalry[1]. Willingness for self-delusion demonstrated the worst aspects of science, where scientists were seduced by the exclusivity of purpose-built equipment, specialised training, and national pride. Let's not fool ourselves. The same conditions exist today in science, especially in a world of massive military and corporate funding and ownership, and with new knowledge being regularly classified as secret or being patented for profit.

The Blondlot event was described in John Grant's book *Corrupted Science*[2], as if this was not real science, not part of a 'sacred' ideal. On the contrary, I argue that to understand the workings of science we need to include the enduring, the discarded, and the corrupted as genuine parts of the scientific project that seeks to understand our world and to control our environments.[3] Furthermore we need to see science as being part of and as operating within our social, political, and cultural domains.

Therefore this paper reviews and critiques the cognitive-only interpretation of science that includes successes but, so often, ignores failures. I shall conclude with some concepts that seek to provide a social and historical understanding of the scientific enterprise. Though critical, my aim is not to debunk science and its achievements. But rather I see scientific knowledge as a valuable part of our broader social knowledge and, as such, may be of good or bad social value. Not surprisingly then, I see science and its practitioners, as having social responsibilities for their work and its outcomes. I take the view that all knowledge and knowledge-making are value-laden and, as such, may not be necessarily worthwhile. I am not of the view that new knowledge is automatically self-justified, independently of consequences.

[1] US-French rivalry surfaced many years later with the search for and announcement of the HIV virus between Robert Charles Gallo of *Institute of Human Virology* at the *University Of Maryland School Of Medicine* in Baltimore, Maryland and Luc Antoine Montagnier and Françoise Barré-Sinoussi of *Pasteur Institute* in Paris, France.

[2] John Grant, *Corrupted Science*, AAPPL. Artists' and Photographers' Press Ltd., 2007, p.p. 88, 89

[3] Excluding discarded and corrupted activities as non-scientific is similar to Christians excluding any badly-behaved followers as not true Christians. Christianity and science then become empty and valueless concepts for analysis.

Science Seen As Special

Without doubt, the sciences are held as the epitome of rational knowledge-seeking in today's industrialised and information world. Many sociologists argue that science has effectively replaced the pre-Reformation universal church as the central object of the public's trust, respect, and awe, with some diminishing in recent times only. So, like the devoted of some 500 years ago, today's public with little or no knowledge of the inner workings of science laboratories and organisations, effectively relies on blind faith in the 'goodness' of scientific progress. Fortunately, we feel vindicated with the regular flow of new technologies from smart mobile phones to 3D televisions. Sociologist Steve Fuller goes further to suggest "*that our continuing faith in science in the face of its actual history is best understood as the secular residue of a religiously inspired belief in Divine Providence*."[4]

Other writers also see the similarities between the promises of religions and science. Political philosopher, John Gray, when discussing atheism, wrote of science and religions both serving human emotional and symbolic needs to make sense of our realities.

> *Science is the best tool we have for forming reliable beliefs about the world, but it does not differ from religion by revealing a bare truth that religions veil in dreams. Both science and religion are systems of symbols that serve human needs - in the case of science, for prediction and control.*[5]

Gary Laderman, Professor of American Religious History and Cultures at Emory University, sees that the media view of inherent conflict between science and religion doesn't reflect their real-world commonalities and intersections. "*Indeed, both seek to understand human life and the nature of the universe; both depend upon belief systems and ritual actions that impose order and ward off chaos; both are driven to better understand the truth about reality by combining theory with practice; and both are motivated by personal and social commitments that shape realities, bind communities, and lead to cultural revolutions.* "[6] This is heretical stuff for both conservative Christians and religious critics alike.

And, finally, a surprising result of surveying religious beliefs amongst scientific practitioners is that the greater numbers of conservative Christians are present in physics and biology research than are in the softer sciences like sociology and psychology.[7] British sociologist Steve Bruce suggests that the realist orientation of physics (like X-File's catch-phrase 'Truth is out there'), for example, coheres better with religious metaphysics than the interpretative and constructivist approaches of sociology.

Religious knowledge has claimed to be transcendental and certain and is supported by the ultimate authority of a god or gods. Christian claims, in particular, were and are built on the revealed truths of God/Jesus, the ultimate universal. From our Greek intellectual traditions, 'Logic' also became instantiated as a universal truth, transcending the particularities of human experience. Socrates was

[4] Steve Fuller, *Science*, Acumen Publishing Limited, Durham, 2010, p. 1.
[5] John Gray, *John Gray - "The Atheist Delusion"*, http://www.investigatingatheism.info/johngray.html
[6] Gary Laderman, *Sacred Matters*, New Press, New York, 2009, p.86
[7] Steve Bruce, *God is Dead*, Blackwell Publishing Ltd, Maiden, 2002, pp. 110-117

always going to be mortal in all possible worlds, if the premises of Aristotle's famous syllogism were true.[8] So logic, like Christianity, offered consistency and certainty.

To the public, science also fulfils their need for the certainty of universal or transcendental knowledge. Instead of invoking gods, scientific authority comes from the claim of objectivity, knowledge generated independently of human bias. So, here is the odd thing. Scientific ideas and 'truths' are not certain, unlike the claims of religions and logic: they are regularly overturned from generation to generation. Yesterday's Earth-centric planetary system has become today's helio-centric one. Yesterday's Newtonian billiard-ball universe has become today's curved space reality. Scientific truths of the past are today's forgotten fictions.

Furthermore, scientists are often proud of such things, seeing change as inexorable signs of progress towards ultimate truths and therefore the great achievement of science. Again, note this very Christian view of our progress towards an 'ultimate'. Modern science also continues the dream of the Enlightenment by placing human reason at the centre of our progress, replacing the 'blind' adherence to past traditions. So, science's history of constant change and overt rejection of previous certainties makes its predominance in social knowledge-seeking or, perhaps I should say knowledge-making, all that more remarkable and, perhaps, puzzling.

Before looking at the 'whys' - the reasons offered for science's unique place in knowledge-making - let us examine the idealised view of science – the objectivist view that has been the promoted as orthodox until recent times.

