ROLES AND RESPONSIBILITIES OF SCIENTISTS IN MODERN SOCIETY

- It is believed that in the world we find ourselves in 2006, it is un-deniable that scientists hold a great number of responsibilities to themselves, their colleagues, and to the larger non-scientific public in general.
- I believe that there is a significant abyss between science and society, and that this gulf is affecting the way that scientists work, and their respective responsibilities.
- Scientists are increasingly seen as outsiders; they are no longer seen as an integral part of society. There is no doubt that the public is largely not interested in science (or at least ignorant to it's existence), and that perhaps the public's view of science in general is somewhat different to what life is like at academic and scientific institutions.
- So how has science become so alienated from society?
- Although I don't know the full answer to this, I believe that science's portrayal (or lack thereof) in the media has played a significant role.
- One rarely hears of scientific stories in the general press, and this lack of publicity leads to public scientific ignorance, and ultimately, disinterest.
- Therefore, less people are taking up science at university, and we are left in the situation where a small minority of people are involved and interested in the longest running human endeavour. Thus, the general public are left largely unaware of what is happening in science today.
- This lack of interest on the public's part leaves the scientist with more responsibility than ever; if science is to continue to evolve, then which direction should it take, and what are our scientific priorities?
- I believe the only way to progress is for greater unity in the global scientific community. Scientists from across the world must work closer than ever before to establish their common goals, and to work towards these goals together, rather than nations wasting resources by 'racing for the prize'. For this direction to be successful, scientists must respect the fact that they have

certain responsibilities to each other, which, if ignored, will thwart this scientific process.

- Primarily, professionalism is of utmost importance. We are always learning, whether it be through our own discoveries, or through what has come before us.
- Although we should avoid taking anything for granted, we must at some level trust our colleagues and forefathers who came before us.
- In doing so we must also accept the fact that others will put their trust into our work and discoveries.
- Therefore the need for accuracy and honesty is vital in the scientific community. It is all too easy to dismiss an unexpected result, and pretend that it didn't happen, rather than investigating into why the result may have occurred.
- It must be accepted that this is part of the scientific process, and scientists should, from a philosophical point of view, always expect to be surprised and not take current theories for granted.
- Another responsibility of great importance is the ability of the scientist to share their knowledge and findings with others. Science is historically riddled with examples of supposedly 'great minds', for example Newton and Darwin, being territorial and selfish over their work.
- When one makes a discovery, one must tell the scientific world in aid to further progress and to inspire others.
- The scientists must put the progress of mankind ahead of egotistical ambitions and rivalries.
- So, what responsibilities does the scientist owe the public? As discussed, the scientist holds a large amount of power due to their knowledge, education, and research.
- The way the scientist uses this power is the main responsibility they have to the public. So, the scientist must consider the implications of their work on the

world.

- Primarily, the scientist must believe that their work is for the better good, that they are making the world a better place. The scientist must not use their knowledge to knowingly contribute to work that would be detrimental to the world.
- They must be careful and considerate of what their work tells them, and if they identify an area of their work which could be used for detrimental purposes, they must do all they can to prevent this from happening.
- This is simple enough on paper, however, when a scientist is offered a lucrative contract, or perhaps the promise of subsequent funding for a later research project, they may be tempted to ignore their conscience, and partake in work which in other conditions, they would be unwilling to contribute towards.
- The scientist must be strong in these scenarios, and accept that there are people out there who wish to appeal to their greedy side in order for them to gain.
- The scientists must stay strong, and not 'sell out' their professional ethics and integrity because a carrot is being dangled in front of their faces.
- This is another reason for greater unification of scientists. If the scientific community were in agreement of the direction of science, it would be harder for individual scientists to get bullied by people with dishonest intentions.

- Finally, the scientist must work harder to communicate their findings, both to people within the scientific field, and outside of it.
- They must listen to others, and develop the skills necessary to explain to 'laypeople' how they are conducting themselves, and what their discoveries mean to society.
- After all, society puts trust into scientists, with the hope that science will make their lives better, and ultimately, they often pick up the bill for research, so it is only right that scientists inform them in the appropriate way of their findings.
- So, what is the way forward? Well, to reiterate, I believe it of utmost importance for a greater integration of scientists and scientific fields. Luckily, I believe the emerging technologies will aid us in this quest. Thanks to the rise of global communications and the Internet, there will be greater pooling of information, and research will become available as soon as it is completed.
- Hopefully this will also lead to greater transparency of work; if this technology helps us to observe each other work, we can see exactly how experiments are carried out, and have far easier access to advice and evaluation from our peers. Hopefully this greater transparency and freedom of data will also make science more exciting and accessible to the public.

