Commentary
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There is no common ground between science and religion

1. Introduction

It is fairly common to introduce science and religion as relatively different modes of understanding the world in which we live that may interconnect in several ways, and that this interaction is useful and may promote the advancement and development of both fields. We strongly object to this perspective.

Although usually restricted to 'humanities' journals, we found surprising the publication of an article in the scientific journal *Evolution* (Reiss 2009) on the relationship between evolutionary biology and religion that we think lacks sufficient scholarship to be relevant to the subject and is clearly negative for the teaching of the scientific approach to objective knowledge.

In that paper, Reiss argues that science and religion may offer various ways of interpreting our world. Reiss deals with the problem of teaching evolution in the presence of creationist believers in classroom. As we see it, this question is inappropriate. From our point of view, Reiss could, too, ask himself how to teach republican or democrat students or followers of one football club or the other. A great majority of people understand that science and politics are two different endeavors (although science usually depends on political decisions for its development, but not for the set of theories and facts that it produces). Science is an approach to knowledge incompatible with unquestionable or revealed truths. Although from a personal point of view, one may entertain any number of unquestionable truths and unvalidated opinions, the social practice that we call science does not work with them. The fact that some of those unquestionable truths prohibit transfusions (Jehovah's Witness) or consider polio immunization shameful (Taliban in Pakistan and Afghanistan), to mention just a couple, points to the personal cost of those unfounded beliefs that should be borne by the consumer.

Reiss proposes a carefully thought-out approach to teaching evolution in the classroom to elude the trouble imparted by believers in intelligent design or other forms of creationism. Although it may be shared by many, Reiss's approach, we think, is contradictory and deleterious to the advancement of science.

Instead of inserting ourselves into a long discussion on the multiple issues for which the article offers *démodé* points of view, we offer a Decalogue (in accordance with the subject at hand) that we think will neither cause too much misunderstanding, nor offer too much opposition.

2. Decalogus

2.1 *Science is a polysemous word: It can mean the social process that produces a special kind of knowledge, and it can mean the knowledge itself*

There is even a 'science of science,' which is exemplified by the studies of Merton (1979), Garfield (1977), de Solla Price (1963) and others. In our view, it is important to distinguish 'scientific' knowledge from other meanings of the word science. *Scientific knowledge can be understood as a set of facts and mental constructs (theories) that are shared on an intersubjective basis by a practicing community*. That the facts and theories are shared, however, does not necessarily mean that they are accepted. We share, for example, different theories about the rhythm of evolution – gradualism, rapid inflationary evolution and cladogenetic punctuationism – and all of these have different levels of acceptance or criticism when applied to specific

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cases. However, the 'intersubjective' condition demands that a hypothesis that any practicing scientist puts forth can, at least potentially, be scrutinized or tested by any other colleague that shares his methodology and knowledge. The insightful analysis that has been applied by Brian W Ogilvie (2006) to the rise of the discipline of natural history during the European Renaissance can be applied to all the scientific disciplines that are practiced today.

In this article we will refer only to scientific knowledge that is the set of theories and data that populate the content and practice of the social community that are devoted to science.

2.2 *The exclusive source of 'data' for scientific knowledge is empirical experience, which is either obtained by careful and repeated observations or through the design of experiments*

There is no scientific knowledge without experience, and that experience should be able to be verified by any other independent observer who is acquainted with the knowledge and technology to repeat it, at least potentially. Revelations and mystic experiences can be described but not shared. There is no way to ascertain whether two mystic experiences refer to the same mental state or the same conditions, or whether the two experiences share all of the variables involved, unless we study them as 'external' experiences (Wulff 2002). It is in this sense that scientific knowledge may be called intersubjective because it is does not belong to a personal and isolated experience but to an experience that anyone may access.

