



SCIENCE, PARTICIPATION AND DEMOCRACY - REFLECTIONS FROM THE SOUTH

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Thank you very much Dr. Asenjo for your kind words of introduction. It is a great pleasure to be here today. I say this from a number of perspectives. First, it is an honor to have the opportunity to address such a distinguished audience, bringing together representatives of the National Academies across the entire Americas and other important guests. Secondly, as many of you in the scientific community know, I am a New Zealander by birth, and continue to be a New Zealand citizen. Consequently, it is very touching to me, to have been invited by my Latin American colleagues, to speak at this important event. Thank you, Dr. Chaimovich, for your kind invitation. Thirdly, being here on Isla Margarita brings back many old memories. The first academic position I held in my scientific career was at the Faculty of Sciences at the Universidad Central de Venezuela in Caracas. That was over the period 1974 to 1978. Living in an entirely different social setting, from the one that I was brought up in, was a very enriching experience. Needless to say, working in a biologically diverse tropical country, was also, very rewarding. After Venezuela, I went on to beautiful Chile.

The term “Science and Democracy” can be interpreted in different ways.

- One possible interpretation of **Science and Democracy** concerns the relationship between **science and society** per se. This is perhaps the most common reading of the term. Given that scientific research is **financed principally from public funds**, which ultimately come out of the pockets of a country’s citizens, through the taxation system, or from the exploitation of the renewable and non-renewable resources, belonging to the state, and hence to the citizens of a country, it is the respectable opinion of many, that **scientists should in some way reattribute**, or in other words, do something for **society**.
- A second reading of **Science and Democracy** is that science should be **made widely available to the public**. Here it is argued that scientists should take it upon themselves, to empower other persons in society through the transference of their own scientific knowledge, and by showcasing the scientific method.
- A third reading of **Science and Democracy** would be that **science as a livelihood should be conducted under democratic principles**. The main question that can be asked here, concerns whether the scientific community is internally organized, in a democratic manner.

Today I will touch briefly on these three interpretations of **Science and Democracy**.

Considering now **Science and Society**

Scientists of the 21 century face huge challenges, yet at the same time, have enormous opportunities for contributing to society. These challenges and opportunities derive, on the one hand, from the state of our planet, and on the other, from the way the globalized economy has transformed how a particular country does business with other countries. In the information-rich world of today, public awareness on these issues is growing at an amazing rate. The average person on the street knows a good deal about things like global climate change, and biodiversity, and will at least have heard of nanotechnology. As a result, governments and scientific research councils are encouraging scientists to practice science that the general public perceives as useful, or worthwhile, over and above reattribution, for the use of public funds.

Unfortunately, our planet has been very badly mistreated by the human race. Using figures supplied in by Dr. Peter Raven in one of his recent papers; in over a mere 400 generations, the human population has grown from several million people, to over 6 billion. As a result of the spread and multiplication of the human race across the globe, pristine areas have been gradually transformed into high intensity agriculture and forestry as you see in the image. According to Raven, cultivated lands globally now occupy the size of South America, and we have lost about a third of all our forests. Two thirds of the world's fisheries are being harvested beyond sustainable levels. On top of this, lakes and rivers are the repositories of pesticide run-off, and the oceans are becoming acidified.

The new IPCC report issued last February (Climate Change 2007: The Physical Science Base), concluded that “most of the observed increase in globally averaged temperatures since the mid-20th century is very likely to be due to the observed increase in anthropogenic greenhouse gas concentrations”.

We can now be fairly certain that global warming is behind the ongoing melting of Greenland ice sheet, and that significant rises in sea level will occur over the next 100 years. Some parts of the earth will experience more extreme droughts, while others will receive more precipitation.

Even the seemingly indomitable Antarctica appears not to have escaped from global warming. According to an article published by Shepherd and Wingham in the March issue of *Science* (2007) Antarctica has also been losing mass. In the same vein, evidence exists for glacier shrinkage in many parts of the South American Andes, and in other high elevation areas of the world. For example, Mount Huascarán in Perú, an important source of water for lowland areas and especially campesinos is reported to have lost more than 20% of glacial coverage since 1968.