- The epoch we are living in is typical for the frequent occurrence of crises, which affect lives of masses of people.
- The consequences of these crises impose the responsibility on science as a force, participating in these situations and therefore, it places a great responsibility on those, who are actually responsible for science, the scientists.
- One can often hear the harsh criticism of the science and this is natural. Many disasters happen as a result of the modern technologies.
- It is enough to mention the Chernobyl catastrophe of 1986 to visualize, how disastrous the consequences of mistakes in technology can be. There was a nuclear reactor explosion, which ejected a huge amount of radioactive matter

into the environment, polluting the soil and water for many years.

- Except for the technogenic cataclysms, there is also an opinion that all the geological and meteorological catastrophes happen because of humans' fatal influence on the environment. This can actually be confirmed by a fact, that the frequency of these phenomena, taking place nowadays, is much higher than that in the past.
- Obviously, science is nothing without those who possess the knowledge of that and push technological progress forwards, the scientists. For that reason, they carry great responsibility towards humanity.
- The distinctive feature of modern science is its close link to manufacture, when the newly introduced ideas receive their practical application in a short period of time.
- In this case the scientists' responsibility increases, because they are in power of the events of the near future, and as an ancient philosopher truthfully said, "the great power demands the great responsibility".
- The area where the matter of scientists' responsibility remains extremely sharp is the field of nuclear research and its applications.
- From one point of view, nuclear fission is a powerful source of energy, which can move vehicles and heat houses, but on the other hand, a small defect in the fission system may cause a huge disaster, which could destroy lives of thousands of people.
- The other disadvantage of nuclear power is the pollution of the environment due to the nuclear waste. Since the geological energy resources are running out, scientists develop new ways of the nuclear energy usage, making it safer for people and the environment.
- Now researchers are close to the realization of a project of small nuclear plants, which would be heating up the ordinary urban houses and would be located in the city area. An obvious question arises: will it be safe? A tiny spark in the electrical wiring of such a plant will have irreparable consequences.

- Other disputable areas of research include genetics, bioinformatics and neurobiology. There is a constant disagreement between people of different professions concerning the right for scientists to perform such investigations.
- The hottest disputes occur between atheistic scientists and religious people, where the first state that they are trying to help people overcome some diseases, which cannot be healed in any other way, but many of those who believe in God consider the genetics experiments as an interfering with Divine Providence.
- It is a question of ethics, whether scientists should work in this area. There is a blurred boundary between the accepted and unconventional areas of research.
- Something, which falls within the unaccepted region, is cloning, and especially the human cloning, which definitely goes against the ethics. One can say that animal cloning should be totally accepted, that there are no contradictions in religious, ethic and social aspects; but this may eventually lead to human cloning.
- Since the required technologies for cloning have been achieved and some experiments were successful, experiments on humans could potentially be started. It is impossible to predict the results of such experiments.
- Although we are able to forecast the genetic properties of a clone, it is absolutely unknown, what kind of character the clone would possess. What would that child of science bring to the world? The main difference between an animal and a human is the existence of a unique mentality and an immortal soul. Will clones possess such qualities or will they be human-like animals with the ability to talk, suitable for hunting and consuming by their creators? These are the questions for scientists to be answered before attempting such experiments.
- Another area of scientific exploration, which may cause a possible threat to the society, is robotics and, especially, biorobotics.

- The researchers of the Reading University succeeded in a constructing a robot, which was independently controlled by a biological brain inside the machine. The main components of such a creature are the rat's neurons in a biological fluid connected to tiny electrodes, similar to those in microchips of a computer.
- The neurons appear to "behave" as a collection of interconnected cells, reacting to the external stimuli. After a certain period, the robot, equipped with a camera, started to learn and memorize the operational environment (which was a box in that case).
- Finally, it was stopping its motion if the way was blocked by an obstacle and changing its route.
- This experiment shows that bio robotics, together with neuroscience have progressed very far. Obviously, the scientists involved will modernize their creatures, teaching them to perform more and more complex tasks; but what would happen if something goes wrong?
- The first thing, which comes into one's mind, is the colorful production of Hollywood's "Terminator". We are much closer to the time described in this film, than we think.
- It is a great risk for scientists to work in these areas, because they are playing with fire.
- The modern super-powerful computers and nanotechnologies are great tools for the researchers, but it is vitally important to direct the works into the right channel and to keep the situation under constant firm control.
- It is in the hands of researchers to change all the humanity and provide people a great support for industry, manufacturing and life.
- It is their responsibility to prevent the situation going out of control and putting the society in danger.
- Recall what the world looked like at the beginning of the twentieth century. There was no electricity in many regions of different countries; the aero plane was fantastic without mentioning the space travelling.