The importance of having robust empirical data is not always properly stressed, but the need to obtain it played a key role in the origin of all of the scientific disciplines deriving from Renaissance natural history and in the growth and enormous success of scientific knowledge at the present time. Only when data can be trusted because the person who produced it is experienced or because the original material can be revisited, can further knowledge be built on it. We can smile at the 'narratives' of XVI century books that, for example, state that the 'capercaillie eject semen from the mouth and in touching the soil it converts to a pearl that is good for (human) conception' (du Pinet 1584), but there remain some current areas of molecular and human biology where the robustness of data is far from an acceptable level of reliability (e.g. Henrich *et al.* 2010; Song *et al.* 2008)

The term data may include the methods employed for obtaining such data. As Galison (1987, 1997) remarked in the field of physics: 'despite the slogan that science advances through experiments, virtually the entire literature of the history of science concerns theory'. Darwin himself in a letter to Wallace (1857) pointed out: 'I am extremely glad to hear that you are attending to distribution in accordance with theoretical ideas. I am a firm believer, that without speculation there is no good and original observation'. In fact, careful attention paid to development of experiments, materials used and analysis of results, leads to a more realistic image of the advancement of knowledge. However, the conceptual distance between the knowledge obtained by careful observation and that obtained by using 'strict' experimental methods is much less than is normally presumed. So there is no knowledge that can be gained without experience, and to be reliable, that experience should be repeatable.

2.3 *Scientific knowledge is not only achieved from experimental design and testing of hypotheses*

In a book that was recently published in the field of evolution, two of the most enthusiastic defenders of the experimental method (Rose and Garland 2009) are immediately followed by two authors (Futuyma and Bennett 2009) who, while recognizing the potential and robustness of knowledge that is obtained by the experimental method, declare that 'it is not suited to answering all questions about evolution, particularly evolution in the natural world' (which is not the least of all the possible forms). In this sense, robust empirical observations that are subject to the Bayesian probabilistic approach are another source of scientific knowledge (Gotelli and Ellison 2004).

For instance, it is not a waste of scientific inquiry to try to reconstruct the possible causes of accidents like the Space Shuttle Columbia disaster (1 February 2003), as this appears to be the most effective way to avoid another accident of this sort. Scientific diagnoses like this share many conceptual and methodological nuances with what are traditionally considered to be 'historical sciences' (e.g. paleontology), and there are many other examples of useful 'non-experimental' scientific knowledge being produced that could be mentioned.

There are, in fact, any number of phenomena that are not subject to investigation via experimental approaches (at least at the moment) that deserve study through alternative approaches. The development of the probabilistic theory applied to Natural Sciences (Hájek 2001), for example, derives in part from the dispute between the 'experimentalist' RA Fisher and the expert 'historicist' in the field of earthquakes, H Jeffreys, in the second quarter of the 20th century (Howie 2002)

We should, therefore, avoid any kind of simplistic representation of what scientific knowledge is, besides recognizing that it is rational thinking applied to robust empirical data. In this sense, we share Weinberg's (2003) dictum that the history of science is more important than the philosophy of science for new researchers, and we think this is often true for senior researchers as well.

2.4 *There is no limit, in principle, to what topics scientific questioning can be applied, and there are no special issues reserved to religion*

We cannot anticipate how we are going to present questions related to the origin or the existence of the universe or to the origin of life or of the human mind. In some ways, we are biased by an understanding that comes from our previous experience and knowledge, but we cannot anticipate how we are going to frame these questions in the future because increasing knowledge will surely change what questions we will ask and how we will ask them.

The scientific approach to these questions is to suggest feasible scenarios that take into consideration processes with solidly established scientific foundations and to then formulate questions to test the robustness of these models.

An excellent example of this is the current debate over hypotheses set to explain the origin of life on earth. Present-day hypotheses arise from our knowledge about the structure and replication mechanisms of nucleic acids, which have been well-established by experimental means to be involved in the organization and transmission of biological information. With this information in hand, the next step is to formulate questions related to a particular conceptual framework (evolutionary theory, for example) that has been established based on diverse sources of empirical knowledge. For example, we could ask how the biological world that we live in today could have been established, taking into account the physico-chemical properties of these molecules (Orgel 2004; Boto *et al.* 2009).

In this way, it is possible to build hypotheses, for instance, that the prebiotic world was based on RNA instead of DNA (Gilbert 1986). These scenarios still contain many uncertainties that subsequent empirical observations can address and that still may result in refutation of the original hypothesis.

The proposal of the existence of an RNA world which preceded our current DNA world gave rise to the dilemma of the replication of primordial material in the absence of proteins. The dilemma disappeared with the discovery in studies on *in vitro* evolution of molecules that RNA molecules with enzymatic activity (ribozymes) can autoreplicate RNA molecules (Bartel and Szostak 1993; Ma and Yu 2005). The recent discovery of a naturally occurring ribozyme adds new evidence in support of this scenario (Vicens and Cech 2009).