Turning to biodiversity, the IPCC report states that, a significant increase in extinction probability can be expected.

It goes on to say that “There is a risk of significant biodiversity loss through species extinction in many areas of tropical Latin America”.

This last situation is particularly worrying given that:

- a) LAC has five of the world's ten most biodiverse countries. These are: Brazil, Colombia, Ecuador, Mexico and Peru
- b) The **most** biologically-diverse area in the world is found on the eastern slope of the Andes
- c) The region contains high percentages of the world's mammals, plants, reptiles, birds and amphibians
- d) In fact the whole Latin American and Caribbean Region is biodiversity-rich. This can be seen by the presence in the Region of eight of the currently-recognized 34 global biodiversity hotspots. Note that these hotspots are located not only in the tropical countries, but also in the extreme south of South America.

Much of our **Latin American biodiversity has huge economic potential**. Consider the following case. In the 1970s, Chilean and Brazilian species of *Alstroemeria*, the plants you see here, were taken to the Netherlands. By 1996, the *Alstroemeria* flower industry in the Netherlands, was netting around 37 million dollars, on a mere 117 hectares of land. And this was probably just simple floriculture, without use of any of the newer biotechnology tools.

Although clearly there are many problems in the world at the moment, **opportunities for doing creative science** relevant to the environment and society at the moment **are endless**. For example, the predictions on how biodiversity will react to climate change are based, on things, like climate envelopes. Such predictions give little consideration to the biological capacity of individual species to respond to global climate change. The final word as to how plants and animals will react to climate change, in my opinion, is definitely not out. In particular, in Latin America, we need to develop creative field experiments, to determine how species will respond to future climate scenarios. Very little work of this kind seems to be going on at the moment in the Region. Likewise, the large scale climate models of the IPCC are generally too crude to make accurate predictions about precipitation and temperature trends at the subregional and country levels. Thus, there is still much to do here. **Our main tasks as scientists are to understand the effects of climate change in our own back yards, and to narrow down the many uncertainties, thus providing society with the most accurate information possible on these very complex problems.**

As I mentioned a short while ago, other processes have been bubbling up, of late, that impinge directly upon the issue of **Science and Society, and the opportunities for doing creative science**. The globalized economy of today is having a chain-reaction effect. It has thrust every nation on the earth into what might be called the **"Innovation Arms Race"**. Huge economies like those of the

United States of America fear that it will be difficult to compete with the larger of the emerging economies, **without significant innovation**. It is not just the larger nations that are worried - these kinds of concerns affect nations of all sizes and at all levels of development. As a reaction to all of this, governments, worldwide, have begun to adopt the notion of a “**knowledge-based economy**”. At the same time, as never before, governments are looking to their scientists to provide novel scientific, and technological solutions, as well a know-how, for marketing their works.

It would be naïve to think that the kinds of changes being discussed here are not causes for concern in the scientific community. **One issue** that comes up continuously in informal discussions in Latin America is that, **by over-stressing a role for science in society**, scientists will be required to abandon basic science for doing applied science. This concern is not ungrounded. Gregory Fowler for example, who wrote an article in the Professional Ethics Report a few years ago, claims that the practice of science in the 21st century will be entirely different. Fowler feels that **application** is fast becoming the dominant operative tool in science. **A second concern** of scientists in Latin America is that governments and national research councils will tend to focus on a narrow set of priorities, and in doing so, leave many scientists to fend for themselves, in terms of funding. **A third concern** is that the long lead-up time required to discover something innovative might strain the patience of governments and funding bodies.

In the past, as we all know, **science had been practiced mainly in the ivory tower**. Science conducted in this manner, which is driven chiefly by curiosity, and freedom of thought, has enabled us to understand how life began, the structure of genes, the inner workings of the cell, the complexity of the phenotype, the way our planet functions, and numerous things about the universe. Without having had such freedom, referring again to global climate change by way of example, we probably would **not have been able** to make predictions concerning the extent of sea-level rise, on the effects of burning forests on CO² accumulation in the atmosphere, or on the numbers of plant and animal species that will be at risk. We most certainly would not have gotten to the moon, and landed vehicles on other planets. And most probably, there would not have been a human genome project.