- Now we get to the farthest part of the Earth in several hours, we can talk to our friends, holding a small device, which is literally connected to nothing.
- On the other hand, millions of people have died because of scientific progress, which brought us the nuclear weapon. These are the different aspects of the consequences of science, which can save lives, but take them away even more rapidly.
- The responsibility of all of these events lays with those, who pushed the progress forwards – the scientists. We worship them because they granted us with many blessings and blame them for poisoning our lives.
- Those who are in power over science are in power of billions of lives, which expect the magicians of nature to make great discoveries for the blessing of the humanity.
- Scientists have an important role not only in avoiding inappropriate and dangerous decisions, but also advising policymakers and other stakeholders about the best and wiser moves to make towards a human-centered society, thereby fomenting scientific knowledge and enhancing cross-cultural connections and joint research.
- They should also not forget the objective limitations of Science, which is always incomplete. With this purpose, we stress the importance of transferring knowledge among all scientific disciplines, using a transdisciplinary cross-talks approach.
- A few examples of how this may be done are presented in the paper.
- Science and technology are essential tools for innovation.
- To reap their fullest social potential, we need to articulate and solve the many aspects of today's global issues that are rooted in the political, cultural, industrial and economic realities of the human world.
- "There are some objective limitations to science itself. Science is still far away from its goal of knowing the truth, which it always needs to be incomplete; also, science is not the only way to search for Truth."
- Our society is witnessing an era of ever-faster growing revolution at all levels,

in an exponential spiral pace that sometimes may awaken a feeling of vertigo. It doubtless goes towards objective improvements in humanity and nature.

- However, the society is not immune to eventual serious unintended consequences. Scientists have to be alert, therefore, in not only avoiding inappropriate and dangerous decisions, but also advising policymakers about the best and wiser moves to make, since having a human-centered society is advantageous to everybody.
- We should not forget that there are some objective limitations to Science itself. Science is still far away from its goal of knowing the truth, which it always finds to be incomplete; also, science is not the only way to search for Truth.
- There are other valuable ways, such as philosophy, ethics, and religion, which are unfortunately limited too, because we always arrive at concepts of reality which are unintelligible to reason. Now or later, we will always find unintelligible mechanisms that are "left face to face with the awful mystery which is reality" (Dampier, 1971, p 501).
- Before elaborating on these points, we will start clarifying some conceptual generalizations of interest in this context.

Conceptual Generalities

- What do we understand from Science? Etymologically, the term "Science" comes from the Latin scientia (scire = to learn, to know), meaning a process of studying and knowing the fundamental laws of nature, through a dialogue between theory and experiment.
- It is one of the most remarkable inventions of humankind, a source of inspiration and understanding, which lifts the veil of ignorance and superstition, is a catalyst for social change and economic growth, and saves countless lives.
- The function of science is to expand continually our knowledge of the phenomena of nature, giving us an insight into the complex interrelations of

phenomena, or rather between the concepts used to interpret those phenomena.