With our current state of knowledge, it is true that we do not know the answers to all of the questions that have been proposed on the question of the origin of life, but we do have at our disposal important tools for testing the robustness of our hypotheses, and it is possible that, in the near future, more efficient tools might be incorporated to address these questions.

A paradigmatic example of this is horizontal gene transfer between organisms and its role in prokaryotic evolution (Boto 2010). Twenty years ago, we were ignorant of the contribution of this process to the evolution of Bacteria and Archaea because vertical evolution was the only model of evolution accepted at that time. However, relevant observations of the presence of genes of distant phylogenetic origin in many Bacteria and Archaea (and in minor degree in eukarya) introduced the concept of horizontal gene transfer (Hilario and Gogarten 1993) as a force that modulates evolution in the prokaryotic world, and subsequently, new questions concerning the relative significance of horizontal in relation to vertical evolution arose. Only twenty years later, we have precise tools to be able to answer many of these questions.

In contrast to this, the religious approach to these processes does not engage in any experimental methodology or offer any empirical data, and does not permit any questioning: it consists of revelations that, once made, are the only explanations that are accepted for these processes (see the following point). In

this sense, the religious approach is immune to the advance of science. This is true of the three main monotheistic religions – Christianity, Judaism and Islam – and a separate treatment should consider those other 'beliefs' that are more philosophical speculation than revealed truth, as is the case of some oriental practices (Yoga, Buddhism, Zen) that may include a personal 'empirical' route to truth – although when reached, it may not be intersubjective.

In summary, the examples discussed above clearly show that the scientific and religious approaches to sensitive questions such as the origins of life and the universe and the emergence of the human mind are radically different, and attempts to combine them do not bring us to a common ground.

2.5 *We maintain that what defines scientific knowledge is not the set of questions explored but how these questions are investigated*

As discussed above, there is no limit to what topics rational thinking, observational analysis and experimental approaches may be applied. Even phenomena that only occur a single time, such as facts of a historical nature, are prone to rational questioning, and the knowledge that is obtained from such an examination can be extremely useful. In this sense, even miracles can be a source of human inquiry. For instance, one may question on what basis the 1912 Nobel Prize Winner Alexis Carrel decided that an anomalous instance of healing that took place over more than seven hours should be ascribed to a miracle, and not to a poorly understood physiological phenomenon (Carrel 1912). So, by definition, scientific knowledge is a way to examine all kinds of natural phenomena, and it is the responsibility of those people who claim the contrary to demonstrate that there are phenomena in this world that are not of a natural kind, i.e. to demonstrate an example of something that is not feasible based on the physical and biological laws that govern the natural world. Furthermore, because of the continual nature of the growth of knowledge, we cannot deny the possibility that we will be able to find a natural explanation in the future for a phenomenon that presently escapes our powers of elucidation

2.6 *The Popper falsifiability criterion is not the only criterion by which scientific knowledge may be distinguished from pseudoscientific knowledge or simple opinion*

The falsifiability criterion, taken alone, is not especially powerful for discriminating scientific knowledge from pseudoscience in many situations. The additional criteria of Kuhn and Lakatos, or a combination of them as suggested by Bunge, Kitcher and others (see review article by Hansson 2008), are more robust for delimiting what can be considered scientific knowledge. In this sense, Oakley's (2009) complaint was fully justified when this investigator stated what had been well known for more than a decade in the field of evolutionary studies: (a) that there are statements that are not falsifiable but that are scientific because they are testable and (b) that strict falsifiability is rarely followed, even in experimental disciplines.

Taking this argument to its extreme, following scientists such as Steven Weinberg (1993), we can say that the scientific method is simply empirical data plus rational thinking, and the totality of the discussion on theories of the scientific method (Nola and Sankey 2007) in its practical incarnation converges in that dictum.

Once again, because religion, as remarked above, employs neither empirical data nor rational thinking, it falls outside the bounds of this definition.