Without continuing on with basic science, **we will not be able to monitor the health of our planet** during the next 100 years. Nor will we be able to test the many predictions on the behavior of plants and animals under global climatic change, as I mentioned earlier. When it comes to major innovation, **the situation is even clearer**. Some innovative solutions obviously will come out of earlier scientific endeavors, such as the Human Genome Project, and for that, countries evidently need to train more applied scientists. However, in today's world, with some notable exceptions, like the internet and the cell phone, what is innovative today, tends to become obsolete tomorrow. Therefore as long as the “**Innovation Arms Races**” keeps up, countries will be obliged to make significant inversions in basic science. Doing science that is relevant for society and development, thus,

requires keeping up excellent basic science, while at the same time expanding the capacity to do applied science. It does not mean reducing basic science at the expense of applied science.

Nonetheless, in order to make significant contributions to society and socio-economic development we basic scientists **will be required** to focus on particular systems, selected organisms, a limited number of diseases, and critical ecosystems and areas of the world. What is badly needed at the moment, are propositive mechanisms, to get basic scientists to think about where they can make worthy contributions for the good of society. The challenge facing us is to frame important societal problems in ways that create opportunities for using the best basic science and technology. A useful framework for starting such discussions, are the Millennium Development Goals. Perusal of these goals show that there is much room for basic science in almost any discipline you want name. The next step would be to have groups of high level scientists in a country come up **provocative research themes**, which are then circulated throughout the scientific community. This last idea is borrowed directly from David Omenn's AAAS Presidential Address delivered in St. Louis last year. In that address, the major challenges in many different areas of science were compiled, based on what the scientists themselves came up. The next slide gives you a selection of some of these **Grand Challenges** cited in the Omenn's paper - a huge variety of themes. It would seem useful to undertake these kinds of exercise in Latin America where the expertise and the needs are different. A predicted result of such an exercise is that the scientific community should eventually come to feel more at ease, with its societal responsibilities.

Institutional arrangements are a critical part of the changes that science is presently experiencing. The great challenges in science today require a collage of big laboratory science, informatics, long term ecological studies and global level comparisons. This translates into larger and longer-term financial commitments. Ideally, basic scientists and applied scientists should be able to interact on a daily basis. In Latin America, most science is still practiced in university departments, which break down along traditional disciplinary lines. Thus, we are not in an ideal position for integrating basic and applied science in this part of the world. The possibility of integrating the social, natural and exact sciences, as is called for in the Millennium goals, is even more remote.

Turning now briefly to the issue of **priority setting**. This is clearly a difficult question for scientists who have been brought up to do research on the topic of their choice. From a democratic point of view, the setting up of priorities can be looked at from different angles. Where there is a chance of an important economic gain, which, theoretically should trickle down into the population at large, as with the development of biofuels in Brazil, it could be argued that the democratic thing for a government to do, is to set a priority. Nevertheless, when the aim is develop science for long-term, socio-economic sustainability, I would argue that **Governments and Society should be tread carefully**.

For long-term sustainability, a country needs to **use the collective skills of its scientists**, both in terms of scientific excellence and leadership, in order to come up with the right mix of science. When it comes to determining that mix, I believe that a bottom up approach rather than strict priority setting is preferable. By this I mean, that a researcher or group of researchers should have the right to come up freely with some novel idea for funding. Such a bottom-up process, apart from being more democratic, should have the effect of distilling out of the scientific community what can **realistically**, be done in a country. A bottom up process is also more likely to lead to transdisciplinary scientific efforts.

A bottom-up approach can also help a country **detect major knowledge gaps and guide future capacity-building efforts**. At the same time, it should help to avoid inappropriate imbalances. Consider the following example. In Latin America today, biotechnology tends to be seen as a major window of opportunity for enhancing innovation. This decision has been endorsed at high political levels, with the emergence of many research groups across the region. In the meantime, research relevant to the environment has been lagging behind.

