ASPECTS OF OPEN SCIENCE

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ABSTRACT
In the main section of this paper I survey a selection of the writings which have connected openness with science. This survey comprises, for the most part, direct quotations without comment. Readers are encouraged to make connections and interpretations at will. My own conclusions come in a separate section. Some of the conclusions are (i) *contest* - more universally than conflict - between openness and closeness is a recurrent feature (ii) in a social relationship model, openness and closeness occur in a social context and are manifested in the attitudes and the behaviour of actors, and this model permits a clarification of scenarios (iii) there is no simple trend towards or away from openness (iv) the review of project funding proposals should be comprehensive and open (v) openness will be enhanced gradually through an understanding of a chain of concepts, *openness - confidence - trust - empathy - integrity - more openness* (vi) the way in which these qualities are applied in the less fraught domain of science can act as a beacon in other, more testing, aspects of human relations.

INTRODUCTION
Open and *Science* are words that go together. The phrase Open Science has nevertheless been used in a number of ways. In this paper I survey briefly a selection of the writings which have connected openness with science.

Since s*cience* expands seamlessly to s*cholarship* and to *knowledge* I have included some works relevant to open scholarship and to open knowledge. My aim in the article has been to help those interested to get a sense of the current state of thinking and practice in respect of the openness of science.

In this paper *open* usually means visible and accessible, but other meanings sometimes occur in connection with science and I indicate some of these briefly in an appendix.

The first part of this paper, the Survey, comprises about 70 brief extracts from texts relating to open science, or summaries of them, usually without comment. I invite the reader to make what he or she will of these short pieces of evidence, which are

backed up with references. Each extract appears in one of 18 sections although many are relevant to several of them. There is much overlap and interaction between the sections. Readers may make connections between them at will. Separately, in the Conclusions section, I present some of my own views on what openness in science currently means in our culture and on what developments are possible and desirable.

Openness is a quality generally considered desirable and important. We like it and respond to it when we see it in others. Yet its practice requires confidence and courage. This applies to the conduct of science as to the conduct of public affairs in general and to the conduct of personal relationships.These remarks notwithstanding, I endorse the warning of Sissela Bok (1982) against an assumption that unlimited openness must be an unqualified good and all secrecy is to be deprecated. "A degree of concealment or openness accompanies all that human beings do or say. We must determine what is and is not discreditable by examining particular practices of secrecy, rather than by assuming an initial evaluative stance" (page 9). This warning is especially pertinent is discussions of the conduct of science. As Bok says (page153) "Denunciation of secrecy is ritualistic in science."

Since the conduct of science is not something apart from human culture, I have included brief reference to a few events, writings and teachings that I consider especially instructive in connection with openness and the human condition, and in which we may find things relevant to our considerations of open science.

I organise the material under the following headings ...
SURVEY

SURVEY
A: A Brief Note on the Historical Context

A*a Strong and partly effective calls for greater openness have occurred in recent decades in numerous social institutions, such as government and the law. Science differs from other social institutions in that there has been an ideology of openness since the 17th century. Yet this openness has always been subject to restrictions. William Eamon's (1994) *Science and the Secrets of Nature* gives insight into those restrictions. Eamon has also written (1985), in the Conclusion section of his article *From the Secrets of Nature to Public Knowledge: The Origins of the Concept of Openness in Science,* "The debate over secrecy versus openness continues. While denunciations of secrecy in science are almost ritualistic nowadays, the pressures to withhold information are greater than ever before, both from outside the scientific community, as increasing numbers of scientists are drawn into military and industrial research, and from within, as intense competition among scientists increases the pressure to make claims to priority of discovery."

A*b The nature of science has changed continually since the 17th century. The open/closed dichotomy is a changing property of a changing institution. Today, the term *science* is used very broadly, and it can refer to a body of knowledge, or a useful means of developing practical techniques, or the human institution in which the knowledge and techniques are generated, or to all of these at once.

In his essay *The Notion of an Open Scientific Community in Historical Perspective*, Sheldon Rothblatt (1985) examines "two different sets of pressures that affect the way in which science as an organized and institutionalized form of intellectual activity is carried out. The first … consists of outside demands for a wide range of scientific services. Originating in government, in the military, in industry or more vaguely from the public, such demands are often considered inimical to either the best interests of scientists or to the nature of the scientific enterprise itself as it has evolved over the centuries ... The second set … are the pressures that derive from the internal constitution of science, from its cultural or value system and from the institutions that scientists themselves have built or have cooperated in building in order to maximise the conditions under which their work is performed."

B: Open, Secret and in Between

B*a Too Many Spectators. "From the moment he embarked on the proof [of the Taniyama-Shimura conjecture, which would imply proof of Fermat's Last Theorem], Wiles made the remarkable decision to work in complete isolation and secrecy. Modern mathematics has developed a culture of cooperation and collaboration, and so Wiles's decision appeared to hark back to a previous era … Wiles explained that part of the reason for his decision to work in secrecy was his desire to work without being distracted: 'I realised that anything to do with Fermat's Last Theorem generates too much interest. You can't really focus yourself for years unless you have undivided concentration, which too many spectators would have destroyed.' … Another motivation for Wiles's secrecy must have been his craving for glory ..." Simon Singh (1997)

B*b Data Selection and Responsible Conduct: Was Millikan a Fraud? "This paper addresses a problem in reporting scientific research. The problem is how to distinguish between justifiable and unjustifiable data selection. Robert Millikan is notorious for an infamous remark that he used all his data when in fact he had used a selection ... This paper discusses two main issues that arise in assessing his conduct, whether he was intentionally misleading and whether he actually did mislead the scientific community ..." Richard Jennings (2004). The connection of this 'case' with openness is Millikan's "remarkable honesty in evaluating the data that the paper contained" (Jennings, page 640)

B*c Secrecy Based on Fear of Causing Public Alarm. "The [UK] Government was preoccupied with preventing an alarmist over-reaction to BSE [bovine spongiform encephalopathy] because it believed that the risk was remote. It is now clear that this campaign of reassurance was a mistake. When on 20 March 1996 the Government announced that BSE had probably been transmitted to humans, the public felt that they had been betrayed. Confidence in government pronouncements about risk was a further casualty of BSE." (from page xviii of *The BSE Inquiry*, Phillips, Bridgeman and Ferguson-Smith 2000)

B*d Nuclear weapons and secrecy. The extreme levels of fear and secrecy connected with nuclear weapons spread to many related areas of society, including science. In *Nuclear Weapons: Who's In Charge?* Hugh Miall (1987) says, at the end of the chapter on secrecy, "Nuclear weapons have bred secrecy and secrecy has sustained nuclear weapons. By allowing the growth of secret government in this area, the public has lost its right to know whether, how and under what conditions its government will go to war."

B*e Born Secret. "The term 'born secret' applies in a strict sense only to information classifiable under the [US] Atomic Energy Act. Research in this category is to be kept secret from the very outset, unlike other research, which is presumed open unless it undergoes classification. The NSA [US National Security Agency] has tried to extend the 'born secret' concept to the cryptography area by voluntary agreement rather than by legislative process." page 166 of Bok (1982)

B*f Four Levels of Openness in Science. (Cottey http://www.uea.ac.uk/~c013/open_science/open_science.html) This is a classification I have proposed as showing the spectrum from completely secret to radically open. The first three levels are already established. Steps towards the fourth kind have been taken in the last few years, notably Open Notebook Science (R*j).

> ~ *Secret Science:* even the existence of the project is concealed
> ~ *Restricted Science:* publication of the results is subject to strict limitations in respect of timing and level of detail. Most commercial and applied government (including military) science is in this category
> ~ *Circumspect Science:* the scientists publish when the project is complete, but till then are quite 'close'. Academic science, as practised to date, and when not Restricted, is in this category
> ~ *Open Science:* Here this term means a radical kind of openness, an Open Science Project being open from beginning to end. It is discussed in the section Radical Openness near the end of this paper.