2.7 *On the definition of 'creationist'*

Despite the huge amount of literature on the evolution vs creationist debate of the past decade, it is very difficult to find a conceptual definition of creationist. Many of the definitions that do exist are of the 'by example' mode, such as saying that a creationist is one who thinks that the narrative of the Bible is the natural explanation of this world. However, we think that a conceptual definition is of central importance in any discussion between science and religion. Therefore, we suggest that a creationist may be defined as *someone who accepts that an Entity who is not available to human empirical and intersubjective evidence is the explanation of phenomena such as the origin of the Universe (generalist creationism), the origin of the human mind (specific creationism) and the like*. This definition is not too far from Sedley's (2007)

definition of creationism, which is one of the few that is available in the literature dealing with religious explanations of the world.

This Entity cannot be studied with experimental techniques in laboratories or observed empirically in nature. This is why the verb 'believe' is used to build religious statements, which is very different from what we call 'empirical or experimental evidence'.

Additionally, a perceived compatibility of religious and scientific thought does not imply relevance. A scientist may be a follower of a particular team of American football, but its relevance to her work in the lab or in the rainforest is immaterial. An excellent exercise in compatibility between religion and biological knowledge has been provided by Joan Roughgarden in her book *Evolution and Christian Faith* (2006). On page 19, for instance, Roughgarden tries to make the Bible compatible with current understanding arising from the fields of ecology and evolutionary biology, and she states, citing the scriptures, that St Paul tells his audience that the church is like a body and that all of the parts are interdependent. In the same way, continues Roughgarden, ecology tells us that parts are essential components of wholes in evolutionary biology and ecology. Although the analogy here is clear, the relevance is null.

Similarly, one could cite the argument regarding the incompatibility of religion and evolution proposed by the journalist Lee Strobel in his book *The case for a Creator* (2005). He mentions various biologists, including the philosopher of science Michael Ruse, who consider Darwinism and a belief in God to be incompatible. Strobel states (p 41) that he personally cannot understand what meaningful role is left for God in the context of a Darwinian explanation, blind natural selection, that, by definition, is undirected.

2.8 *Anyone is free to believe in the existence of any entity to explain the world or to give meaning to his/her existence, but this is outside of the realm of scientific knowledge*

Any type of creationism, as we have defined above, is based on a departure from the natural course of investigation that is the key to scientific research, but this is the contradiction that many scientific researchers who are adherents of religious faith are living with. However, this contradiction need not be a problem, as long as personal beliefs are kept far from the lab. The true conflict arises when an attempt is made to elevate declarations that are made in sacred texts to the level of objective knowledge, as nobody knows from whose authority these come, and they allow neither corrections nor addendums to be made based on increasing experience.

At the extreme, one may behave as a scientist when dealing with earthly subjects and as a creationist when dealing with sensitive ones. For example, TC Wood is a biochemist who has made significant contributions to science, as is evident in his numerous scientific papers and, in particular, in his contribution to our knowledge of the rice genome (Goff *et al.* 2002). However, Wood (e.g., 2002 and 2006) is one of the most active proponents of a 'scientific' creationism. In his case, it may be said that the natural link between empirical data and reasoning is broken when he postulates the existence of an Entity who is not susceptible to additional empirical inquiry. Similarly, Collins (2006) has been the successful director of one side of the Human Genome Project, but he clearly abandons the arena of scientific knowledge when he declares that phenomena such as the origin of life and the nature of human thought require an explanation of divine intervention (whatever this may mean). Collins is against a particular form of creationist thinking, Intelligent Design, but he defends another form of a long and obsolete tradition, that we may call Intervention Creationism – the intrusion of an extra world entity in key steps of the origin of Universe, life and human mind – that is represented by Teilhard de Chardin and emulators. Obviously in both cases, the fact that Wood and Collins are well respected in their own fields gives them (as in the case of Alexis Carrel) no special legitimacy to explain natural phenomena in terms of the unknowable.

2.9 *On the worldview projected by scientific knowledge*

There are worldviews that promote more scientific knowledge, and there are others that do not. Religions clearly do not promote scientific knowledge; at best, they are neutral to it. Scientific knowledge projects a

special way to approach any natural phenomenon. As such, it is an unlimited and unending and fascinating enterprise, and this is also why it is such a rewarding endeavor.

2.10 *Abandoning empirical evidence as the main criterion for evaluating scientific knowledge makes things meaningless and confusing*

Paraphrasing Laplace's answer to Napoleon, the question is not whether we need God for explaining the world in which we live; the question is whether the methodology we use to know this world needs the concept. In this sense, there is no place for religion in the world of science, and religion should not be taught in science classes.

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