- The extension of the concept coincides with the extension in the classical Greco-Roman times, in English the word “science” is limited to natural sciences, also known as “hard sciences”, something done in a laboratory; which involves taking measurements with instruments, accurate to several decimal places; and controlled, repeatable experiments where you keep everything fixed except for a few things that you allow to vary. Areas that often conform well to these stereotypes include chemistry, physics, molecular biology.
- This divide between natural sciences on the one side, widening our knowledge of the phenomena of the nature and the relation between the different concepts used to interpret them, and philosophy and arts, on the other side, focused more on human origin and destiny, the project of life, the Weltanschauung, even when it realizes its impossibility of achieving this purpose because there is no human way of solving everything, started in the 19th century (indeed, the word “scientist” was not coined until 1833) and according to Richard Holmes (2016), it was destructive as it was neither a natural nor a necessary divide.
- They are traditionally divided between a primarily basic science, which studies the fundamental laws of nature: in a free search for progress of pure knowledge, from microcosms (atoms) to macrocosms (universe), and a secondarily applied science on how the power of thinking can be increased by pursuing useful purposes and eventual specific practical advantages like medicine, engineering, industry, cyberspace, economics, quality of life, environmental and climatic changes…
- "No single discipline can capture real-ity fully or claim to have the complete knowledge."
- A new call to abolish this traditional division came from Venkatesh Narayanamurti, former Dean of Harvard John A. Paulson School of

Engineering and Applied Sciences (SEAS), in 2008, who described it as artificial, as it assumes a linear relationship that does not always exist—discovery goes both ways, while inventions draw on scientific knowledge and scientists gain insight from new devices and applications.

- Narayanamurti proposes organizing science as a cycle that moves from discovery to invention and back again, a highly nonlinear model, because they must feed on each other, in a cross- and interdisciplinary work that breaks down disciplinary walls and encourages collaboration, which has been successful in some of the top scientific institutions.
- Some of the world's most important inventions were made not by basic scientists and applied scientists working sequentially in isolation, but by those who teamed up, sharing ideas and insights and even sometimes switching roles in cross- and interdisciplinary work. For instance, Bell Labs, home to many important discoveries, such as the development of the transistor in 1947, which laid the foundation for modern electronics and earned eight Nobel Prizes, blurred lines between disciplines, talented personnel, ample resources, and leadership (Powell, 2017).
- There are other disciplines such as social sciences (sociology, economics, political science, history…), and human sciences (philosophy, ethics, theology, art, psychology, anthropology…), usually known as soft sciences. Do they really constitute science at all, and do they deserve to stand beside the hard sciences?
- A key problem is that the task of operationalizing intuitive concepts is inevitably more difficult and less exact in the soft sciences, because there are so many uncontrolled variables.
- Far from colonizing social science under the banner of natural science, some social scientists consider their disciplines as science, and others want to think that the robustness of the philosophical approach is even more intense and transcendent than the so-called natural sciences, say, nuclear physics, because

they offer achievements of great importance. Philosophy is forced to consider science as the best available evidence.

- In its intention of achieving a complete construction of reality, philosophy focuses on human origin and destiny, and its Weltanschauung, or project of life, even if it realizes the impossibility of achieving this purpose—solving all problems, because there is no human way of solving everything (see: Ramirez, in press).

Limits of Sciences

- "What is im-portant is not the objective reality, but subjective perception."
- The continuous appearance of new scientific discoveries—some by serendipity, like the usefulness of some drugs or the law of gravity, which was discovered after Newton observed the fall of an apple—shows that science has no borders.
- Once, when Max Planck went to Munich to study Physics in 1875, somebody advised him not to do so because “there was nothing left to be discovered”, when it is probably Physics that shows better the living continuity of knowledge.
- The desire to know the unknown is what inspires humankind’s search for knowledge; the more we know, the more questions we ask. We want our understanding to be completely harmonious, which is never totally accomplished.
- Science’s quest for knowledge about reality presupposes the importance of truth, both as an end in itself and as a means for resolving problems.
- When we are using science, we are trying to arrive at the truth. In many disciplines, we want the truth to translate into something that works.

- But if it is not true, it is not going to speed up computer software, it is not going to save lives and it is not going to improve quality of life. However, experience says that science can only disclose certain aspects of reality, but not the whole truth.
- Universal truth is beyond the scope of any scientific enterprise. Science is not synonymous with truth. Let us base this assertion on a couple of arguments: the tentative nature of Science, by definition, the subjectivity of the perception, and the undeniable fact of the existence of many scientific studies subject to error and to fraud.
- The nature of Science is tentative by definition, by a scientific self-limitation to believe only what is empirically verifiable, and the emphasis that reality is measurable. Scientific concepts are not realities, but just models: Science is a hypothesis which produces laws which, to be universally acceptable, do not need to have an overall contradiction, even when described from different coordinate systems.
- Examples of common assumptions, which have played significant roles in pursuit of truth: the laws of energy conservation and of entropy increase, causality, constant light velocity in vacuum… Science expands our knowledge of nature, giving us an insight into the complex interrelations of phenomena, or rather between the concepts in which phenomena are expressed.
- But these generalizations, even if they are universally accepted as ultimate scientific concepts, have often proven to be mistaken; they are just inductions, which may be useful, only working hypotheses, drawing more or less probabilistic

conclusions.