C: Knowledge Claims

C*a Public Knowledge. John Ziman (1968) argues, on page 144, "Objectivity and logical rationality, the supreme characteristics of the Scientific Attitude, are meaningless for the isolated individual; they imply a strong social context, and the sharing of experience and opinion" and, a little further on, "I am arguing that all genuine scientific procedures of thought and argument are essentially the same as those of everyday life, and that their apparent formality and supposed rigour is a result of specialization. The demands of public communication, the pressures of overt criticism and comparison, have sharpened and strengthened these procedures so that we come to believe in them as authorities in their own right."

C*b Open Science and Ring-fenced Science. In Cottey (1998) I write "'Ring-fenced science' is defined to be science with an element of secrecy, in the sense that an agency does scientific research and/or development inside the fence and full

details are kept from a wider public … An essential principle for the open versus ring-fenced science dichotomy concerns the status, and indeed the nature, of scientific knowledge: *'scientific knowledge within the fence' cannot be exported simply by asserting results.* Such assertions must be regarded as 'general claims' and not as 'scientific truth claims'."

C*c "No names, no proof, no consensus - MPs jump the gun in calling for action on mystery report that claims social services 'snatch' children from parents". In this investigative article Jonathan Gornall (http://politics.guardian.co.uk/publicservices/story/0,,1781767,00.html) finds that "no one - including the MPs demanding action - knows who was responsible for the 104-page document."

D: Commerce; Patenting

D*a Science as a Commodity: Threats to the Open Community of Scholars. In his Introduction to this collection of essays (Gibbons and Wittrock 1985), Michael Gibbons writes (p x) "the title of the workshop … touches a deeply held belief of a large number of people carrying out different tasks in a wide variety of institutions broadly concerned with the development of science and technology. That belief is exposed in the tension between the way science (or knowledge) is *used* in our societies and the way in which it is supposed to be *generated*."

D*b Science Commons. http://sciencecommons.org/about/details/ **"**Science Commons was launched with the goal of bringing the openness and sharing that have made Creative Commons licenses a success in the arts and cultural fields to the world of science."

D*c The Advance of Technology and the Scientific Commons. In this paper Richard Nelson (2003) writes "Most of that [science] base [of technology] is part of a commons open to all who have expertise in a field. The proprietary aspects of technology traditionally have comprised a small topping on the commons. But recently parts of the commons have become privatized. While the justification for the policies and actions that have spurred privatization of the commons is that this will spur technological progress, the argument here is that the result can be just the opposite."

D*d The Economic Logic of 'Open Science' and the Balance between Private Property Rights and the Public Domain in Scientific Data and Information. Paul David (http://ideas.repec.org/p/wpa/wuwpdc/0502006.html) writes " 'Open

science' institutions provide an alternative to the intellectual property approach to dealing with difficult problems in the allocation of resources for the production and distribution of information. As a mode of generating reliable knowledge, 'open science' depends upon a specific nonmarket reward system to solve a number of resource allocation problems that have their origins in the particular characteristics of information as an economic good. There are features of the collegiate reputational reward system - conventionally associated with open science practice in the academy and public research institutes - that create conflicts between the ostensible norms of 'cooperation' and the incentives for non-cooperative, rivalrous behavior on the part of individuals and research units who race to establish 'priority.' These sources of inefficiency notwithstanding, open science is properly regarded as uniquely well suited to the goal of maximising the rate of growth of the stock of reliable knowledge."

E: Publication and Media

E*a The Naked Scientists "are a media-savvy group of physicians and researchers from Cambridge University who use radio, live lectures, and the Internet to strip science down to its bare essentials, and promote it to the general public." http://www.nakedscientists.com/HTML/Background/background.htm

From this quotation it can be seen that the term naked is used as a marketing device. There is however a connection between nakedness and the openness that is the focus of this article. Scientist broadcasters who 'take science questions on any subject live from the listening public' are practising science with a high degree of openness. This requires a rare combination of qualities - courage, willingness to make mistakes in public, and perhaps some brazenness. Open science of this kind, like open science of the various other kinds, is valuable but can be scary to practise.

E*b The Public Library of Science (PLoS) "is a nonprofit organization of scientists and physicians committed to making the world's scientific and medical literature a public resource." www.plos.org/about/index.html

E*c Will *e-Science* Be *Open Science*? by Paul David, Matthijs den Besten and Ralph Schroeder "examines various aspects of 'openness' in research, and seeks to gauge the degree to which contemporary 'e-science' practices are congruent with 'open science.'" Available from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1317390

F: Science Policy

F*a Panel Faults US Science Policy. Ted Agres (http://www.the-scientist.com/news/display/23575) reports in *The Scientist* "The US government risks jeopardizing the 'quality and credibility' of federally sponsored scientific research by failing to encourage the open exchange of scientific information, according to the National Science Board (NSB), which recommends the administration establish a consistent policy for exchange of government research."

F*b Open Science: Tools, Approaches and Implications by Cameron Neylon and Shirley Wu "Open Science is gathering pace both as a grass roots effort amongst scientists to enable them to share the outputs of their research more effectively, and as a policy initiative for research funders to gain a greater return on their investment." http://psb.stanford.edu/psb-online/proceedings/psb09/wkshp-opensci.doc

G: Democracy

G*a Merton on Openness and Democracy. In an influential article first published in 1942, Robert K Merton (1968) declared "Four sets of institutional imperatives - universalism, communism, disinterestedness, organized scepticism - comprise the ethos of modern science." Summarized briefly, these norms mean - scientific knowledge transcends variations in human cultures, scientific knowledge is not private property, the search for scientific truth abjures all special pleadings, and truth claims are subjected to rigorous testing. Merton connected this ethos of science with democracy although he did not succeed in explaining this connection clearly, and expressed himself tentatively thus (page 606) "... some basis for the provisional assumption that 'science is afforded opportunity for development in a democratic order which is integrated with the ethos of science'." Nor did Merton focus explicitly on openness. I suggest that openness is in fact an important link in that both science and social democracy thrive under conditions of openness and, conversely, they wilt under conditions of secrecy.

G*b Open Science and Closed Science: Tradeoffs in a Democracy. Daryl Chubin (1985) compares Merton's attitude to democracy ("the obvious environment in which science flourished" Chubin's article, page 73) with conditions in 1985. "… how does the democracy that Merton postulated as supportive (and therefore analytically unproblematic) function as an arbiter of scientific openness and secrecy? One answer can be found in the institutions within which science occurs. Corporate science has blossomed and it now interacts with many university research programs; likewise,

government patronage, especially in biomedicine, has been tied more closely to several mechanisms of accountability ... liberal-democratic society has complicated the production, communication, and utilization of science."

H: Transparency

H*a See-through Science. This is the title of a Demos pamphlet by James Wilsdon and Rebecca Willis (2004). The subtitle is 'why public engagement needs to move upstream' and is the key concept of the paper. The authors start with a critique of the 'deficit model' which assumed that the lack of public engagement in science derived from a lack of understanding of science which could and should be corrected by a programme to educate the public in science. In the UK this thinking led to the COPUS (Committee on the Public Understanding of Science) programme. Advocating upstream engagement, and observing that one element of scientific activity is *performance*, Wilsdon and Willis say "the task of upstream engagement is to remove some of the structures that divide the back-stage from the front-stage. It seeks to make visible the invisible, to expose to public scrutiny the values, visions and assumptions that usually lie hidden."