Objectivist View

The popular lay conception of science is as dispassionate scientists, endeavouring to uncover truths about our reality. It's a view that has also been promoted by many scientists, philosophers of science, and even government policy makers over many years. According to this view scientists are more akin to archaeologists or detectives, seeking and uncovering facts to rationally deduce truths about the world. In a 2008 *Sense About Science* lecture, Alan Sokal of the *Social Text* hoax fame[9], characterised this view of science for the talk as:

> *…a worldview giving primacy to reason and observation and a methodology aimed at acquiring accurate knowledge of the natural and social world. This methodology is characterized, above all else, by the critical spirit: namely, the commitment to the incessant testing of assertions through observations and/or experiments-the more stringent the tests, the better-and to revising or discarding those theories that fail the test.*[10]

The *Sense About Science* trust, which hosts annual lectures like the one mentioned by Sokal, was formed to "*respond to the misrepresentation of science and scientific evidence on issues that matter to society, from scares about plastic bottles, fluoride and the MMR vaccine to controversies about genetic modification, stem cell research and radiation. We work with scientists and civic groups to promote evidence and scientific reasoning in public discussion*."[11] This group was formed in

[8] Though not an actual example of the syllogism from Aristotle, himself.
[9] In 1996 Alan Sokal submitted an article for the Science Wars special edition of *Social Text*, a leading post-modernist academic journal. Though a practicing physicist, Sokal appeared to be supporting post-modernist criticisms of science as more about promoting Western ideologies than seeking knowledge. In fact his article was a hoax to show that post-modernist intellectuals were unqualified to criticize scientific methods and achievements. See http://www.physics.nyu.edu/sokal/ and many other sites for more info.
[10] http://www.senseaboutscience.org.uk/PDF/AlanSokalLecture2008.pdf
[11] http://www.senseaboutscience.org.uk/index.php

opposition to such post-modernist attacks on scientific endeavours as being more ideological than rational.

So what are the fundamental beliefs or claims of the objectivist view? These are some in a somewhat stereotypical way.

Firstly, a separate reality exists independent of human experience, *realism* in philosophical terms. The separate reality is assumed to be physical only and extends beyond our direct human perception. Examples of 'unobservables' are black holes and sub-atomic particles.[12] Secondly, this reality is ordered and, therefore, predictable, and most importantly is theoretically knowable with due acknowledgement of the probabilistic nature of quantum theory. Unlike religious traditions, science treats nothing in reality as inherently mysterious. Thirdly, the scientific method, which combines observation, critical human reasoning, and extensive peer reviews, is seen as the most effective way of knowing this reality and essentially removes all corruptions, resulting from personal, social, and political influences. And, finally, by accumulating knowledge and improving research techniques, scientific endeavours are inherently progressive and are ever approaching the ultimate truths of reality. As José Carlos Somosa wrote his novel, Zig Zag, "*I want you to do the following: look at those numbers, all those little numbers, and Greek letters on the board, and repeat to yourselves, 'This is reality', repeat it over and over…*".[13]

So, typically, science textbooks promote a single scientific method, like the one described on a web-site of Prof. Frank L. H. Wolfs, Department of Physics and Astronomy, University of Rochester, NY 14627, USA[14]:

> ***Introduction to the Scientific Method***
>
> *The scientific method is the process by which scientists, collectively and over time, endeavor to construct an accurate (that is, reliable, consistent and non-arbitrary) representation of the world.*
>
> *Recognizing that personal and cultural beliefs influence both our perceptions and our interpretations of natural phenomena, we aim through the use of standard procedures and criteria to minimize those influences when developing a theory. As a famous scientist once said, "Smart people (like smart lawyers) can come up with very good explanations for mistaken points of view." In summary, the scientific method attempts to minimize the influence of bias or prejudice in the experimenter when testing an hypothesis or a theory.*
>
> *I. The scientific method has four steps*
>
> *1. Observation and description of a phenomenon or group of phenomena.*
>
> *2. Formulation of an hypothesis to explain the phenomena. In physics, the hypothesis often takes the form of a causal mechanism or a mathematical relation.*
>
> *3. Use of the hypothesis to predict the existence of other phenomena, or to predict quantitatively the results of new observations.*
>
> *4. Performance of experimental tests of the predictions by several independent experimenters and properly performed experiments.*

[12] It is worth acknowledging the circularity of the assumed nature of reality and the design of the research methods.

[13] As José Carlos Somosa, *Zig Zag*, as quoted from John Grant, *Corrupted Science*, AAPPL Artists' and Photographers' Press Ltd., Wisley, 2007, p.6

[14] http://teacher.pas.rochester.edu/phy_labs/appendixe/appendixe.html

> *If the experiments bear out the hypothesis it may come to be regarded as a theory or law of nature…"*

Some writers will add the concept of falsifiable hypothesis to counter the known limitations of seeking confirming evidence only. Karl Popper[15] proposed *empirical falsification* as the way to certainty in the scientific enterprise.

This public view and the resulting trust have suited scientific communities. It enabled science to be conducted free of public scrutiny; enabled extensive government and corporate funding; and, finally, enabled non-conforming practices to be successfully excluded as pseudo-sciences. So, post-modernist ideological criticisms of science of the late twentieth century were met with 'you are not qualified to criticise', similar in tone to Jack Nicholson's famous '*You can't handle the truth*' speech as Colonel Nathan R. Jessep in the 1992 film, *Few Good Men*.

> *"You can't handle the truth! Son, we live in a world that has walls. And those walls have to be guarded by men with guns. Who's gonna do it? You? You, Lt. Weinberg? I have a greater responsibility than you can possibly fathom. You weep for Santiago and you curse the Marines. You have that luxury. You have the luxury of not knowing what I know: that Santiago's death, while tragic, probably saved lives. And my existence, while grotesque and incomprehensible to you, saves lives...You don't want the truth. Because deep down, in places you don't talk about at parties, you want me on that wall. You need me on that wall. We use words like honor, code, loyalty...we use these words as the backbone to a life spent defending something. You use 'em as a punchline. I have neither the time nor the inclination to explain myself to a man who rises and sleeps under the blanket of the very freedom I provide, then questions the manner in which I provide it! I'd rather you just said thank you and went on your way. Otherwise, I suggest you pick up a weapon and stand a post. Either way, I don't give a damn what you think you're entitled to!"*[16]

Specialness of Science – Claims & Realities

Let us look at two cognitive reasons given for arguing the continued special status of science. One concentrates of the unique processes of science – empirically-based evidence - and the other on the values held by scientific communities.

Scientific Knowledge is Empirically-based

According to this claim, scientific knowledge is based on observation and measurement and therefore offers unique reliability. Although still popular with the public in general, the empiricist argument, as justifying science's unique status, has largely lost its force with philosophers.

Briefly, here are some reasons. Most scientific observations are dependent on specially-trained interpretations, and that alone can perpetuate self-fulfilling erroneous thinking. Remember the continued French observations of N-Rays, long after U.S. debunking. Worse still, much of today's observations are not done directly but with specially constructed instruments, constructed within the same intellectual framework as the hypotheses that they seek to test. This is further complicated

[15] Karl Popper(1902-1994), philosopher of science, sought to overcome science based on induction with empirical falsification.
[16] http://www.whysanity.net/monos/fewgood.html and http://www.youtube.com/watch?v=5j2F4VcBmeo

by high experimental costs and difficulties that actually limit the frequency and variety of testing. So the upshot of these realities is that empirical processes are often more limited and theory-dependent, than is commonly thought or promoted.