I would be willing to bet, that with access to 25% of the resources put into biotechnology, the environmental and social scientists, could have made enormous contributions toward projecting the biological uniqueness and green image of Latin America, to the benefits of the tourism industry, with all the attendant benefits, that tourism provides for local communities. I have nothing against biotechnology in principle. My main point here is that socio-economic sustainability requires a **well balanced canasta of scientific efforts**, including the most adventurous and esoteric in order to foster national pride.

Moving on now to making science widely available to the public:

There are numerous societal advantages, and potential gains, for the scientific community itself, of making science widely available to the public, at all levels. Science requires precision, repeatability and non-ambiguity, in terms of how it is communicated. Consequently, the case may be made, that use of the scientific method, as a framework for thinking, tends to **enhance the self-sufficiency of citizens**. If you think about it, scientific tools are useful for any citizen, in his/her daily livelihood. Or course, sociologists, artists and poets would probably come to a similar conclusion, with respect to their own particular skills. In Latin America language comprehension and mathematical skills, still lag behind in many countries. Therefore, instilling the scientific method into school children, through real world examples, is bound to have positive effects. On the other hand, improving science literacy at all levels, should lead to greater public support for science per se, and thus benefit the scientific community at large.

In the environmental sciences in particular, transferring scientific knowledge about biodiversity, climate change and related subjects, to national park guides,

school children, high school teachers, and land-owners, can have concrete, **practical benefits**. Let me refer to the case of biodiversity, which I know best. According to United Nations figures for the year 2003, protected areas presently occupy 11.5% of the Earth's land surface. Nobody really knows how much of the world's biodiversity these areas contain when it comes to individual species. What we do know, however, is that it will be impossible to include all species in protected areas in certain parts of the world, because of the way plants and animals are distributed across the landscape, in relation to agriculture, rangelands and forestry development. This means that significant amounts of biodiversity will, necessarily, have to be protected in the managed landscape itself, or in local parks, botanical gardens and zoos. A very good case is seen in central Chile where I have been working on this kind of problem. Around 19% of Chile's land surface is found in protected areas - a very high figure by international standards. However, the distribution of protected lands is unequal along the length of the country. Central Chile and central-south Chile comprise an internationally-recognized biodiversity hotspot for conservation priority, but as you can see in the graph, very little land is protected in the hotpot area. The uncomfortable thing is that 45% of the species, using the large genus *Senecio*, as an indicator, are not found in any protected area. Many of these species are found somewhere in the managed landscape in central Chile. In the Institute of Ecology and Biodiversity (IEB) that I direct in Chile we have been undertaking workshops on biodiversity conservation with school children, professional people and national park guides, in order to encourage local conservation measures in the managed landscape. We have also been working with young school children in the extreme south of the country, on Navarino Island, where a new Biosphere reserve was recently set up.

Another area in ecology where transferring scientific knowledge to children and local people could become very important, concerns **invasive species**. Invasive or exotic species are those brought to a particular geographical region accidentally or intentionally, by man. Many are troublesome weeds, causing economic loss. We know, from dating molecular phylogenies that plants and animals have always been migrating from one place to another, all over the globe, as seen here in the genus *Lupinus*, which moved into South America, about 2 million years ago from North America. We also know that evolutionary lineages have been moving up and down steep environmental gradients, as in the Andes, giving rise to new species, as seen from the molecular phylogeny of the genus *Chaetanthera*, studied in our laboratory. But these natural, non-man assisted migrations have occurred slowly, over millions of years. When it comes to exotic species, carried around by man, the situation is very different. Without being able to go into detail, I have estimated the rate of exchange of exotic species, between Chile and California, to be orders of magnitude higher than the background rate of natural dispersal, between the two continents. Right now, every country in the world, including its seaports, is being silently invaded by exotic species. Such exotic species turn up in the most unexpected places. The latter tells us that we need well-trained national park guides and local people to recognize when a strange creature, be it a plant, or an animal, turns up. This could be achieved by scientists transferring their

knowledge on invasive species to local people, so as to make them, more vigilant. And these of course, are just two examples.

With respect to **science outreach**, it is worthwhile pointing out that Latin America and the Caribbean has made enormous strides, over the past decade or so. Many National Research Councils, Ministries and Academies now have special Outreach programs. These range from the more traditional national science fairs, to radio talks, drawing competitions, etc, etc. It is really exciting to see so much progress.

