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### Key Words

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Non-Science Majors

We live in a scientific world. Science is all around us. We take scientific principles for granted every time we use a piece of technological apparatus, such as a car, a computer, or a cellphone. In today's world, citizens frequently have to make decisions that require them to have some basic scientific knowledge. To be a contributing citizen in a modern democracy, a person needs to understand the general principles of science.

## Non-Science Majors

A major challenge in this scientific world, however, is that most people are not scientists; neither should they be, since the human endeavour shouldn't start and end in science. Thus, most of the people in our world are not as scientifically knowledgeable as we would like them to be in order to understand the world that surrounds them. These people, who comprise the majority of the population, have great power in the world, and some are involved in decision-making — politicians, businessmen, judges, CEOs, and so on. These are the ones who decide the funding and policy of scientific research. This segment of the population might be called "non-science majors".

It is therefore in the interest of society that non-science majors understand the basics of science in order to make informed decisions. Unfortunately, most people do not have the most basic scientific notions and do not understand the nature of science.

## Evolution

A few months ago, in a Republican Debate, three candidates to the Presidency of the United States of America stated that they do not believe in evolution. This is scary! And it is especially surprising, since they clearly are very knowledgeable and intelligent persons. One reason for this belief may be that the three candidates do not have a very sophisticated understanding of the nature of science. And the biggest problem is that many other American citizens share the same belief — several millions of them according to some polls. It is troubling to consider that these individuals may be in a position to make decisions that will profoundly affect the future of science in our society.

The solution to this problem should not be to take a passive attitude, or to blame religion, and expect that things will magically turn out right. Neither should it be to turn this into a "holy war" between science and other as-

pects of human life. The solution has to lie in educating people. Knowledge is humanity's most important weapon.

Scientists, educators, and communicators of science often disagree about the methods to achieve their goal. But it is the same goal for all: scientific literacy.

There are many misconceptions about the nature of science among the population, and these, to me, are the ones we need to focus on. For non-science majors, in formal or informal learning environments, the scientific details are practically irrelevant. According to Carl Sagan, the "big picture" is the best knowledge to transmit to persons who are uninterested in the scientific nitty-gritty. The details are vital in scientific research but hide the essential points from the majority of the population.

## Misconceptions about the Nature of Science

With evolution, there are clearly several misconceptions about the nature of science. One is that the population thinks that science is a question of belief. This happens most probably because science is usually

transmitted in schools and also in informal environments, such as science centres, books, articles, and so on, as being “the truth”, something that must be believed instead of understood. Science is viewed as a belief! On the other hand, people don't recognise all the science around them — there appears to be a disconnect between science and the general population. By saying that they don't believe in evolution, they are not only saying that they don't understand science, but they are also saying that they do not believe in the scientific process. This is shocking, since they enthusiastically use televisions, aircraft, and cellphones, all of which work on scientific principles and were developed using the scientific process. It's as if I said that I do not believe that my car works while I'm driving it; or writing in a blog that I do not believe the internet or computers exist! It makes no sense for people to fully trust science in certain areas — like when their life depends on it in a hospital — but not in others that follow the same scientific principles; and it makes even less sense for people to state that they do not believe in science (evolution, for example) while using and trusting it (example: on television).

Neither do most people have any idea of the meaning of a scientific theory. They assume a theory is just an idea that someone had. They don't realise that a proper scientific theory, like evolution, was and continues to be, tested repeatedly, and that the results of these tests create a bulk of evidence supporting the theory, making it as close to “fact” as it can be. Furthermore, people have difficulty comprehending that the gaps in our understanding are minor details that do not bring the overall theory into question. We send probes to other planets, we have computers, we deal with science daily, even though we do not fully know how the Universe works; and we don't need to! Science is work in progress; it is an ongoing human endeavour. It will never be fully complete, otherwise curiosity, and thus part of what it is to be human, would die. The communication of science needs to emphasise this point.

