Bruce Alberts

Bruce Alberts, Editor-in-Chief of *Science* magazine, and one of President Barack Obama's first three Science Envoys, spoke to *Current Science* on 20 January 2012 during his visit to India. Alberts, who served two six-year terms as President of the United States National Academy of Sciences (NAS), once quoted Vernon Lyman Kellogg, an important early leader of NAS: Let science, then with all encouragement, play undisturbed its glorious role of bettering the lot of individuals ... . Let it prove all things, discover truth, and teach truth and the way of its discovery. Let it attend, undistractedly and unwearyingly, to its great effort to make our land a better land for our children and our children's children to live in, and the human future broader and better than the human present[1].

In many ways, Alberts' career mirrors these sentiments, but on a global scale. While at NAS, he travelled to schools and villages in countries such as Africa and India, studying the application of science to society. He was part of two Frontiers of Science programmes – one with China and another with Japan – which involved interaction between scientists from the participating countries. For the period 2000–09, Alberts served as the co-chair of the InterAcademy Council, an organization in Amsterdam governed by the presidents of 15 national academies of sciences and established to provide scientific advice to the world.

Throughout his career, Alberts has emphasized scientific values such as 'honesty, generosity, a respect for evidence, and openness to all ideas and opinions irrespective of their source'[1], while promoting science education. Many of his editorials in *Science* have focused on redefining and improving science education, both in the US and around the world. At his home in San Francisco last year, he played a major role in developing the first Bay Area Science Festival, an event attended by over 70,000 people, with over 100 events designed to inspire children into science.

Alberts was born on 14 April 1938 in Chicago and completed his undergraduate degree in biochemical sciences (1960) from Harvard College and his doctorate in biophysics (1965) from Harvard University. After his postdoctoral fellowship at the National Science Foundation (1965–66), Alberts held various posts at Princeton University and at the University of California, San Francisco (UCSF). He is one of the authors of a leading textbook, *Molecular Biology of the Cell*, now in its fifth edition, and currently serves as Professor Emeritus of Biochemistry and Biophysics at UCSF.

He has numerous awards and honorary degrees to his credit, and serves on many advisory boards for non-profit institutions. He has made a number of appearances on national and international television as a spokesman for science education, such as the 'Charlie Rose Show' in 2008 and 2010. At 73, Alberts is still a tireless steward of science.

Bruce Alberts interacting with young scientists at the Indian Institute of Science, Bangalore on 20 January 2012.

Have you been to India before?

Many times.

When was your first visit?

My first visit to India was in 1993 when I had just become President of NAS. There was an important meeting – the first ever meeting of all the academies of the world. It was hosted in New Delhi by INSA, the Indian National Science Academy. Prakash Tandon, who had since become a close friend, was the President of INSA at that time. The meeting focused on providing a voice for scientists on the population issue that was going to be the focus of the famous Cairo UN meeting in 1994. Because of this effort of the academies, Tandon was invited to Cairo to present the position of the science academies on population issues. But the most lasting contribution was the formation of the InterAcademy Panel (IAP). On the last day, a half-day session was held to discuss whether there should be a permanent organization of academies set up, and everybody was enthusiastic. I was very naïve about international science issues and was mostly a listener at that meeting. This was my first real experience with international science at INSA. Since then, I have been back to India many times.

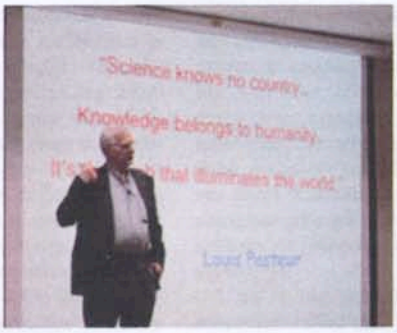
When was the InterAcademy Panel actually set up?

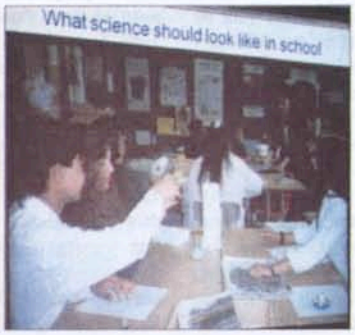
About a year later after that...people say it was really set up at that meeting, but getting it all set up and going took more time. Now of course, it is a permanent non-government organization centred in Trieste, Italy and the Italian government is supporting it.