The press is clearly another **crucial vehicle** for getting scientific results into the public domain. In preparation for this talk, I decided to survey the five main newspapers in each country in Latin America and the Caribbean, for inclusion of a science section. You can see that many of the main newspapers in Region, today, have Science and/or Technology sections, or a combined Science and Technology section. It is interesting that, such newspapers span the gamut from the more developed to the less developed countries, in the Region. This seems to indicate that Latin America values science as a vehicle for development.

Nevertheless, we all need to be aware, that, as science become more widely reported in the press and in magazines, cases of inaccurate or unfair reporting are likely to appear. As a possible an example, I would like to refer to an article published in the May 19th (Page 13) issue of the *Economist*. The *Economist* ran an article commemorating the 300th anniversary of the birth of Karl Linneaus, who you will all remember, is the father of taxonomy. After explaining the contributions of Linneaus, the article went on to explain that taxonomy was an evolving science, later citing the newer molecular methods, and that the taxonomists did not always get things right the first time. However, then the article went on to insinuate, that some biologists were **upgrading subspecies** to the species level, so as to be able to show that a particular geographic area contained more species. By doing this, it was argued, they could then argue for more conservation measures. This conclusion was based on, **quote**, “a suspiciously large number of new species have turned up in the limited group of big, showy animals known somewhat disparagingly as “charismatic megafauna”, in other words, the species that the public, as opposed to the experts, care about”, unquote.

No data on other groups of organisms were given in the article, nor was anything said about the relative intensity of sampling among the different groups of organisms. There was no indication that this analysis had been published somewhere, or whether the author of the article had obtained information from a scientist. If a scientist has supplied the information, his/her name should have appeared in the article. This article clearly would not have been published in a peer-reviewed journal. Yet the *Economist* is a magazine that is read by many professionals worldwide, to the extent that an article of this kind could have negative effects on the public perception of science. Of course, to be fair, one needs to track down the original scientific article (s) in order to see where the

original information came from. In any case, scientists need to be trained on how to interact with the press.

Does the scientific community function internally in a democratic way?

I think it is fair to say, that the perception exists, in the general public that **science is about searching for the truth**. Thus, if science is looked up to in society, the **internal behavior of the scientific community**, ideally, should **minimally, reflect democratic and strong ethical values**.

Notwithstanding the fact that science is based on excellence, and is considered by some to be elitist, the scientific community does have a number of democratic practices that it can be proud of. Some examples are the peer review process for acceptance of scientific papers, the right of a scientist to challenge a reviewer's comments, and the rotation of scientists on research panels.

Referring more specifically to Latin America, it is difficult to know exactly how we are doing in these various areas, because of a lack of information in the public domain. The democratic process seems to be adequately installed, insofar as the scientific journals are concerned. However, whether the process of research proposal review is entirely democratic in each country of Latin America is not entirely clear. A good starting point (where it is not already being done) would be to periodically publish a list of the reviewers of grant proposals. It is true, that publishing a list of names is not a total guarantee in itself, but, it would certainly help.

It is widely recognized that **the participation of woman in science** is one area in which the scientific community, all over the world, has still a long way to go, in order to receive the stamp of democracy. Experts seem to agree, that the overall intelligence of men and woman is similar, although there may be differences in some aspects of our respective cognitive abilities.

According to UNESCO figures, in Latin America, woman presently make up 50.3 % of the population. The issue of gender in science has begun to take off, as seen in the Bariloche conference, which was organized by UNESCO and the Secretary of Science and Technology of the Ministry of Culture and Education in Argentina. Some national research councils, as in Chile, have inaugurated special sections on **Woman in Science**. However, it is difficult at the moment to come up with reliable Regional figures on the participation of woman in scientific research. The Red de Indicadores de Ciencia y Tecnología Iberoamericana y Interamericana (RICYT), has now started to maintain data, according to gender. However in RICYT, data are still lacking for many years and entirely for several countries. Notwithstanding all these various pitfalls, using the RICYT data, the following trends arise: a) major differences exist among the Latin American countries in terms of the participation of woman in research, from a high of 51% to a low of

26%. The **country-wide average for Latin America comes out at 38.5%**. This last figure, interestingly, is quite high.