An extreme example of testing complexity as well as theory and observation interdependency is the *Large Hadron Collider* (LHC), the world's largest and highest-energy particle accelerator, in Geneva. Designed to explain the contradictory theories of quantum mechanics and general relativity (amongst other things), the LHC is a 30 year project. It first ran in September, 2008, followed by equipment failures. It is not expected to run fully until 2014. Project costs are estimated to be in the order of US$8 billion.[17]

Another criticism of the empiricist argument is that, in practice, contrary research evidence isn't routinely used to invalidate a hypothesis. The judgement is made by the researchers, often depending on prior commitments to a hypothesis. They typically seek mitigating factors, such as (1) experimental errors – faulty equipment, contaminated samples; (2) misinterpreted results; or (3) unaccounted for influences or explanations. Finally researchers may even sideline adverse results for later analysis and explanation. Thomas Kuhn showed that only an overwhelming number of anomalies may force scientists into re-thinking the dominant mind-set or paradigm of the time to accommodate these anomalous results - the famous *paradigm-shift*. As experiments become more dependent on interpretation, any sense of hypothesis falsification becomes rather problematic.

Finally, philosophers have long known of the conceptual problems of generalised rule-making from specific examples – process of *induction*. As induction has been the mainstay of scientific research, science at best can justify provisional acceptance only and not 'truths' and universal knowledge so often claimed. Scottish philosopher David Hume said some 330 years ago:

> *It is impossible, therefore, that any arguments from experience can prove this resemblance of the past to the future; since all these arguments are founded on the supposition of that resemblance. Let the course of things be allowed hitherto ever so regular; that alone, without some new argument or inference, proves not that, for the future, it will continue so… Can I do better than propose the difficulty to the public, even though, perhaps, I have small hopes of obtaining a solution? We shall at least, by this means, be sensible of our ignorance, if we do not augment our knowledge.* [18]
>
> *…we may observe, that the supposition, that the future resembles the past, is not founded on arguments of any kind, but is derived entirely from habit, by which we are determined to expect for the future the same train of objects, to which we have been accustomed. This habit or determination to transfer the past to the future is full and perfect; and consequently the first impulse of the imagination in this species of reasoning is endowed with the same qualities*.[19]

[17] http://www.neatorama.com/2008/09/12/10-things-about-the-large-hadron-collider-you-wanted-to-know-but-were-afraid-to-ask/ and http://en.wikipedia.org/wiki/Large_Hadron_Collider
[18] David Hume, *A Treatise of Human Nature*, 1737
http://www.marxists.org/reference/subject/philosophy/works/en/hume.htm
[19] David Hume, *A Treatise of Human Nature*, 1737
http://nothingistic.org/library/hume/treatise/treatise050.html

As an aside, I want to make a special mention about the 'naturalness' of scientific experiments: they are not. Scientific experiments achieve results by creating artificial worlds, constructed with very controlled conditions, controlling and eliminating factors found in the natural world. We then also need to be very circumspect about extrapolating these laboratory results to general metaphysical conclusions about the world out there.

Special Norms and Values of Science

Although scientific processes as being decisive seems unconvincing, another argument centres on the accepted moral norms and knowledge values encouraged and enforced within scientific communities. Sociologists, like Robert Merton[20], have described the social norms that warrant science being given a special status in human affairs. These norms both describe the normative values, the 'shoulds', that are applied within scientific communities and, at the same time, describe how these communities actually produce sound scientific knowledge. Commonly quoted norms are[21]:

Universalism – ideas should be evaluated independently of their source according to impersonal criteria

Communalism – knowledge is regarded as communal property and shared with the science establishment

Disinterestedness – scientists seek knowledge divested of personal interests

Organised scepticism – scientists employ moderate scepticism to critically examine ideas to avoid automatic acceptance or rejection.

However there are many instances of attitudes and behaviours within scientific communities that contradict these norms for other reasons and are still seen as acceptable. *Universalism* suggests that contributions from non-Western and non-elite establishment backgrounds should be treated as potentially valid sources of scientific information and research. This is often not the case. One study of the US space program showed that overwhelming amounts of information forced scientists to limit their attention to work from well-established authorities in their fields or even to researchers personally known.[22] [23] There appears to be an on-going tension for scientists between the ideal of universalism – to consider sources regardless of background - and the pragmatism of particularism.

Disinterestedness implies the production of knowledge without personal commitment to ensure success. However scientists regularly champion or sell their ideas for which they have great passion and commitment. They recognise this as the only way of getting novel ideas off the ground. Furthermore *communalism*, willing sharing of research results, is often replaced by the need for solitariness or secrecy to be first published or to patent potentially valuable developments. Or, more generously, a scientist may hold back from publicising an idea not to waste others' time or not to

[20] Robert Merton (1910-2003) was a distinguished American sociologist, http://en.wikipedia.org/wiki/Robert_K._Merton
[21] Steven Yearly, *Making Sense of Science*, Sage Publications Ltd., London, 2005, p.8
[22] Ian Mitroff, *The subjective side of science: a philosophical inquiry into the psychology of the Apollo moon scientists, Elsevier Scientific Pub. Co.,* New York, 1974, pp. 27-46
[23] http://en.wikipedia.org/wiki/Mertonian_norms

embarrass him or herself, until the proposal is sufficiently robust. Even the doyen of science, Charles Darwin, waited some 20 years before publicly announcing his theory of evolution. Despite ongoing doubts about his evidence, Darwin was forced to publish with the risk of a rival announcement by Alfred Russel Wallace.

In practice, there seems little relationship between adherence to these behavioural norms and career rewards in science, such as the assigning of prestigious jobs and grants. Personal reputations for good work, connections with prestigious establishments, and long list of highly cited publications are more relevant factors. And, finally, there is little monitoring of norms except, perhaps, for checking correct article citations in scientific publications.[24]

Others observers of science have suggested its unique position can be attributed to particular values that scientists use towards knowledge acquisition rather than their conforming to normative practices. One example is from Newton-Smith[25]. They should be:

1. In agreement with experiments and observation
2. Internally consistent
3. Consistent with existing accepted theories, including neighbourhood theories e.g. from physics and from biology, as well as consistent with general metaphysical assumptions[26]
4. Be adaptable to new anomalous experimental results
5. Bring order to observed phenomena; and encourage further research

However, everyday scientists demonstrate that these are not inviolate values. They regularly prioritise the values for each particular situation, based on other separate needs and desires. Even though some theories better explain phenomena, they may be rejected as contradicting other previously accepted theories or metaphysical assumptions. So, value 3 (consistency with existing theories) may trump value 1 (experimental explanation). That is a typical value judgement that scientific communities regularly make, and those value judgements will vary over time in different situations. So, again, it becomes problematic seeking any obvious link between these broadly held (and at times contradictory) values about knowledge and science's unique status.