How many academies are part of it?

There are now more than a hundred academies and it keeps growing.

Box 1. Science and the world's future





In a lecture at the Indian Institute of Science, Bangalore on 20 January 2012, Bruce Alberts spoke on important policies for strengthening science, and lessons from his personal life that could help young scientists. Some points from his lecture are presented below:

- Scientists are optimists, having seen problems being solved all over the world.
- One can learn from failures; Alberts' own failure in a Ph D exam at Harvard in 1965 was the most important point of his career. Senior scientists can help as mentors to younger scientists, as they have failed many times and learnt from these failures.
- Our textbooks lead us to believe that we know 95%, but what we know is only 5%; there is a lot of scope for discovery.
- It is critically important that science and scientists achieve a much higher degree of influence, throughout both their nations and the world.
- To generate scientific temper for a nation – we need good science education for all. This requires constant attention from the scientific community.
- Science should be approachable. Students should feel good about science, and this depends on how we teach it.
- To keep science healthy, we must work to stimulate innovation. Science should be like art; the most effective scientists are the most creative.
- The fundamental reason for the explosive growth of science is that – 100 units of knowledge can be combined in 100 times more ways than can 10 units of knowledge. But there is a catch: as knowledge grows, it is difficult to find the right combinations. Also, there are unexplored and overcrowded experimental spaces.
- Alberts suggests that institutions should support modest-sized laboratories (maximum of 9–12 people), each headed by an outstanding, innovative and independent investigator. These laboratories should be embedded in a cooperative culture in which techniques and equipment are freely shared. Risk-taking, originality and random collision of people and ideas have to be encouraged.

What about Indian academies?

Of course; in fact, Tandon was a leader of IAP in its initial years. The rule has been only one academy per country, and the member has been INSA.

How practical would it be to hope for collaboration among scientist-peers who are concerned about patents and plagiarism? Even within institutions (especially in India), there is very little interaction amongst scientists in different departments.

My observation in many different contexts is that true collaboration begins when you get people together to do something that is meaningful – like teach a new kind of course that is partly chemistry and partly biology, or try to write a report with advice on an important issue. At our Academy, we write many such reports. We put a mixture of very different people on each panel that tries to provide advice to government on how science should inform decision-making – on an issue like some aspect of agriculture or the environment that is important for society. Our Academy in Washington has nearly 600 different committees working at one time. So, we are doing a lot of mixing of people with different backgrounds, and after the committee is over, those people then often continue to interact.

A suggestion that I would have for India would be for at least one of the academies to have a strong focus on providing the same kind of scientific advice to Indian society and to the Indian Government. I know they do a little bit of that now, but not nearly enough.

Is the trust between scientists and society eroding? People used to believe that what the scientist said was true, but now people are getting more educated and aware. Each scientist tells you different things and the layperson gets confused on what is happening and whom to believe....

This is an important issue. Of course scientists can, on occasion, get famous for correctly challenging the conventional wisdom. But the consensus of the scien-

tific community is usually right. In the United States, if you have a discussion on climate change, the media can always find somebody who does not believe in the science of climate change. This scientist gives the public misleading information – so that for many people it becomes unclear whether there is a problem or not. This is why our Academy in Washington is such an important entity in the United States. It is asked to report out the scientific consensus on issues like this; the Academy's consensus has a lot of prestige and it goes out to the newspapers and to the government. Our Academy keeps saying over and over, in successive studies, that it is 95% certain that a dangerous amount of global warming is going to incur due to human activities. The problem, of course, in communicating science is that we never want to say we are 100% sure of anything; this is because the past shows that sometimes we find out new things and what we thought was true becomes no longer true.

The critical issue of science communication calls for a much greater effort by the scientific community – to interact and speak with all kinds of groups in the public – not only the politicians but people in society, the business people, the organizations in their local community. That means scientists have to spend some time away from their research; otherwise science will not be successful. It also means we have to train scientists on how to communicate because, as you know, if a scientist talks the way he or she would talk to colleagues, he or she would use all kinds of words and abbreviations that nobody else understands.