H*b Behind Closed Doors: Military influence, commercial pressures and the compromised university. (www.sgr.org.uk/ArmsControl/MilitaryInfluence.html) Chris Langley, Stuart Parkinson and Philip Webber (2008) estimate "that the average level of military funding of UK universities is up to five times higher than government figures suggest. The report also reveals the pervasive extent of the military influence in UK universities".

I: Inclusivity. Peer Groups and Wider Constituencies

I*a Rupert Sheldrake's One Per Cent Proposal. A traditional argument from scientists resisting 'outsider interference' is that only experts are competent to judge the value of proposals and the validity of completed work. In discussions, however, which start from this point of view, there is usually little recognition that large areas which could be studied fruitfully are neglected for long periods of time. Funding goes in directions determined by experts who have decades of intensive personal effort invested in their own positions of authority and status. For this reason, there is a case for broadening the spectrum of persons who have an input into the selection of the direction of scientific research.

Sheldrake (2005) has proposed, in an article entitled *Democratising Science*, "spend one per cent of the science budget on research of real interest to laypeople, who pay

for all publicly financed research through taxes ... To avoid the one per cent fund being taken over by the science establishment, it would need to be administered by a board largely composed of non-scientists ... Funding would be restricted to areas not already covered by the other ninety-nine per cent of the science budget."

This proposal shifts power away from scientists more radically than most, albeit on a modest scale, and it is perhaps appropriate to note that some of Sheldrake's work is unconventional, for example investigations relating to telepathy (Sheldrake Online http://www.sheldrake.org)

I*b National Center for Complementary and Alternative Medicine. (www.nih.gov/about/almanac/organization/NCCAM.htm) The interest of NCCAM in relation to inclusivity is that in 1991 the US Congress passed legislation "that provides $2 million in funding for fiscal year 1992 to establish an office within the National Institutes of Health (NIH) to investigate and evaluate promising unconventional medical practices". In 1999 NCCAM itself was created and made the 25th independent component of the NIH.

I*c The BA (British Association for the Advancement of Science) (http://www.the-ba.net/the-ba/) "is a charity which exists to advance the public understanding, accessibility and accountability of the sciences and engineering." The BA has, since its formation in 1831, worked for inclusive science. This ethos continues to the present, as shown by the thumbnail definition quoted above, by its strapline *connecting science with people*, and by the phrase *promoting openness about science in society* on the 'about the BA' web page.

I*d "Unthinking Subservience to the Principle of Participation". Dick Taverne (2004) has expressed concern that some kinds of openness in science may be inappropriate. In a letter with the title 'Let's be sensible about public participation' he writes "Of course more openness and transparency are to be encouraged where possible. But let us not display unthinking subservience to the principle of participation. In Britain, involvement by victims of rail accidents in deciding policy on railway safety has led to the investment of billions of pounds to save some five lives a year. Meanwhile, twice that number die on British roads every day. The fact is that science, like art, is not a democratic activity. You do not decide by referendum whether the Earth goes round the Sun."

I*e Global Environmental Change Open Science Conferences (http://ncclcs.cma.gov.cn/Website/index.php?ChannelID=27&NewsID=1888) "On 9-12 November 2006, the Earth System Science Partnership (ESSP) Global Environmental Change Open Science Conference was held in Beijing… All the

scientists with various nationalities and specialties in natural sciences, social sciences and engineering sciences exchanged and discussed on latest progress on earth environmental change caused by nature and human activities." Here 'open' evidently means open to a wide range of science specialists and means the same as the more descriptive and widely used term 'interdisciplinary'.

I*f The Open-Source Science Project
(www.theopensourcescienceproject.com)"is the first, and only, organization wholly dedicated to rendering transparent the *black-box* of contemporary scientific research and democratizing its participation by providing all individuals - irrespective of geographic, cultural, socio-economic, academic, or personal background; access to high-quality, comprehensive, scientific information; and the opportunity to participate directly in the scientific research process."

J: Accountability

J*a The Missenden Code of Practice for Ethics and Accountability. The Commercialisation of Research in Universities - an Ethical Intervention. This 39 page document by Rory Daly (2002) discusses the issues for UK universities before presenting the Code.

J*b Defence Money Supports Farm Research. (New Scientist 1988) In 1988 researchers studying airborne pathogens in farm animals at the Veterinary School of Bristol University, having failed to obtain funding from the normal sources, accepted a substantial grant from the Ministry of Defence. Some colleagues interpreted this is a shift of focus from agriculture to biological warfare. A bitter controversy followed but the university continued with its acceptance of the grant. I suggest, in the Conclusion section, that this controversy highlights the importance of adequate ethical oversight *before* funding has been obtained.

K: IT; Open Source; Science Blogs

K*a Open Source Initiative. www.opensource.org "OSI is a non-profit corporation dedicated to managing and promoting the Open Source Definition for the good of the community, specifically through the OSI Certified Open Source Software certification mark and program."

K*b The Open Source/Open Science Conference. This conference, the first of its kind, was hosted by Brookhaven National Laboratory in 1999 and was motivated by

the observation that the free exchange of ideas is central both to the Open Source movement and to science in general. Stephen Adler (www.linuxjournal.com/article/3739) reports that the goals of the conference were to highlight the use of open-source software in science, to encourage the private domain to contribute their software technology to the open-source code base, and to provide an opportunity for the public to relate to the science done at BNL and other national laboratories and universities nationwide.

K*c Open Science Grid.
(http://www.opensciencegrid.org/About/Learn_About_Us/Our_Mission) "The Open Science Grid aims to promote discovery and collaboration in data-intensive research by providing a computing facility and services that integrate distributed, reliable and shared resources to support computation at all scales."
K*d Towards a Global Digital Commons: the iCommons Summit.
(http://www.soros.org/initiatives/information/focus/access/events/icommons_20060623) "The past few years have seen the burgeoning of a number of initiatives aimed at opening the fields of creativity, science, and knowledge in communities around the world. Practitioners from these movements currently identify themselves as falling within a particular community - 'free and open source software', 'open access', 'open content', and 'open science', among others - but they share key processes and values whose common elements are yet to be fully realized. Supported by OSI [the Open Society Institute], this year's iCommons Summit aims to bring together in a creative, stimulating, and cooperative environment the pioneers from these communities, to inspire and learn from one another and establish closer working relationships around a set of incubator projects."

K*e OpenScience Project. (www.openscience.org/blog/?page_id=44) "The OpenScience Project is dedicated to writing and releasing free and Open Source scientific software. We are a group of scientists, mathematicians and engineers who want to encourage a collaborative environment in which science can be pursued by anyone who is inspired to discover something new about the natural world.

Much of the work of science depends on having appropriate tools available to analyze experimental data and to interact with theoretical models. Powerful computers are now cheap enough so that significant processing power is within reach of many people. The missing piece of the puzzle is software that lets the scientist choose between models and make sense of his or her observations. That is where the OpenScience project can help." Notable among the OSP's linked programs is "advocacy for a distributed model of doing scientific research".

In a lecture 'The OpenScience Project: Catalyzing Open Source Development in Science' the Project's creator J Daniel Gezelter (www.openscience.org/talks/bnl/img0.htm) discusses falsifiability and verifiability in science and concludes that it is "imperative for skeptical scientific inquiry that software for simulating complex systems be available in source-code form."