Biomedical Research Today – An Insider View

In a recent *Scientific American* issue[27], John Ioannidis, professor of medicine at Stanford University, wrote an opinion piece, provocatively titled *An Epidemic of False Claims*, on the endemic problems with today's biomedical research. Ioannidis identified serious flaws in research practices, which he traces to meeting the public's ever-increasing expectations; fragmentation of exponentially increasing research programs; and researcher conflicts of interest with meeting the demands of lucrative corporate funding and achieving personal successes through highly-visible publishing. This

[24] Steven Yearly, *Making Sense of Science*, Sage Publications Ltd,, London, 2005, p. 11
[25] William Newton-Smith, *The Rationality of Science*, Routledge and Kegan Paul, London, 1981 p.p. 122-4
[26] Often a problem here is *underdetermination*, where the evidence is insufficient to choose definitely one theory over another, and hence the need to be consistent with other theories. From the Stanford Encyclopedia, *"At the heart of the underdetermination of scientific theory by evidence is the simple idea that the evidence available to us at a given time may be insufficient to determine what beliefs we should hold in response to it."* http://plato.stanford.edu/entries/scientific-underdetermination/
[27] John P. A. Ioannidis, *An Epidemic of False Claims*, *Scientific American*, June 2011, p. 8

is all under the control of "*the oligopoly of high-impact journals [that] also ...[have]... a distorting effect on funding, academic careers and market shares*".

John Ioannidis's observations belie simple claims of scientific objectivity. Contrary to the objectivist view of science, he identifies the following problems: (1) claims based on single studies, with replication being done "*sparingly and haphazardly*"; (2) withholding research data for competitive financial reasons and so preventing replication studies; (3) selectively reporting research results for maximum impact; and (4) deliberately designing and reporting studies to produce most favourable outcomes for research and, by implication, for the financial backers.

Social Models of Science

Science portrayed as a purely rational process is superficially appealing although unsustainable under scrutiny. As I have mentioned previously, typically the failures and 'corruptions' are ignored. An alternative approach, one that causes much angst for scientists, is to see science as a social activity that has changed over time like other human enterprises. Now the focus is on historical changes, social relationships, inter-group behaviours, and social knowledge-making. The great fear for science is its loss of legitimacy, its special place, when science is portrayed in social, non-rational terms. Ironically, science is already being challenged by the general public, particularly the youth, who are willing to question scientific pronouncements by supporting non-scientific explanations or simply being science sceptics or deniers. The Internet and its social networking readily inculcate such distrust.[28] But, for all that, the greatest challenge facing science is the declining numbers of young people, wishing to pursue science careers. This is particularly of concern in the United States. I suspect that relying on and promoting of no-fault idealised views of science is treated sceptically by today's critical, pluralist, and post-modernist youth.

So, social researchers examine science in its totality of successes and failures - the 'good' sciences, the 'discarded' sciences, and the 'corrupted' sciences.[29] Instead of reviewing their particular social theories, let us look at some interesting ideas that underpin their work.

Underdetermination

Scientists often seek to explain empirical data with competing hypotheses. Quite commonly, many are equally capable of doing so and therefore are said to be *underdetermined* by the evidence. And, as a result, scientists have no logical way of conclusively selecting one over another. Scientists must resort to other criteria.

Tycho Brahe (1546–1601)[30], 16th century astronomer, developed a modified geo-centric (Earth-centred) model of our planetary system that explained the best astronomical data of his day. I should note that Tycho's observations were remarkable for both accuracy and quantity and exceeded those of his contemporaries. He effectively combined the latest research with the broadly-

[28] It seems that most modernist projects and their metanarratives (to us a post-modernist term) are rejected or ignored by todays 'connected' Western generations. They include science, secularism, humanism, modern-day Christianity, and socialism.

[29] The argument to say that 'good' science is true science and 'discarded' and 'corrupt' science are not reminds me of defining a Christian as automatically a good Christian and excluding those followers of Christ who behave badly. It reduces the definition of Christian to a non-existent ideal that removes the working value of any definition of Christianity.

[30] http://en.wikipedia.org/wiki/Tycho_Brahe

accepted and intuitive Earth-centred view. To the surprise of many today, Tycho was able to explain the observed data equally well as Galileo's[31] helio-centric one. According to Wikipedia it was only until, "*The discovery of stellar aberration in the early 18th century by James Bradley convinced people that the Earth did in fact move around the Sun, after which Tycho's system fell out of use among scientists.*"[32] Even more interestingly, Galileo ignored Kepler's earlier work to propose that the planets had circular orbits (not elliptical ones), despite available contrary data. So the evidence for Galileo was not conclusive at the time, and there were compelling alternatives that conformed to the accepted Ptolemaic view. Often, science history presents the Church and traditional astronomers as denying and therefore resisting the 'obvious' truths of Galileo and the sun-centred system. This is a contrived perspective based on today's sensibilities.

So how do scientists choose? A popularly-quoted cognitive criterion is that of elegance and simplicity, the so-called *law of parsimony*[33], where we should make the fewest number of new assumptions. But that principle assumes that reality also prefers elegance and simplicity, and, not surprisingly, there is no 'proof' for such an idea. Alternatively, some sociologists seek reasons for these decisions within social and political domains to explain scientists' commitments to some explanations while rejecting others. Let us continue to look at these social and historical ideas that have influenced sociologists' thinking.

Thomas Kuhn and Paradigms

In 1962 Thomas Kuhn, scientist turned philosopher, published his analysis of scientific practices over time.[34] Controversially, he rejected popular historical narratives of simple progression, conducted by science heroes with ever-increasing reservoirs of knowledge. Kuhn described scientific history as, in fact, long periods of normal or routine science, punctuated by major revolutions or shifts in our understandings. The existing mindset or paradigm to use Kuhn's term would then be fully replaced, with the older one being seen as quaint fiction. By paradigm, Kuhn included such things as generalisations e.g. laws of motion; metaphysical assumptions e.g. light as waves; values e.g. seeking simplicity; and exemplars e.g. paradigmatic textbook or laboratory examples and practices.[35] Typically the generalisations and assumptions are contained within the scientific theories.