- Science, thus, is only a guide to what is probable, an affair of probability; even if the odds in favor of much of it are very high, it is impossible to reach the exact complete knowledge.
- There are no scientific dogmas, there are no certainties in science: all scientific theory is open to challenge; scientific findings cannot be ignored, nor treated as mere matters of faith.
- Our own experience tells us that the subjective perceived phenomena, the human sensations, are not reliable, because what is perceived cannot be separated from the perceiver.
- Knowledge is inevitably constructed by the knower in interaction with his nervous activity, and we should never forget that each scientist has his own values, priorities and may also have all sorts of cognitive biases, prejudices or unfounded speculations.
- Much of the public hears what it wants to hear.
- Thus, although science attempts to unify different ideas, prejudice and self-righteousness, it bases itself on an illusion from a particular viewpoint, and there may be struggles. Many things have to be scientifically understood.
- The same things may look different if our viewpoint is different, as it is evident from the quite well known Indian tale about six blind men who touch an elephant to learn what it is like: The one who feels the leg says the elephant is like a pillar; the one who feels the tail says the elephant is like a rope; the one who feels the trunk says the elephant is like a tree branch; the one who feels the ear says the elephant is like a hand fan; the one who feels the belly says the elephant is

like a wall; and the one who feels the tusk says the elephant is like a solid pipe.

- The different interpretations of the elephant imply that one's subjective experience is inherently limited by its failure to account for other truths or a totality of truth.
- At various times the parable has provided insight into the relativism, opaqueness or inexpressible nature of truth, the behavior of experts in fields where there is a deficit or inaccessibility of information, the need for communication, and respect for different perspectives.
- We cannot thus ignore the subjective experiences and the limitation of our faculties of perception, given that the human cognitive capacity is limited.
- The daily experience also tells us that many scientific studies are subject to error: for instance, wine testers have more sophisticated sensations than ordinary people; the visual field does not perceive any blind spot, even if there is one, known as optic papilla, in the area of the retina where the optic nerve arises; the phi phenomenon takes place when two successive lights are turned on, a sensation of movement of light is perceived, even if in reality nothing moves; or take cryptomnesia, the capacity of remembering something we are not conscious of remembering, mixing real and imaginary memories.
- Many aspects of scientific progress may also be inhibited by fraud, not unusual at all, since that the scientific system is based on trust: some 14% of scientists say that they have witnessed it. For instance, given the logistical difficulties of providing visual evidence or replicating precisely remote field

work, there may be a number of irreproducible (and often poorly conducted) studies, which may foment dishonesty, when scientists or researchers invent data, but which in reality may have come from major manipulation to outright fabrication of data.

Ethical Values of Science

- We do not wish to close our presentation without a brief comment on one of the most important issues a scientist must face in his contribution towards a human-centered society: the relationship of science with ethics.
- Science has been a catalyst for social change and economic growth, and saved countless lives. But, even if in se science is not good nor bad, it is evident that there is always an eventual danger or evil concerning its application.
- For instance, a new anti-malaria drug dispenser of a drug called ivermectin kills Anopheles mosquitoes, the sort that transmit malaria. But, in addition to helping in the eradication of this illness, protecting the people indirectly, by making their blood poisonous to Anopheles, it may also cause other obvious ill effects in the digestive system, turning human beings into chemical weapons.
- The atomic research, besides its deadly applications we all know about (nuclear weapons), may also lead to peaceful applications, like the “tracer elements”, which can be applied as a radio-active method of diagnosis, in cancer radiotherapy or as effective fertilizers.
- All stakeholders have to be conscious of the importance of investment in Science, fostering scientific knowledge through

the interconnections between all its branches with an open mind, transdisciplinary approach, enhancing joint research and cross-cultural connections, and providing funds not only focused on real life problems, but also on the fundamental tenets that will underpin the future of a human-centered society.

- If development of science is important, what is even more important is human development, i.e. development of human beings themselves, which is all about “growing up truly to human beings, capable of governing themselves and the universe through the well-balanced development of science, art & religion”.