K*f Open Data + Open Source = Open Science. In a paper entitled *Open Science - combining open data and open source software: Medical Image Analysis with the Insight Toolkit*, Terry Yoo and Dimitris Metaxis (2005) describe the genesis and development of ITK (the Insight Toolkit), a suite of open source software for Medical Image Analysis. The research programme developing ITK is large, due to the sophisticated and demanding nature of state-of-the-art MIA. It had been observed that individual groups of software developers lacked the resources to create an MIA software suite sufficiently well tested and widely known to become useful worldwide. The ITK programme was therefore deliberately designed as a large scale cooperation involving numerous funders and research centres. The world wide community of MIA software developers already have an affinity with Open Source and it was judged that open source software was especially advantageous in this case, allowing the incremental improvement of complex suites of computer programs to the stage of being highly reliable and user-friendly applications. It is expected that there will be, in due course, collections of data which are also open, and open to all as a resource for training in the use of ITK, in its development, and in the practice of MIA. It then becomes possible, in the MIA field, to practise scientific research in an open manner by studying the performance of standard and modified open source software on open data sets. This research would be open in that competent workers anywhere could repeat it and subject it to criticism and further analysis and could use it as a springboard for further developments.

K*g Top Five Science Blogs. Declan Butler (2006) “asked five leading science bloggers about the reasons for their success.”

K*h Doing Science in the Open. Michael Nielsen (2009) writes that, in contrast with others’ creative use of the internet “scientists show a surprising reluctance to share knowledge that could be useful to others. This is ironic, for the value of cultural openness was understood centuries ago”. The reason is that the established system of “subsidising scientists who published their discoveries in journals now *inhibits* the adoption of more effective technologies.”

L: Education

L*a An Approach for Harmonizing Engineering and Science Education with Humaneness. In this article Krishnasamy Selvan (2004) says "The world is facing an apparently increasing dose of violence ... Since lack of openness of thought appears to be a fundamental contributor to this unfortunate problem, attempting to cultivate this quality at all levels can perhaps go a long way towards making our earth a better place to live in." And, a little further on, "education (at all levels) is a natural medium through which this cultivation can be attempted." Selvan's ideas expressed in this paper are close to the connections implied in the later sections of the present paper, openness - confidence - trust - empathy.

L*b PsychExperiments (http://psychexps.olemiss.edu/AboutPE/about.htm) "consists of a set of interactive [psychology] experiments, a cumulative data archive, download utilities for both data and experiment source code, downloadable Excel macros for analyzing data from the experiments, and support materials for those who want to use and/or develop experiments at the site."

L*c Bradford Robotic Telescope. (www.telescope.org/index.php) "The telescope is focused on space and astronomy access for all ... It can service many thousands of users. It is an autonomous robotic system integrated into an e-learning web site. The objective of the learning programmes is to use your images of the heavens to support understanding of the basic ideas that underpin our modern views of the Earth and its place in the Cosmos ... The telescope is completely free. Register yourself and log in ..."

L*d OpenCourseWare. The Massachusetts Institute of Technology's OCW initiative is described by its director, Anne Margulies (2004), thus ... "Utilizing the Internet, MIT OpenCourseWare (MIT OCW) has opened MIT's curriculum and educational materials to a global audience of teachers and learners ... The committee ... convinced that open software and open systems were the wave of the future, came to a very simple conclusion: that MIT should use the Internet to give its teaching materials away."

M: Beyond Science - Open Scholarship and Open Knowledge

M*a Open Scholarship. Although the present article is about science, its concern with reliable knowledge renders the boundary between science and other forms of scholarship especially fuzzy. And the contest between openness and secrecy exists in all areas of scholarship. Technical patents may not be relevant but copyright is.

Social taboos, economic information, interpretations of history, personal privacy - any of these, if relevant, influence the balance between openness and secrecy chosen by an author.

M*b Open Scholarship and Research Universities. In this essay on open access to published scholarship, Malcolm Getz (2005) writes "A move to digital publication could induce a change in how publishing is organized and financed. One notion is to move from subscription fees to open scholarship wherein access to all readers on the Internet is without charge. The cost of publication would be borne directly by universities and through author fees."

M*c Access to Knowledge
(http://www.soros.org/initiatives/information/focus/access) is a programme within the Soros Foundations Network. It "supports four initiatives which enable access to knowledge in poorer countries: a project on the reform of intellectual property; the eIFL [Electronic Information for Libraries] library consortium; the Open Access Initiative, and an East-East translation program".

M*d Aptivate (**http://www.aptivate.org/AboutUs.html**) "an NGO and not-for-profit organisation that provides IT services for international development."

M*e Open Knowledge: a proposed adaptation of Open Science, focusing on guidelines for knowledge claims.
http://www.uea.ac.uk/~c013/open_science/open_knowledge.html I outline a schema that defines a standard of openness of knowledge. The central element of the schema is a set of guidelines for those who would participate in the generation of OK. Knowledge claims conforming to the guidelines would be published on the web. Such publications must provide ready access to supporting evidence and arguments for its claims. Criticism and testing of the claims should be made as easy as possible. The OK proposal is an adaptation, to the broader field of knowledge-in-general, of the Open Science proposal.

M*f Neoliberalism, higher education and the knowledge economy… Mark Olssen and Michael A. Peters (2005) write "The ascendancy of neoliberalism and the associated discourses of 'new public management', during the 1980s and 1990s has produced a fundamental shift in the way universities and other institutions of higher education have defined and justified their institutional existence. The traditional professional culture of open intellectual enquiry and debate has been replaced with an institutional stress on performativity…"

N: Openness and Confidence

Here, I use the term confidence in a way that applies to groups and institutions, as well as individuals. It relates to assurance, poise and centredness. It excludes meanings relating to 'in confidence' (confidential).

N*a A Rather Unconventional Way to Protect his Work. "Early in January 1987 the [high-temperature superconductivity] sensation was there ... [Paul] Chu found himself confronted with the problem inherent in the conventional publishing system: possible information leaks and delays. Thus he chose a rather unconventional way to protect his work and ensure his priority. First he submitted a paper containing two systematic mistakes making it useless to any reader. The second precaution he took, for fear that another team could in the meantime independently find 'his' new compound, was to give a press conference on 15 February announcing - without giving any detail - the discovery of a new material superconducting at about 98K. Only on 18 February, at the latest possible date, did he send his corrections to the journal". Ulrike Felt and Helga Nowotny (1992)

N*b The Medvedev Papers. This translation of manuscripts by the biologist Zhores Medvedev (1971) gives a vivid insight into the conflicts between the dominant world ideals of science and the culture of control of the government of the Soviet Union during the middle part of the twentieth century. In my view, no better proof is needed of the cruelty, pettiness and absurdity to which control and secrecy can lead. How did the SU get into such a negative condition, founded as it was on more-or-less diametrically opposite principles? I suggest that *confidence* is a key concept here. Lack of confidence (in its ability to cope with dissent) started the SU on the path to a closed secretive culture and after that the feedback loop

Insecurity → Secrecy → Unaccountability → Misuse of Power → Mistrust → Insecurity

had its baleful effect.

N*c Glasnost, or openness, was given high priority and profile by Mikhail Gorbachev in the Soviet Union, starting in the mid 1980s. Glasnost, as a word absorbed into the English language, refers to the political and cultural reforms in the Soviet Union from that time to, principally, the early 1990s. Glasnost does not relate specifically to science but is relevant for this article because science is intertwined with political and cultural affairs. The level of openness achieved by the end of the Gorbachev era, and partially maintained thereafter, is not impressive by the standards of many other states worldwide, and especially not by the standards of science (the ideals and the practice). It is, however, very impressive compared with the horrific

repression, injustice, secrecy and lies of much of political life in Russia and the USSR in earlier times, especially from the 1930s to the 1980s.

My purpose in mentioning glasnost in this article is to draw attention to the human condition - to the interplay of forces which produce confidence, openness and justice, and suspicion, fear and secrecy in cultures. An account of Gorbachev's glasnost may be found in chapter 3 of White (1993). Understanding this interplay is important for our culture generally, and this includes science. I have included a few remarks or references on this in the later section on Openness and Empathy.