His work showed that popular writings of science history are so often just fictional reconstructions to explain today's views and that past participants are re-interpreted with today's motivations. We rarely speak of Newton's alchemical research in the same breath as his work on physical motion, even though he spent more time on the former than the latter, and we have every reason to believe Newton was similarly motivated for both types of research areas. Discarding previous paradigms as non-science and re-interpreting past people and events are often referred to the so-called 'Whig' history of science.[36]

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[31] Galileo Galilei (1564-1642) http://en.wikipedia.org/wiki/Galileo_Galilei
[32] http://en.wikipedia.org/wiki/Tychonic_system
[33] *Lex parsimoniae* is Latin for The Law of Parsimony, or succinctness.
[34] Thomas S. Kuhn, *The Structure of Scientific Revolutions* 2nd Edition, Chicago University Press, Chicago, 1970
[35] http://philosophy.wisc.edu/forster/220/notes_8.html Philosophy Department, University of Wisconsin
[36] '*The British historian Herbert Butterfield coined the term "Whig history" in his small but influential book The Whig Interpretation of History (1931). It takes its name from the British Whigs, advocates of the power of Parliament, who opposed the Tories, advocates of the power of the King.*

Kuhn saw normal science as periods of steady progress or 'puzzle-solving' contained within well-defined and relatively unchallenged limits of the prevailing paradigm. Research directions, experimental designs, theory proposals, corporate and government funding, and research observations are influenced by or, perhaps controlled by, the views of the time. Education and socialisation of incoming scientists guarantee the on-going support for the prevailing views. Normal science is probably the stage we envisage when thinking of its activities.

However, as experimental anomalies mount (no longer able to be ignored or adjusted), some scientists, particularly the less indoctrinated younger ones, conceive of different paradigms. I should note that this may not be a rational process as the *underdetermination* principle often comes into play.[37] For some time, both paradigms co-exist until the newer one becomes the new orthodoxy. Scientists continuing to support the previous paradigm then become marginalised and separated from future funding. Even though Kuhn's specific arguments have less force today, his overall observations are still seen as highly influential.

Thinking of paradigms leads us to two interesting ideas – *theory-dependent observations* and *incommensurability*. Before looking at those concepts, let me briefly mention one expressed concern (and there are others) about his analysis. Steve Fuller[38] sees Kuhn's approach to analysing science history is essentially syncretistic in that he blends disparate parts of science history into a common framework with all participants portrayed in similar social contexts. It is quite a stretch, for instance, to see the relatively independent and free-wheeling natural philosophers of the early Royal Society, who sought God's divine work, in the same lights as today's career scientists beavering away in government and corporate laboratories. Ignoring these differences fits the grand scale of his theory. However there appears to be no continuous period of science history that simply fits into his revolution-normal-revolution model.[39]

Despite Kuhn's normalisations of science history, it is fair to say that the concept of paradigms and shifts has had an enormous influence on social scientists. Researchers have not sought to validate or replace Kuhn at the broader paradigm-level but have worked with his ideas at the micro levels of laboratories, so-called 'micro-Kuhnian'. As an aside, philosopher Malcolm R. Forster amusingly warned that "*One of the most serious influences of Kuhn's book has been to provide support for*

The term has been applied widely in historical disciplines outside of British history (the history of science, for example) to criticize any teleological or goal-directed, hero-based, and trans-historical narrative.' Quoted from Wikipedia http://en.wikipedia.org/wiki/Whig_history

[37] Again, this is an example of underdetermination where results can be explained by more than one theory.

[38] Steve Fuller, *The Philosophy of Science And Technology Studies*, Routledge, New York, 2006 p.p.21-25

[39] To give you some sense of the diversity of science over time, Jerome Ravetz, a specialist in the history and philosophy of science, describes three very different periods of modern science: (1) *Little Science* – up to World War II – '*small-scale enterprise, led by independent persons and largely self-governing in its priorities and in its procedures for quality-assurance*' and is characterised by idealism and isolation; (2) *Big Science* – since WW II – introduction of massive funding from governments and corporates, the so-called military-industrial complexes, that challenged the independence of scientists and created conflicts in their social and moral responsibilities. Research units of scholars transformed to fully-fledged industrial enterprises, constantly seeking new research funding; (3) *Mega Science* – modern – replacement of large science civilian laboratories by smaller corporate research and development units or incorporation within the military enterprise. Science is now enterprise property to fulfil overall profit or military objectives.
Jerome Ravetz, *The No-Nonsense Guide to Science*, New Internationalist Publications, Oxford, p.p.47-60

those who want to turn away from the philosophy of science towards the sociology and psychology of scientific communities."[40] Heaven forbid!

Theory-Dependent Observations

Psychologists have long recognised that observations are shaped by personal and social expectations and that seeking confirmations regularly falls foul of the so-called 'confirmation bias' (a term coined by psychologist Peter Watson in the 1960s) - seeing what is sought and ignoring what is contradictory.[41] This is uncontroversial and is recognised as a genuine problem in many research fields.

Similarly, claims that researchers of different disciplines or sub-disciplines will interpret the same observed data in vastly different ways would not surprise anyone. We would almost expect, for example, a sociologist and an evolutionary psychologist to seek and identify different causes for particular human behaviours, each drawing from different sets of assumptions. Again this is uncontroversial. In a recent interview the Edge web-site, an on-line intellectual forum, Timothy D. Wilson, professor of psychology at the University of Virginia, questioned the efficacy of evolutionary psychology with its ease of creating plausible but fictional explanations for human behaviour. He compares it to the earlier psychoanalytic approaches that have gone out of favour for research psychologists.

> *There are some striking parallels between psychoanalytic theory and evolutionary theory. Both theories, at some general level are true. Evolutionary theory, of course, shows how the forces of natural selection operated on human beings. Psychoanalytic theory argues that our childhood experiences mold us in certain ways and give us outlooks on the world. Our early relationships with our parents lead to unconscious structures that can be very powerful.*
>
> *But both theories led to a lot of absurd conclusions, and both are very hard to test rigorously. The influence of psychoanalysis waned in research psychology because it was too broad. It made too many assumptions that were very hard to test, and basically it explained everything.*[42]

The claim of theory-laden observations though is quite different. In his book *Patterns Of Discovery*[43], philosopher N. R. Hanson argued that our observational language and theory language are inseparably interwoven. It is not simply a matter of different interpretations of the same data. Hanson separates the receiving of sense data ('to look at') from its perception ('to see'), so that the first involves processing by sense organs, while the second by sub-conscious brain processing and organising. Supporters of this claim do not deny a common external reality: they are not

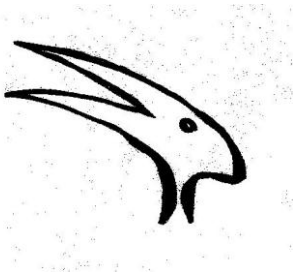
[40] http://philosophy.wisc.edu/forster/220/notes_8.html