According to the European Union She-Figures (2006) women comprise 29% of the total number of scientists (2003). Figures given in Handelsman's (2005) recent paper in *Science* for the top 50 departments per each of 12 research areas in the United States, provides an average of 22% across research areas, for the level of assistant professor, which is even lower than in Europe. As to other tendencies, in the three regions mentioned, there are indications that the proportion of women transitioning into the higher ranks of science drops off dramatically, as seen for the European Union, and the USA. Some data for Brazil suggests a similar situation. Some recent data for Chile show that, as in the USA, physics and mathematics attract proportionately fewer women. In Chile, we also see a trend for projects submitted by women for funding to CONICYT, to be less frequently approved than those submitted by men, although this tendency seems now to be leveling off. The reasons for the latter trend are not clear.

Although the Latin American figures for the participation of women in research are auspicious, I believe it would be **unwise for us to sit on our laurels**. As more sophisticated and more competitive scientific communities emerge within the Region, it stands to reason that it will become more difficult, for women to keep abreast. As Latin America's population becomes more educated and the average income increases, the possibility of being able to count on childcare in the home, will tend to become a luxury. Access to child care in the home would seem to explain, at least in part, why proportionately more Latin American women can go into science than in North America and Europe. Given the ongoing trends in science, and the evolving socio-economic setting in Latin America, all other things being equal, the participation of women in science in Latin America over the next couple of decades, might not increase.

To finish, I would like to make a few general statements.

A) With respect to **Science and Society**, we scientists need to realize that presently there are probably more opportunities for carrying out science relevant to society than ever before. But the ball is squarely in our court. Scientists should carefully nurture the emerging "contract" between science and society in its various dimensions for the good of society, as well as for the future of science.

B) With respect to promoting **science literacy in society**, I would like to make a concrete suggestion to the National Research Councils and other funding bodies. Why not require a **mandatory outreach component in every research proposal**. By doing this, we would have much to show at no, or very little extra cost. However, as far as I can tell, very few research grant competitions per se, require an outreach component as part of a grant. If one outreach activity were required of every researcher in Latin America every year, we would rapidly come to have a

lot of things, to show, in this domain. Also, credit needs to be supplied to scientists who undertake Outreach.

The countries of Latin America are rapidly catching up with the developed countries in terms of the quality of their science. As an example, currently, for research proposal evaluation, CONICYT-Chile gives credit to publications indexed in ISI, and takes the impact factor of the journal into account. If the scientific community and governments agrees that increasing scientific literacy in society is desirable, then this kind activity should be given some recognition in academic reports, grant proposals and grant reports. **This is not to say that Outreach should become a substitute for ISI papers.**

A parallel situation of course, applies to patents. The issue of giving credit for undertaking outreach has another angle. In highly competitive societies, individuals tend to act primarily within their own self-interests. Such individual, can get to the point of losing touch with the outside world, including in their own academic departments. I have noted that, scientists who engage in outreach in addition to writing scientific papers, tend to have a different mystic, suggesting that they become motivated by a concern for the common good. Giving credit for outreach efforts, thus, is not only desirable for those persons already involved, but, would also tend to encourage more scientists to engage, in a healthy activity

C) In relation to the democratization of the scientific community, **one of the biggest challenges is the issue of woman in science.** In Latin America better regional data bases are fundamental to grasp and analyze this problem in an objective manner. It might also be useful to analyze the careers of woman who have had successful careers in order to get a better understanding of the difficulties woman face. We need the help of the social scientists here. Having said all this, it is my personal opinion that a woman who opts for bringing up her children combined with less demanding work, should in no ways be considered inferior. In fact this last possibility should also be open to men. In the past, for reasons that are comprehensible when there is a major societal issue, there has been too much stereotyping on both sides. The ideal situation would be a **diversity of options open to both man and woman.** This would allow individual members of both genders to make the most appropriate choice for leading a fulfilling, productive and happy life, which ultimately is what really counts.

Thank you for your attention.

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