N*d Niels Bohr, Openness and Confidence. Bohr was an ardent and successful champion of an open, collaborative, personal and international way of conducting scientific research. He built up the Institute for Theoretical Physics in Copenhagen to be a Mecca for theoretical physicists. He played a key role in the early researches in nuclear fission and he was the first person to recognise clearly the dangers of nuclear proliferation.

In this context, he proposed international "openness as a primary condition for the progress and protection of civilization." His message was not widely heard or accepted, neither in 1944 when he gained interviews with US President Roosevelt and British Prime Minister Churchill, nor for the rest of life. The above quoted phrase appears in his (Bohr 1950) *Open Letter to the United Nations*. In Cottey (2006) I argue that a major reason for Bohr's failure to be heard was an error concerning the relation between openness and another condition to which Bohr (correctly) attached great importance, namely confidence. From the Open Letter, one can see that Bohr assumes that openness would lead to mutual confidence between nation-states in the new nuclear age. With sixty years of hindsight we can see that the nations' failure to move towards nuclear openness derived exactly from a lack of mutual confidence. In practice, if openness and confidence are to move forward, they must do so together. This idea applies in all areas of human relations, including the conduct of science.

O: Openness Earns Trust

O*a Responsible Conduct of Research. Adil Shamoo and David Resnick (2003) write, on page 36, "openness is a key principle in research ethics. Scientists should share data and results (1) to promote the advancement of knowledge by making information publicly known; (2) to allow criticism and feedback as well as replication; (3) to build and maintain a culture of trust, cooperation and collaboration

among researchers; (4) to build support from the public by demonstrating openness and trustworthiness."

O*b Public Openness at the FDA. Reporting on the controversy about the ability of the US Food and Drug Administration to assess adequately the safety of new drugs, Meredith Wadman (2005) writes "The past year has seen a beleaguered Food and Drug Administration publicly denounced as unable to protect the US public ... Acting FDA commissioner Lester Crawford ... has also announced that a new board for overseeing drug safety - an advisory board of mainly FDA employees - will publicize worrisome side effects more quickly than has happened in the past. Critics immediately assailed the board as toothless, because it will lack the power to require label changes or to pull drugs from the market. But Crawford says that it will herald a new era of public openness at the agency."

P: Limits and Cautions Concerning Openness

P*a "the conflicts between insider and outsider about control over secrecy and openness arise in every form of human encounter. And within each perspective, the same tensions are felt: for outsiders between seeking to probe secrets and refraining therefrom, and between accepting and avoiding what is revealed; and for insiders, between keeping secrets and divulging them, and between seeking to overcome the restraint of outsiders with respect to what is no way a secret, and acquiescing." (page 40 of Bok 1982)

P*b Pentagon Sets Its Sights on Social Networking Websites. Paul Marks (www.newscientist.com/article.ns?id=mg19025556.200&print=true) opens his report with a quotation from a chief security officer who is "continually shocked and appalled at the details people voluntarily post online about themselves."

Q: Openness and Empathy

Q*a The Relevance of Empathy. A subtle concept, the term empathy has, since the late nineteenth century been used in several ways. Here, I follow the definition - *a respectful understanding of what others are experiencing* - and ideas of Marshall Rosenberg (2005). These ideas and their application are not specific to science but they apply generally to communication between humans. They provide, in my opinion, an aid to dissolving any lack of confidence which may be an obstacle to our practising openness. I develop this theme further in the Conclusion section.

Q*b Marshall Rosenberg on Communication. Rosenberg (2005) has spent most of his life developing and teaching *A Language of Life*. It is a method of human-to-human communication that is straightforward, frank, honest and not judgemental about persons. Exactly the kind of communication that is appropriate in science!

Of course it is sometimes far from easy to communicate in this manner and the teachings are much concerned with how people engage in alienating discourse, for example with moralistic judgements, denial of responsibility, and demands. Rosenberg has developed a technique - he calls it Nonviolent Communication - for achieving life-enhancing communication. Persons are taught to observe exactly, to express exactly what they observe, feel and need, and to make specific, practical requests. The other(s) do likewise and communication continues.

In my opinion NVC and science communication share some ideals, with NVC paying, in addition, serious attention to the emotional side of human communication (feelings).

Q*c The Ills of Excessive Standards. In a section with this heading (page 493) of his book *Science and Society*, Joseph Agassi (1981) writes "The current view of standards is moralistic and pedantic ... this situation creates a neurotic vicious cycle of an unresolved tension between standards of conduct and actual conduct ... I suggest to view all standards that are unattainable and tension-creating as undesirable. I recommend that we make our standards as realistic as possible, ie just comfortably above current usage. This would enable people to relax, be undefensive, learn to raise the level of their conduct to the standard, and permit the raising of the standard again by just a little so as to cause further improvement with no excessive tension."

R: Radical Openness

R*a "... secrecy affects *all* reasoning and creativity, quite apart from its susceptibility to every form of abuse and pathological excess. But the damage is perhaps especially noticeable in science because of its reliance on reasoning and creativity". (page 155 of Bok 1982)

R*b Ambivalence in the Royal Society. Eamon (1985) writes, on page 342, "... at their very first meeting, the Fellows of the Royal Society resolved to take detailed notes on all of their deliberations, and to preserve the notes in a permanent record book." On the other hand, page 346, "violent polemics against the Royal Society ... caused some Fellows to press for a more restrictive policy in matters of the privileges

of members and the dissemination of information."

R*c Open Science Project is a term used by the present author (Cottey http://www.uea.ac.uk/~c013/open_science/open_science.html) for a science project done in a specific, radically open manner that can be encapsulated in the phrase 'open from beginning to end' conforming to an Open Science Protocol.

R*d Open Science Protocol.
(Cottey http://www.uea.ac.uk/~c013/open_science/open_science.html) The core of the Open Science Protocol is that the following stages of an Open Science project are all open, as they occur ...

- passage through institutions' ethics and safety committees
- application for funding
- review by funding body
- funding body's terms for support
- institution's terms
- log of the course of the project
- reports
- manuscripts submitted for formal publication
- referees' comments, revisions, published papers
- archiving of concise but detailed records of all the above stages.

R*e No Need to Fear Openness: From today's perspective, some aspects of what I propose in the above section (R*d *Open Science Protocol*) may seem alarming. For example, the editorial preface to some scientific papers would reveal that a certain, named referee had raised objections that did not carry the day. Some scientists may feel uneasy about this prospect. Again, some interested parties may think that open discussion of research in progress on matters of great public concern, for example the possible BSE/CJD [Creutzfeldt-Jakob disease] link, does more harm than good.

I argue that such fears are, for the most part, unnecessary. Disclosure in a secretive society has a disproportionate impact, sometimes even producing a scandal. There is a feedback loop

Secrecy → Fear Of Sensation (on disclosure) → Fear Of Openness → Secrecy

By contrast, in an open society, objections of a named referee, or disagreements on research in progress, would usually be no great deal - merely single items in a large amount of available information.

R*f* Openness and Trusting Research Colleagues. An objection frequently raised to the proposition that scientific research projects could be done in a radically

open manner is that no investigators would be willing to risk being overtaken by competitors in the race to discovery. It is true that scientists - and indeed others whose work involves creativity and originality - are concerned about this. I suggest (Cottey http://www.uea.ac.uk/~c013/open_science/open_science.html) that the objection often stems from fear - lack of confidence - and is usually misplaced. For nearly all researchers, the problem is not having brilliant ideas stolen but being heard!

R*g What Kinds of Project Could Be OS Projects? The 'open from beginning to end' protocol outlined in the section 'Open Science Protocol' is very different from the normal way of doing science. As far as I know, nothing close to the full Protocol has yet been done. The Protocol outlined allows for the 'full works' of a funded and ethically approved project; the institutional aspects could in some cases be heavier than the substantive ones (just doing the science).