[41] For example see research paper: *Biased assimilation and attitude polarization: The effects of prior theories on subsequently considered evidence,* Lord, Charles G.; Ross, Lee; Lepper, Mark R. Journal of Personality and Social Psychology, Vol 37(11), Nov 1979, 2098-2109. Abstract states, "*People who hold strong opinions on complex social issues are likely to examine relevant empirical evidence in a biased manner. They are apt to accept 'confirming' evidence at face value while subjecting 'disconfirming' evidence to critical evaluation, and, as a result, draw undue support for their initial positions from mixed or random empirical findings.*"

[42] *The Social Psychological Narrative — or — What Is Social Psychology, Anyway?* http://edge.org/conversation/social_psychological_narrative

[43] Norwood Russell Hanson, *Patterns of Discovery: An Inquiry into the Conceptual Foundations of Science*, Cambridge University Press, Cambridge, 1958

metaphysical idealists. However people 'see' the same external reality in quite different ways, even before invoking their conscious interpretations. His example is Tycho Brahe, the geo-centrist mentioned previously, and his assistant Kepler, helio-centrist, seeing quite different sunrises from the same physical event. Hanson uses optical-switching illusions to demonstrate the pre-conscious organising of data. The figure here could be a pelican or antelope when viewed against different backgrounds.[44]



So what is the significance for science? As an on-line paper by Prof. Henry Folse, Loyola University New Orleans, stated about Hanson:

> *Hanson is working from a perspective already pioneered by Wittgenstein that different languages in effect express different world-views, or in the language of the specific sciences, different theories of the world. Rival theories about the world express their claims in different "languages" in which key terms (although perhaps expressed by the same "word," e.g. "sun") are given different meanings. Therefore those who hold rival theories will make different, and logically incompatible observation statements when "looking at" the same thing. Thus observation cannot settle the choice between rival theories, and thus cannot provide the "authority" to justify its acceptance over its rival.*[45]

So, even repeated observations will lead to differing observational statements within differing paradigms. This directly challenges the claim that science holds a unique status in our society with its foundational use of empirical evidence.

Also the claim becomes even more problematic when you appreciate that much observational data comes from machines, machines often specially built for the task. Then the scientists need to interpret machine output ('to see' in Hanson's terms) into meaningful observations before even seeking to interpret in light of an existing model or hypothesis. And so, it is not a great leap to see that the subsequent interpretations of those already interpretive observations are couched within the researchers' own previous experiences and education as well as the expectations of the surrounding scientific culture. So this is the concept of *theory-laden observations*.

Incommensurability

Another serious implication of Kuhn's description of scientific history is that paradigms are *incommensurable*. Like philosopher Paul Feyerabend[46] some ten years before,[47] Kuhn claimed that the problems, concepts, and methods of one paradigm would seem incomprehensible when viewed from another. Einstein's universe would seem incomprehensible in Newtonian terms. One outcome of this, mentioned previously, is to write fictitious scientific histories and to ascribe modern motives

[44] Discussed in http://www.loyno.edu/~folse/Hanson.html
[45] http://www.loyno.edu/~folse/Hanson.html
[46] Feyerabend was a critic of the single scientific method claim. http://en.wikipedia.org/wiki/Paul_Feyerabend
[47] *"Although Feyerabend first used the term 'incommensurable' to describe successive fundamental scientific theories in 1962, he had developed his notion of the incommensurability of scientific theories more than ten years prior to the appearance of Kuhn's Structure of Scientific Revolutions (1962)."* Eric Oberheim and Paul Hoyningen-Huene , "*The Incommensurability of Scientific Theories*", The Stanford Encyclopedia of Philosophy (Fall 2010 Edition), Edward N. Zalta (ed.), http://plato.stanford.edu/archives/fall2010/entries/incommensurability/

from the perspective of the current paradigm. As sociology lecturer, Sergio Sismondo says: *"Isaac Newton's physics looks strikingly modern when rewritten for today's textbooks, but looks much less so in its originally published form, even less so when the connections between it and Newton's religious and alchemical research are drawn."*[48]

A more serious attack of incommensurability is our inability to have any truly neutral language that can compare the effectiveness of different paradigms. If this is true, then we have no rational means, no reasoned way, of justifying the replacement of one paradigm with another. If it can be a matter of faith only, this is a serious indictment of the claim that science is a rational process. A useful insight from Ludwig Wittgenstein, later post-modernists, and concept of language-games, is participants within a paradigm will "*…create their own vocabularies by giving special meanings to ordinary terms and phrases*."[49]

Even though the most extreme implications of incommensurability have received little general support, even from Kuhn's own later writings, the implications continue to be debated amongst philosophers, sociologists, and scientists. It may be that incommensurability is better characterised as incomplete communication or problems with translation between paradigms. In fact, given that a paradigm will usually share the resources - measuring equipment, experimental results, and the like – with the previous one at least during transition, does suggest the some capacity to relate, even if a common observations and measurements are recast into very different interpretations.

Finally, incommensurability may operate at a deeper, non-rational psychological level, similar to the so-called tacit knowledge acquisition of exemplars mentioned previously as a part of a paradigm. Philosopher Alexander Bird argues this perspective in his paper '*Incommensurability Naturalized*'[50]. He develops a more psychological view:

> *The key idea in what follows is that we all use in thinking various cognitive capacities and structures that have the following features: (i) they cannot be reduced to general, formal rules of reasoning (e.g. formal logic); (ii) their existence and the mechanism of their employment are typically unconscious, so that they are deployed in a manner that is akin to intuition—what I call a semi-intuitive manner; (iii) they are often acquired as a matter of practice and repeated exposure and practice, so that they have the character of skills. The sorts of skill or capacity I am referring to here include: mental schemata, analogical thinking, pattern recognition, quasi-intuitive inference.*[51]

[48] Sergio Sismondo, *An Introduction to Science and Technology Studies* 2nd Edn., Blackwell Publishing Ltd, West Sussex, 2101, p.17

[49] See discussion at http://postmoderntherapies.com/word.html

[50] "Incommensurability Naturalized" in Rethinking Scientific Change and Theory Comparison (Boston Studies in the Philosophy of Science 255, eds LÃna Soler, Howard Sankey, and Paul Hoyningen-Huene) Dordrecht: Spinger (2007) 21–39. http://web.mac.com/alexander.bird/research/papers/Incommensurability-naturalized.pdf

[51] Philosopher of science, Jerome Ravetz characterises science as a craft – socially-embedded, aesthetically driven, client-responsive, and skill-based. See Teaching Company course, *Science Wars: What Scientists Know and How They Know It* by Professor Steven L. Goldman, Ph.D., Boston University, Lehigh University, http://www.thegreatcourses.com/tgc/courses/course_detail.aspx?cid=1235

Social Constructionism

Social constructionism is a powerful, confronting theory of knowledge that moves 'what we know' - facts, truths, and knowledge - from corresponding to an external reality to being created from our social interactions. So, truths are now propositions that cohere with widely-accepted socially created knowledge and no longer depend on any claims about external realities, physical or otherwise. At a minimum, constructionists assert that "*human decision and human culture exert profound and often unnoticed influence*"[52] on our 'realities'. Many even question our capacity to know of separate non-social existences at all. Taken-for-granted ideas like gender, sexuality, beauty, goodness, evil, the self, purity, and religious beliefs and, similarly, scientific 'objects' like phlogiston[53], vitalism[54], N-Rays, black-holes, and subatomic particles are all seen as socially constructed. Of course, is social constructionism itself a social construct? Even physical objects are not always what they seem. Uluru (Ayres Rock) can be a large rock, Australian iconic symbol, sacred place, and sub-atomic particle collection, and each construction or meaning affects people in very different ways. And who is to say one meaning is more real to us than another? So, not surprisingly, social constructionism threatens the claims of necessary universal truths – both from empiricist traditions like science and from most religious traditions. Constructionism stands in stark contrast to beliefs like 'natural law'.