Maybe these popular misconceptions come from formal teaching or informal communication, which is presented as if everything were already known. For instance, in science classes, the current news is rarely emphasised. Science is taught as something complete, a finished endeavour. On the other hand, in TV news reports, only new, possibly still unconfirmed discoveries at the frontier of science are emphasised. This can give people the mistaken impression that all scientific results are as shaky and as vulnerable to revision as the latest discoveries. But this is not the case: most science is not vulnerable at all. We don't hear much about it,

because is not newsworthy. It is important that people know where the boundaries lie. Science education needs to focus on this too.

Finally, there is also the popular perception that a scientific theory is limited to one area of science. Evolution is perceived as being about biology. But that's not the case. The theory of evolution is, as with most scientific theories, an interdisciplinary theory, with strong footholds not just in biology, but also in geology, physics, chemistry, astronomy, paleontology, and other disciplines. Therefore, not to support the theory of evolution is not to support several sciences or science in general, which, of course, is absurd — especially taking in consideration the examples of driving a car or writing a blog, mentioned above.

We can't blame the general population for these misconceptions. If people don't understand the nature of science, that's probably because the agents of transmission of science to the population are not communicating effectively. A change is imperative!

## Astrobiology is the Answer

My solution is directly related to astrobiology. If taught appropriately, using critical thinking and scientific speculation, astrobiology can be an excellent vehicle for teaching the nature of science.

Astrobiology, as defined by the NASA Astrobiology Institute, is: “*The scientific study of the living Universe: its past, present, and future. It starts with investigating life on Earth, the only place where life is known to exist, and extends into the farthest reaches of the cosmos. It ranges in time from the Big Bang and continues on into the future*”. It studies the origin, evolution and distribution of life in the Universe; thus, it studies life on Earth, and searches for life beyond our planet. Astrobiology covers many questions, of which the best known is: “*Are we alone in the Universe?*”

From the misconceptions mentioned earlier, we can see that astrobiology, especially with respect to extraterrestrial beings shown everywhere, has already incorporated a belief system. Instead of ignoring it, the teaching and communication of astrobiology can use this belief in its favour, by clearly demonstrating the line separating beliefs from scientific knowledge. Useful issues in this regard may be science fiction and ufology. A critical analysis of these subjects helps to distinguish scientific knowledge from scientific speculation and from plain beliefs.

Additionally, astrobiology is an interdisciplinary science, with concepts from natural sciences like astronomy, biology, chemistry, geology, ecology, and so on, and also from social sciences like history, sociology, psychology, etc. It's a perfect combination of sciences, which, when integrated, will not be perceived as “island-sciences” with no relation among themselves — as is usually perceived in science classes. At the same time, it will allow people — and most importantly, non-science majors — to have a basic knowledge of many sciences, how they relate to one another, and how scientific knowledge is intrinsically multidisciplinary. Moreover, the incorporation of social sciences connects astrobiology with the society in which it is embedded. Furthermore, almost daily we have news related to one of the sciences spanned by astrobiology, which gives the notion that science is work in progress. All these factors are advantages provided by astrobiology that may help to diminish the misconceptions many people have about the nature of science.

On top of all this, there is a public fascination for the possibility of life in the Universe (and UFOs — where the social sciences enter). In the last ten years, Gallup, Roper, ABC, CNN, and many other polls, have clearly shown that most Americans (and the same happens with Europeans) believe in alien life. In addition, there are several science fiction movies with extraterrestrial life that have been great box-office successes. This shows the interest that people have in astrobiology-related issues. Basically, it enhances the inherent motivation of the general population for this subject. And this makes astrobiology the perfect hook with which to attract people to study science, the nature of science, and the interdisciplinary aspect of science.

Following in the steps of Carl Sagan and others, the teaching and communication of science needs to relate more with the general population; it needs to be engaging, to have an inherent motivation, and to be multidisciplinary. Astrobiology can be the answer to all this!

### Bio

**Carlos F. Oliveira** is a PhD student at the University of Texas at Austin, USA. His PhD is in Science Education, with an emphasis on astronomy. He created and periodically teaches a unique astrobiology course at the same university. He has an undergraduate degree in Astronomy, Astronomy Communication, and Science Fiction from the University of Glamorgan, United Kingdom. He also holds an undergraduate degree in Business from the Universidade Portucalense, Portugal.