It is much easier, especially at first, to do small OS Projects of a more 'independent' character. Such projects are simple, require little or no earmarked funding and no ethical approval. Subjects in which such projects can readily be found include mathematics, software development, environmental impact and lifestyle studies, and some simple technology projects. In Open Notebook Science (R*j) numerous such small contributions (short experiments, ruminations about theory) have been performed over the last few years.

I suggest however that OS Projects are possible in all areas of science. Even in big science, tiny elements of a complex project can be suitable.

Priority, which is such a heavy concern for ambitious scientists doing ambitious projects, will be less important in an OS Project. The greatest concern for potential OS Project investigators will be, I believe, the prospect of exposing their mistakes and other imperfections in real time.

Our culture has however, changed rapidly in recent years, embracing with panache new kinds of openness and confidence made possible by the internet and, especially, the world-wide web. It may help to think of an OS Project as merely a more formal kind of science blog. There has also been, I suggest, a longer term change, as ideas from humanistic psychology have become internalised in large parts of world culture. This thought motivates the sections of this article around the theme openness - confidence - trust - empathy.

R*h What Would Be the Significance of a Set of OS Projects? Principally, I suggest, to cast light on openness *and its limitations* in science. Of the Four Levels of

Openness in Science (B*f), namely secret, restricted, circumspect and (radically) open, the last is only at its beginning. In due course, debates about the conduct of science can become more judicious, along the lines of the quotation from Bok, in P*a, "the conflicts between insider and outsider about control over secrecy and openness arise in every form of human encounter".

R*i Does the OS Investigator Have to Reveal All? No. Only that which is part of the Project and so part of the support for the knowledge claim. It is necessary to define clearly what is in the Project, in particular, where it starts.

R*j Open Notebook Science "is the practice of making the entire primary record of a research project publicly available online as it is recorded. This involves placing the personal, or laboratory, notebook of the researcher online along with all raw and processed data, and any associated material, as this material is generated. The approach may be summed up by the slogan 'no insider information'." http://en.wikipedia.org/wiki/Open_Notebook_Science accessed 25 July 2009

CONCLUSIONS

As noted in the Introduction, I intend that this paper, with its Survey section containing many direct quotations, will encourage readers to reflect and draw their own conclusions about the current state of science in respect of openness. My own conclusions are …

Contest: Considering the quotations, their sources, and the cultural context of those sources, I note in the first place the recurrent theme of *contest between openness and closeness*. Contest implies competition and there is always competition between openness and closeness. Sometimes the stronger attribute *conflict* is present, as in the item J*b *Defence Money Supports Farm Research*. Another feature of this example is that the contest and conflict are public.

In other cases the contest is initially private but becomes public as a result of the exceptional interest of the work, as in B*a *Too Many Spectators*. Sometimes there is an explicit claim to openness, and a (possibly implied) contrast with others' less open contributions, as in I*c *The BA (British Association for the Advancement of Science)*. Yet there always are limits to openness, the point made eloquently by Sissela Bok (P*a *The Conflicts Between Insider and Outsider*).

Often, the contest is not immediately obvious because the discussion is scholarly and urbane, as in C*a *Public Knowledge*. Other items are polemical and contest and

conflict are overt, as in I*d *Unthinking Subservience to the Principle of Participation*.

In some cases we are obviously dealing with great matters of human civilisation, as in N*b* *The Medvedev Papers* and elsewhere with something specialised, for example Lb* *Bradford Robotic Telescope*, or informal (K*g *Top Five Science Blogs*).

The Survey includes references to treatises (O*a *Responsible Conduct of Research*), scholarly papers (G*b *Open Science and Closed Science: Tradeoffs in a Democracy*), advocacy (H*a *See-through Science*), 'straight' journalistic reporting (F*a *Panel Faults US Science Policy*) and partly jocular journalism (E*a *The Naked Scientists*).

There are reports on technical initiatives (K*c *Open Science Grid*) including those with a philanthropic motivation (M*d *Aptivate*) and on conferences (K*d *Towards a Global Digital Commons: the iCommons Summit*). The unusual (N*a *A Rather Unconventional Way to Protect his Work*) and the typical (O*b *Public Openness at the FDA*) find their way into the Survey.

I conclude that in science policy, in the practice of science and in its application, *contest* between openness and closeness is always present. *Conflict* may also be present, but by no means always. Since conflict is newsworthy, it is easy to get an exaggerated impression of its presence in science.

Openness versus closeness always matters. Every minor decision on what to reveal and what to conceal, in every project or discussion, makes a contribution to the construction of what science *is* at a given time.

Such decisions are, however, not necessarily on a simple one-dimensional scale, with bright openness at one end and dark secrecy at the other. Qualifications of complete openness are of various kinds and are not always a sell-out. They may be for reasons of conciseness, discretion, tact or practicality (for example, if a certain marginal revelation would make an entire report unacceptable for publication).

Likewise qualifications of complete closeness (utter secrecy) are not always a betrayal. They may be limited disclosures for pragmatic reasons, such as to dampen the outsiders' ardent curiosity, or to soften the insider's unbearable isolation. Thus we see that secrecy, in particular, is more complex than is generally recognised (although the nuanced exposition in *Secrets*, Bok 1982, must be counted an exception).

A secret is an item of knowledge and the construction of knowledge is a social process. In order to exist, some aspects of any secret must be known by some people.

A secret can be known to a single person, say one scientist with a discovery, only in a severely limited sense. That discovery will be a small addition to knowledge and - even leaving aside the question of its testing by the criticism of others - it gains its meaning from its connections with innumerable elements of public knowledge.

In practice, secret knowledge is normally more social than in this 'lone scientist' example. Secrecy is usually more a matter of controlling and inhibiting the diffusion of knowledge. Secret knowledge is normally created by a social group, and the secret is to be kept from outsiders. The processes of development and validation of knowledge *within the group* are similar to such processes in the generation of public knowledge.

The fence. It was on the basis of such considerations that I used the concept of a *fence* surrounding, say, a military or commercial project (C*b *Open Science and Ring-fenced Science*). This concept allows us to recognise that the usual processes of cooperation and criticism (and with all the usual imperfections) can occur within the fence. The concept also helps us to focus on the exact place where we need to give knowledge claims a resistant reading, namely when we are asked to believe a claim which is exported from inside the fence without ourselves (or our chosen expert advisers) being allowed to inspect the basis of the claim. C*c *No names, no proof, no consensus* is an especially clear example of an unsupported claim. Probably that claim had little effect because even its origin was unknown. Unsupported claims from powerful, prestigious authorities are harder to subject to an adequate level of criticism, especially when such factors as fear inhibit questioning (B*d *Nuclear weapons and secrecy*).

A social relationship model of openness and closeness. The passage quoted from Sissela Bok in section P*a is dense and requires some unwrapping. For convenience I requote it - *the conflicts between insider and outsider about control over secrecy and openness arise in every form of human encounter. And within each perspective, the same tensions are felt: for outsiders between seeking to probe secrets and refraining therefrom, and between accepting and avoiding what is revealed; and for insiders, between keeping secrets and divulging them, and between seeking to overcome the restraint of outsiders with respect to what is no way a secret, and acquiescing.*

I propose that this can be understood in terms of *a social relationship model.* Openness and closeness always get their meaning from some *relationship*, which takes place in a *social setting* and involves *actors*, who bring with them *attitudes* and who *behave* in some way or another. The whole of what happens is a *scenario*. These concepts permit us more readily to comprehend the quoted passage. The social setting may be (preponderantly) one of revelation or of concealment. An actor's

attitude may be (preponderantly) open or closed. Let us consider situations with an insider and an outsider, both, of course, in a social setting. There are then eight possible scenarios (what happens) and they can be displayed in a table, thus ...