In addition to elucidating meaning, most social constructionists are also concerned with power and the capability of powerful groups to define social realities that marginalise the powerless. So, for example, the labelling of asylum seekers as 'illegal immigrants', 'queue jumpers', 'economic refugees' demonises and marginalises a powerless group before any official attempts are made to assess their claims.[55] These pernicious constructions change the realities and affect the physical worlds of the perpetrators, recipients, and observers in very real ways.

Let us take two examples. 'Gender', as opposed to male-female biological differences, is seen as a clear example of social construction and has been the target of many feminist social writers. Society's interpretations of 'gender' and its roles, responsibilities, and rights have varied widely over time and across cultures. We even have cases of societies' switching genders arbitrarily, such as the so-called *Albanian sworn virgins*, "*who take a vow of chastity and wear male clothing in order to be*

[52] Ron Mallon, *A Field Guide to Social Construction* http://xcelab.net/rm/wp-content/uploads/2008/09/mallon-field-guide-to-social-construction-2007.pdf

[53] "*phlogiston theory (flōjis'ton), hypothesis regarding combustion. The theory, advanced by J. J. Becher late in the 17th cent. and extended and popularized by G. E. Stahl, postulates that in all flammable materials there is present phlogiston, a substance without color, odor, taste, or weight that is given off in burning. "Phlogisticated" substances are those that contain phlogiston and, on being burned, are "dephlogisticated." The ash of the burned material is held to be the true material. The theory received strong and wide support throughout a large part of the 18th cent. until it was refuted by the work of A. L. Lavoisier, who revealed the true nature of combustion. Joseph Priestley, however, defended the theory throughout his lifetime. Henry Cavendish remained doubtful, but most other chemists of the period, including C. L. Berthollet, rejected it.*" http://www.infoplease.com/ce6/sci/A0838824.html

[54] "*Vitalists hold that living organisms are fundamentally different from non-living entities because they contain some non-physical element or are governed by different principles than are inanimate things. In its simplest form, vitalism holds that living entities contain some fluid, or a distinctive 'spirit'. In more sophisticated forms, the vital spirit becomes a substance infusing bodies and giving life to them; or vitalism becomes the view that there is a distinctive organization among living things.*" http://mechanism.ucsd.edu/teaching/philbio/vitalism.htm

[55] See research paper, *What's the Story*, by The Information Centre about Asylum and Refugees (ICAR) in the UK, http://www.researchasylum.org.uk/?lid=451

viewed as men in the highly patriarchal Northern Albanian society"[56]. A woman typically assumes the male role to head the family and to protect its assets. She would then be treated as a full male member of society and mix with men but not with women. These variations seem inconsistent with the relatively static and narrow sex roles as seen in other animals. And, therefore, strongly suggests that gender roles come from complex social interactions and learning rather than common biological evolution. A similar argument could be made for sexuality with its extensive variations over time and amongst different cultures. [57]

Sociologist Sergio Sismondo generalises this idea of social constructionism as such. When *knowing* the idea of 'X' changes our behaviour and encourages others to act as if 'X' exists, and when there is general acceptance of 'X' - its wide transmission and its imperviousness to individual contrary wishes – then 'X' exists in a very real sense, unrelated to any external physical reality. [58] By this time 'X' has lost its original 'authorship' and been accepted universally as truth.

Canadian philosopher Ian Hacking[59] recognises that many social constructionists have reformist agendas when identifying constructions like 'gender'. He suggests four conditions commonly invoked with the latter two being the argument for change:

1. 'X' is 'taken-for-granted', assumed to be inevitable and natural. So 'gender' as assumed by most to be a natural consequence of biological differences. Whereas 'Japan', the nation, as a political construct is uncontroversial.

2. However 'X' need not existed under different circumstances. It is not determined by the nature of things. The behaviours associated with 'gender' are not inevitable.

3. 'X' is bad as it is. 'Gender' has many pernicious aspects.

4. We would be better off without 'X' or, at least 'X' radically transformed.

Hacking sees the first point - an idea is 'taken-for-granted' as existing - as an essential requirement for challenging an idea as an undesirable social construct.

'Illness' is a surprising example of constructionism. We think of illness as a consequence of an obvious bodily pathology - a body malfunctioning. Biomedical approaches closely link illness with disease through cause and effect. Sociologists argue illness is in fact a social construction unrelated to specific diseases. Examples like tooth decay, older-age sight problems, and infertility are pathologies not seen socially as illnesses. Are people with malformed limbs ill? Even the way we categorise ourselves as having a 'cold' or the 'flu' suggests a social decision rather than a medical one.

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[56] http://en.wikipedia.org/wiki/Albanian_sworn_virgins and http://www.washingtonpost.com/wp-dyn/content/article/2007/08/10/AR2007081002158.html

[57] This knowledge will change over time and amongst different communities. 2000 years ago in Palestine 'gender' was the most important differentiator between people regardless of status. Societal roles were heavily defined. Today 'gender' in the Australian society is one of many considerations. Most times, a female Chief Commissioner of Police is a senior police officer first and then a woman second.

[58] I have drawn this discussion from a general case mentioned in Sergio Sismondo, *An Introduction to Science and Technology Studies* 2nd Edn., Blackwell Publishing Ltd, West Sussex, 2101, p.58

[59] Ian Hacking, *The Social Construction of What?*, Harvard University Press, Cambridge, 1999 p.p. 6-12

Although constructionists vary in their ideas, social constructionism has some common features. Constructionism challenges psychological essentialism, the belief that we have an essential, discoverable nature – our 'personality' that exists in a sort of pseudo-psychic realm in our bodies. Not surprisingly constructionists reject this and prefer to talk about 'identity', developed through our social relationships. As sociologist Vivien Burr puts it, "*Since the social world, including ourselves as people, is the product of social processes, it follows that there cannot be any given, determined nature to the world or people. There are no essences inside things or people that make them what they are.*"[60]

Constructionists also challenge the concept of realism, where we can know an external reality. We, as a society or culture, construct our own versions of reality through our social discourses. Supporters vary from radical anti-realists - denying any capacity to know of a physical world - to critical realists who acknowledge that our social realities are influenced or shaped by our physical settings. Ultimately, though, all constructionists are suspicious of any realist claims about a knowable external world.