Social Setting	**Insider's Attitude**	**Outsider's Attitude**	**Scenario (what happens)**
Revelation	Open	Open	Open society
		Closed	Insider seeks to overcome outsider's resistance
	Closed	Open	Insider obstructs flow of information
		Closed	Insider and outsider resist official policy
Concealment	Open	Open	Insider and outsider challenge status quo
		Closed	Insider is a Cassandra
	Closed	Open	Outsider probes
		Closed	Closed society

This table shows all of the 'in principle' possibilities. Since the relationship model contains the qualification 'preponderantly', the table is consistent with Bok's statement *conflicts ... arise in every form of human encounter* provided that this is taken to mean 'conflicts at some level'. Thus, for example, an open society would be one in which the social setting was preponderantly one of revelation, and the actors' attitudes were preponderantly open. Residual contests and conflicts could still be present, as always is the case in the real world.

In the second sentence of the quoted passage, *within each perspective* means 'for a given actor'. The sentence refers not to an outsider-insider relationship but to the inner tension felt by a single actor. The actor may be an insider or an outsider, and may be in a social setting of concealment or revelation but in each of the four situations feels a tension between a response marked by openness and a response marked by closeness.

The following table displays the eight responses (four pairs in tension) in the order in which they are mentioned by Bok.

Actor's status	Social setting	Actor feels tension between ...
Outsider	Concealment	Probing into the secret ... and not probing
	Revelation	Accepting the information ... and avoiding it
Insider	Concealment	Keeping the secret ... and divulging it
	Revelation	Overcoming outsider's resistance ... and acquiescing in outsider's resistance

No uniform trend. In science especially, more openness is considered desirable, virtuous. Yet, as noted in the Introduction, the current trend in science is not uniformly towards more openness. The situation is more complex. There is a trend to more formal oversight and accountability, especially in financial and ethical aspects. Scientists are answerable to managers, in more detail than in earlier times. Restrictions following from a commercial ethos play an increasing role.

The entire 'open science nexus of thought', the subject of this article, is to be seen in this context. While having its roots in the 17th century it has evolved in new directions during the last few decades. IT has profoundly changed the setting in which science is practised, used and discussed, affecting closeness and openness in ways that are never simple.

Limits to openness. It is necessary to recognise the complex nature of the openness - closeness question. The phrase 'openness versus secrecy' oversimplifies the matter. Shortfalls from complete openness are often weaker or more subtle than simply secrecy. Discretion, tact and selection (for focus, simplicity, clarity or conciseness) can all be reasons for lack of complete openness.

Four Levels of Openness in Science (B*f) is an openness spectrum that I have introduced: secret - restricted - circumspect - open. This one-dimensional scale does not, however, describe everything about openness and closeness ...

Timing is one aspect that falls outside that one-dimensional scale. In the controversy about military funding of a project done in a university veterinary department, J*b

Defence Money Supports Farm Research, the unusual source of the funds became known only after the award was made.

Funding is nearly always difficult to obtain, and success is a cause for celebration. It should not be necessary to ask questions about the propriety of a project *after* funds have been awarded. *All* fundamental considerations should be included in a thorough application and review process. Ethical and public interest considerations should be included fully at this early stage, besides the usual criteria of scientific significance, feasibility and safety.

Comprehensive and open review. Most scientists set much store by the current process of *peer review*. Applications for funding and submissions for publication in scientific journals have to win the approval of peers, specialists in a narrowly defined field of expertise. Most scientists have little or no appreciation of the principal defect of this process - that it *serves the interest of the peer group* and this does not in general coincide with other interests, such as those of other specialist groups, of other specialist groups or of the public.

If it be accepted that the overarching interest is the *public interest*, then the review process should be open, as well as comprehensive and timely. Only thus can the public interest be adequately represented. Otherwise, more parochial interests dominate - the interest of an individual researcher, a research group, a scientific peer group, a commercial or academic institution, a funding administrator, committee or trust, a government administrator or politician.

All of the above interests can legitimately be *part of* the review process but all other relevant aspects of the public interest should be included as well. That is the meaning of comprehensive review. Naturally this concept is an ideal which may not be achieved always or even perhaps often. The point I am making here is that, at present, the public interest is usually represented only weakly and indirectly in the deliberations that lead up to the granting of public or trust funds for scientific research. There is a strong case for strengthening public interest representation in the process. Non-scientists, as well as scientists outside the specialist peer-group, should be part of the reviewing process, with the brief to represent interests that cannot be represented adequately by the other actors mentioned above. These inputs complement and do not displace or compete with technical criticism and appreciation - that can only be made by highly specialised experts. The broader kind of review advocated here can be described in the phrase *comprehensive and open review*.

The ills of excessive standards. Throughout this paper, I avoid 'the ritual denunciation of secrecy' and simplistic calls for openness and 'science in the general

interest'. The practice of science and its application, as they are at present, are manifestations of human culture as it is at present. Hopes for a more open science - which are indeed widely expressed - need to be considered as ambitions for the immediate and further future, seen in the context of openness versus closeness in culture generally. As indicated at the beginning of this Conclusions section, I suggest that it useful to think of a contest being played out.

The question then arises *what is realistically in the power of those who wish to move science in the direction of greater openness?* Before proposing an answer to this question, I remind readers, and endorse, the advice of Joseph Agassi (Q*c *The Ills of Excessive Standards*) to relax, to be undefensive, to learn to raise the level of one's conduct to a comfortably higher standard, thereby permitting the raising of the standard again by just a little so as to cause further improvement with no excessive tension.

Confidence. I suggest that, with this attitude, we focus first on promoting *confidence* as well as openness. I believe that Bohr's (tacit) assumption, see section N*d, that openness can lead far ahead of confidence was an error. In society as it is, openness and confidence move forward together. This is the case in all areas of human relations, including the conduct of science. Without a commensurate level of confidence, calls for greater openness create, as Agassi notes, "a neurotic vicious cycle".

Trust. How to promote enhanced confidence? I suggest that an essential and related quality is *trust*. I am considering here the relationship between the self and the other, between the insider and the outsider, or between the in-group and the out-group. As we saw in the discussion of the relationship model, openness, in the sense that is the focus of this article, is an attribute of this relationship. Trust does not have to be absolute, unqualified or naive. It can be provisional, as expressed in the aphorism 'trust and verify'. Yet without some level of trust a self-other or insider-outsider relationship cannot even get started.

In general, progress in such a relationship is made if *trust* goes more-or-less one step ahead of *verify*. This requires *willingness to take a risk*. Why should anyone take such a risk? The answer is that there is a possible reward, namely valuable progress in relatedness, in cooperation and in social living. If judicious steps are taken one at a time, the likely reward is greater than the risk.

If a more open, confident and trusting practice of science is desirable, and Agassi's *proceed in small steps* advice is sound, the next question is *where to start?*

Empathy. I suggest that Marshall Rosenberg's (Q*a) definition of empathy - *a respectful understanding of what others are experiencing* – is a good starting point because it provides a basis for a well-founded understanding of the differences and similarities between the self and the other. Such a well-founded understanding is the essential requirement for grounded and robust confidence (distinguished from superficial and brittle forms, such as pride or complacency).

Respect. The qualification *respectful* in Rosenberg's definition merits a brief discussion here. An understanding of what others are experiencing, or an attitude to what others are experiencing, that is not respectful is not a route to reliable knowledge because it is likely to incorporate a distorted version of the relation between the self and the other. The self is likely to construct stories about the other based more on the self's history than on the here-and-now-existent properties of the self-other relationship. For example, the self may project its own concerns, anxieties and tensions onto the other. Respect here means making a fair attempt to observe what the others are experiencing and avoiding, as far as possible, such distortions as projection or wishful thinking.

Human relationships. Discussions like this of confidence, trust, empathy and respect will usually be taken be aspects of the psychology of (individual or social) human relationships. That is, the self and the other are conscious human individuals or groups. In the present article on open science, such discussion is relevant because human self-other, or ingroup-outgroup relationships are a part of the practice and use of science.

Empathy and science. I suggest that there is, moreover, a further connection between these concepts (confidence, trust, empathy and respect) and science. The traditional concept of science is of a study of the outer world that strives to be as objective as possible. (By outer world I mean all that is outside of some investigator or observer. It can include persons who are the object of study by a biologist, psychologist, sociologist or anthropologist of an objectivist school. The outer world is distinguished from the inner world of a person's direct experience, associated with such terms as consciousness, meditation, spirituality and mystical experience.)

Yet science is not wholly objective. The investigators are part of a relationship, which we may call *the scientific relationship*. This is the relationship between the investigators and the investigated. The investigators are persons and their human qualities cannot be removed or fully 'corrected for'. The investigators have attitudes, motives and passions. The investigated is part of the outer world. A principal aim of science is to discover reliable knowledge about the outer world that is, as far as

possible, objective, that is, not dependent on the identity of the investigators. If the study is repeated by other investigators, the same knowledge is reported.

Empathic scientific practice. I submit that the remarks made in the above section on *Respect* apply in almost the same way to the practice of science, except that now we do not refer to 'what others are experiencing' but to 'how the outer world is'. To set out the proposition formally …

An understanding of how the outer world is, or an attitude to what it is, that is not respectful is not a route to reliable knowledge because it is likely to incorporate a distorted version of the relation between the investigators and the outer world. The investigators are likely to construct stories about the outer world based more on their own histories than on objective properties of the outer world. For example, the investigators may project their own concerns, anxieties and tensions onto the outer world.

I therefore suggest that the concept empathy can usefully be applied to scientific practice. *Empathic scientific practice means investigating the outer world with a respectful attitude.*

An example from the Survey that illustrates these remarks is B*c *Secrecy Based on Fear of Causing Public Alarm*. It reveals wishful thinking, brought on by anxiety, affecting the reporting of what was supposed to be scientific work. (Responsibility in this example cannot be laid wholly upon government and administrators because scientists allowed part of science's accumulated store of credibility to be eroded.) On the other hand, in example B*b Millikan's "remarkable honesty in evaluating the data that the paper contained" appears to me likely to be connected with a confident and respectful attitude on his part to the outer world.

Empathy and integrity. The sequence of ideas developed here, openness - confidence - trust - empathy, may, I suggest, be completed with *integrity*. To practise science with integrity is to be whole; to have a grounded, robust connection with the direct objects of study and with the social context of the work. Here, social context includes persons and institutions connected with peer assessment, patronage, the media and applications of the work.

This may seem an impossibly tall order, but some kind of perfection is not meant here. An understanding of what I do mean can be got by considering some of the human manifestations of the lack of integrity, the lack of grounded, robust connection. Manifestations which subvert the scientific ethos in relation to knowledge claims include dogmatism, polemic, special pleading, hype,

indoctrination, narrow-mindedness, tunnel vision, inattention to the relevant, denial of the obvious, compartmentalisation, wishful thinking and fraud.

Manifestations which subvert the scientific ethos in relation to the human relations aspects of scientific work include secretiveness, duplicity, backbiting, plagiary and egotism.

None of these manifestations is compatible with integrity. The manifestations that relate to individuals bespeak some degree of division in the personality. The manifestations that relate to
knowledge claims bespeak human anxieties and tensions that get in the way of the generation of reliable knowledge.

Science is widely held to be valuable in three main ways - it is beautiful, it is a search for truth, and it is useful. I add a fourth way that is less noted, especially in our present commerce-oriented times...

Science as a way of relating has something to show to all of us in our lifelong journey of learning how to relate to each other and the world. This is not a scientistic proposition, that is, not a bid for the expansion of science beyond its proper realm. The realm of science is where an outer world can be identified and investigated with a degree of objectivity.

Many parts of our lives (for example, great swathes of personal relationships, the inner world and politics) are not even approximately separable as 'outer'. The attempt to deal with these areas in a scientific manner creates distorted and fragmentary ideas more than accurate, integrated knowledge. A more holistic approach to these areas is appropriate, which avoids the outer-inner or the outerworld-investigator division from the beginning.

Science open to the rest of culture. *Confined to its proper realm,* science as a way of relating has something to show because it deals with simpler situations which can be approached more readily with openness, confidence, trust, empathy and integrity. The beauty, reliable accuracy and utility of the results of scientific work demonstrate the value of this approach (in its proper realm). While the scientific approach cannot itself be used unmodified outside of its realm, the ideals of openness, confidence, trust, empathy and integrity are, I suggest, useful in human relationships in general. Failure to apply these ideals leads to much confusion and suffering. Those ideals are more difficult to apply to living in general than to science but it can be done. It requires a flexible approach, taking what is valuable from the scientific approach but

being always on the look-out for the blurring, or even dissolution, of the separation between the investigator and the outer world.

APPENDIX. Other Meanings of Openness

In the main part of this article *open* means something like *visible and accessible* but there are other ways in which *open* can be connected with science. This appendix provides an indication of some such usages.

(1) Openendedness

S*a Open Fields. The title of this book by Gillian Beer (1996) relates to a quotation from the Conclusion of Darwin's 'The Origin of Species' "In the distant future I see open fields for far more important researches ..." Beer writes (page 8) "in the nineteenth century - in ways different from our own - scientists were trying to work with discourses open to their educated peers and drawing on non-technical, even non-mathematical, formulations ... Science always raises more questions than it can contain, and writers and readers may pursue these in directions that go past science."

S*b Towards a Democratic Science: Scientific Narration and Civic Communication. In the preface to his book, Richard Harvey Brown (1998) writes "science and narration seem to exclude each other. In this separation we are forced to choose between the amoral rationality of science and the seemingly irrational moralism of storytelling, with little confluence of the two in reasoned public moral action." Although Brown does not emphasise openness as such, he is advocating a much greater openness of the conduct of science towards normative kinds of discourse than exists at present.

S*c Science The Endless Frontier. This influential report by Vannevar Bush (http://www.nsf.gov/about/history/vbush1945.htm#ch6.5)
was commissioned in November 1944 by US President Roosevelt who wrote "New frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war we can create a fuller and more fruitful employment and a fuller and more fruitful life." Bush's response to this, in the Letter of Transmittal accompanying his report is "Science offers a largely unexplored hinterland for the pioneer who has the tools for his task."

S*d What Do Pupils Think Of Open Science Investigations? In this study by C Chin and G Kayalvizhi (2005) openness refers to the exploratory, open-ended nature of the students' work.

(2) Openness to Discussion
T*a Declan Butler (2005) reports in *Nature* "John Paul II was one of the most science-friendly Popes yet ... But this openness ended where sexual issues came into play."

(3) Open Systems
U*a Open system. Defined in the *McGraw-Hill Dictionary of Physics and Mathematics* (Lapedes 1978) thus - "[THERMODYNAMICS] A system across whose boundaries both matter and energy may pass."

U*b An Open-Systems Model of Research Organizations. In the report *Integrity in Scientific Research: Creating an Environment that Promotes Responsible Conduct,* by the Institute of Medicine of the National Research Council of the [US] National Academies (2002), chapter 3, *The Research Environment and its Impact on Integrity in Research*, is based on an open-systems model of research organizations. The organization is embedded in an environment with Inputs/Resources, Outputs/Outcomes and feedback from the Outputs/Outcomes to the Inputs/Resources.

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