Not surprisingly social constructionism feels highly unintuitive, contrary to our everyday common sense. Sociologists Peter Berger and Thomas Luckman warned in their iconic book, *The Social Construction of Reality* that:

> *Reification is the apprehension of human phenomena as if they were things, that is, in non-human or possibly supra-human terms. Another way of saying this is that reification is the apprehension of the products of human activity as if they were something else than human products—such as facts of nature, results of cosmic laws, or manifestations of divine will. Reification implies that man is capable of forgetting his own authorship of the human world, and further, that the dialectic between man, the producer, and his products is lost to consciousness. The reified world is, by definition, a dehumanized world. It is experienced by man as a strange facticity, over which he has no control.*
>
> *It will be clear from our previous discussion of objectivation that, as soon as an objective social world is established, the possibility of reification is never far away. The objectivity of the social world means that it confronts man as something outside of himself.*
>
> *The decisive question is whether he still retains the awareness that, however objectivated, the social world was made by men—and, therefore, can be remade by them.*[61]

Or, to put it simply, we forget our authorship and see socially-constructed knowledge (consensual beliefs) as reified[62] external objects.

The authors stated in their introduction that:

> *Insofar as all human "knowledge" is developed, transmitted and maintained in social situations, the sociology of knowledge must seek to understand the processes by which*

[60] Vivien Burr, *Social Constructionism*, [Kindle DX version]. Retrieved from Amazon.com http://amazon.com , Heading *Anti-essentialism*, position 168.
[61] Peter L. Berger and Thomas Luckmann, *The Social Construction of Reality: A Treatise in the Sociology of Knowledge*, Doubleday, Garden City, NY, 1996 p. 89
[62] *reification* - regarding something abstract as a material thing http://www.thefreedictionary.com/reification

> *knowledge is developed in such a way that a taken-for-granted "reality" congeals for the man on the street. In other words, we contend that the sociology of knowledge is concerned with the analysis of the social construction of reality*[63].

Finally, another interesting example of the interdependency of social and empirical aspects of science is the history of the Pap smear, as described by a research paper by Monica Casper and Adele Clarke[64]. Over the twentieth century the Pap smear moved from general rejection by scientists as expensive and unreliable to almost a mandatory part of women's health and that had more to do with social changes than with science. The changes came from an increase of women's health priorities; use of cheaper female technicians to reduce processing costs; automation of record-keeping enabling large scale testing and analysis; and greater localisation and targeting of benchmarks rather using against strictly universal measures. Until very recently the science has not changed since its early rejections as unreliable.[65]

Concluding Remarks

We have seen two distinct views of science. Each depends on a different understanding of how we create facts and knowledge: are they discovered or constructed?

Empiricism argues that our senses are our best guide to discovering what exists out there, and naturalistic empiricism[66] is our best guide to nature and reality. Science, as traditionally portrayed, is an exemplar of this approach with its rational commitment to: (1) empirically-based evidence; (2) systematic procedures to move from observations to theory - the so-called scientific method; and (3) norms and values that promote critical, open, and disinterested argument. This ensures science will eliminate, even if over time, the deleterious effects of unwanted personal, social, and political influences. This view of science centres on its practitioners.

Social constructionism argues that we live in constructed world of social realities or narratives, our 'making sense' within a background of cultural assumptions and understandings. Therefore science is another enterprise to be seen in its social context, and its social, political, and ethical dimensions cannot be ignored or minimised, when analysing its contributions. As mentioned previously, social researchers will see the accepted, discarded, and discredited as giving the full picture of the scientific project. Typically they acknowledge science offers us greater control over our environments, but not as a benign activity without negative consequences. Overall social analyses reject an idealised view that promotes a single rational process, transcending our social and

[63] Peter L. Berger and Thomas Luckmann, *The Social Construction of Reality: A Treatise in the Sociology of Knowledge*, Doubleday, Garden City, NY, 1996 p. 3

[64] Monica J. Casper and Adele E. Clarke, *Making the pap smear into the 'right tool' for the job: Cervical cancer screening in the USA*, circa 1940-95, Social Studies of Science 28: 255-90, 1998

[65] Recent technical improvements to improve the pap smear do not affect the overall argument that the acceptance of the pap smear are from social changes rather than technical ones. Dorothy L. Rosenthal discusses recent technical improvements in: Dorothy L. Rosenthal, Automation and the Endangered Future of the Pap Test,
JNCI J Natl Cancer Inst (1998) 90(10): 738-749 doi:10.1093/jnci/90.10.738
http://jnci.oxfordjournals.org/content/90/10/738.full

[66] A similar concept here is 'methodological naturalism' as the fundamental assumption of all sciences. Act in scientific research, as if there is nothing outside the physical world - 'supranatural' or supernatural, God, and so. The major challenge by *Intelligent Design* is to this very assumption.

historical contexts. Unlike the first view, all those affected by science – producers and consumers – are seen as full stakeholders in its direction, activities, and outcomes.

I shall conclude this comparison with a radical social perspective proposed by sociologist Steve Fuller[67] to explain science's special status. He argues that it comes not from any unique capacity to generate knowledge, but from:

1. Distinctive social organisation, enabling global concentrated teamwork supported by considerable material resources.
2. Political, corporate, and military 'where-with-all' to apply its research outcomes to all aspects of our society.
3. Capacity to control its own history writing, 'airbrushing' away mistakes and diversions to leave an image of constant progress.

Post scriptum

We seek meaning and control: we cannot help ourselves. Our various intellectual traditions universalise human experiences into different 'meaningful fictions' - call them beliefs, faiths, convictions, claims, constructions, myths, facts, or truths - to make sense of the world and ourselves. The sciences create worlds that can be observed and measured (often extended by rationalised speculations). They ultimately seek human-centred control. Religions place us into all-encompassing worlds created from their respective traditions, where our places are explicated and justified. Philosophers use logic and reasoning to centre us in their rational (and occasionally emotional) realities.

Whenever these worlds provide widespread social meaning with corresponding social behaviour, then they are truly real. Perhaps that is closest we can come to truth and objectivity.

Thank you for this opportunity and look forward to discussing these issues.

[67] Steve Fuller, *The Philosophy of Science And Technology Studies*, Routledge, New York, 2006 p.2