I am a big fan of training students, young people, in not only how to do research but how to communicate and how to teach, in order to give them skills they are going to need in the future. Every nation is going to need scientists who think their job is not only to do their research, but also to teach the next generation of scientists how to be a scientist, and how to interact with the public to explain why science should be meaningful to them and why it makes sense for the government to use public funds to support their research.

What about collaboration with science writers for scientists who find it difficult to communicate? The majority of the scientists and science writers in India don't seem to be able to collaborate.

Some scientists just can't do it, but most could. We shouldn't force people who are very shy or who don't seem to have any ability to interact socially with other people to interact – those people probably won't be effective. But there are many young scientists who would be terrific communicators of science. And I think the public would like to know and see them. It shouldn't be only the older scientists who go out and interact with students in school, public groups and politicians.

I am a big fan of an international movement called the Young Academy. It is a special way to empower the very best young scientists that do something for their country besides their science. This type of institution was first established in Germany; now there are about ten countries that have Young Academies. There is also a Global Young academy with an office in Berlin that is trying to help many other countries form a Young Academy. This is a very different kind of organization than a regular Academy in the sense that one is only a member of a Young Academy while young! So the appointment is for five years, after which the scientist is not a member anymore. In Germany, the Young academy contains about 80 young people who are learning how to be leaders; at age 35 to 40, they are old enough so that it is clear that they are going to be outstanding scientists in the future.

This is a way of training people to communicate, to take responsibility for more than their own work and think about national issues like getting science to work better and improving the education of young people. Very importantly, the older scientists don't tell the young people what to do – they just give them a little bit of resources and tell them: 'You have to do something for your nation', and the members of the Young Academy decide for themselves what they want to do. Many Young Academies have focused on science education for younger people, issues like that.

To what do you attribute the success of Science as a widely read magazine?

All my predecessors. We have terrific people working on our staff. Mine is a half-time job, so I can't take much credit. There is a very talented group of editors who select the papers and edit them. They are all scientists, people who have both graduate student careers and after their Ph D have done postdoctoral work; so they are very sophisticated scientists. Our editors also learn a lot by reading all the papers they have to read every year! Each editor handles about 700 papers a year; so it is a very demanding job. And of course, we only accept about 5% or so of the papers that are submitted. *Science* also employs a similar group of very talented news writers from all around the world.

I think a major challenge is how to get more young people to read *Science* magazine – not only the research articles, but also the front half with News and Commentary, which extends their view of science, makes them citizens of science, empowers them to be better scientists, and also exposes them to a wide variety of different kinds of science from which they can derive new ideas. One of the big issues that we have in science is how to stimulate more innovation – encouraging and incentivizing innovation and risk-taking – because without that we won't have really major advances.

In most cases the education system does not encourage this kind of risk-taking. It is mostly a standard model where you memorize things... Ralph Waldo Emerson said: 'Men love to wonder, and that is the seed of science.'[2] Do we allow our young students to wonder?

I think India is famous for memorizing, and so are many other countries. Lately in the United States, we have damaged science education at lower levels by too much emphasis on studying for tests. In 2008, I didn't want another job; I thought I would be able to retire. But the American Association for the Advancement of Science offered me this opportunity and said that if I took it, I could use *Science* magazine to try to advance science education. In fact, I have been writing about the need to redefine science education, even what the words 'science education' mean. In my redefinition of science education, it becomes active science learning, solving problems – science as inquiry. In many places in the United States, science education has come to mean memorizing all these words about science.

My editorial this week is called 'Trivializing Science Education'[3]. Next week, my editorial[4] is again about education – what we need to do to change it. I give an example of what can be done even with five-year old children – trying to empower them with the skills of scien-

tists for problem solving and for looking for evidence for statements. This is important for everyone, especially in a democracy in which everyone needs to vote without being fooled by politicians with simple answers. I think every democracy, including India, has to worry about its education system just to maintain democratic values and the wise judgements that people must make to ensure the future of the country. This is a huge issue and certainly needs a lot more involvement of scientists, because in order to teach active science learning you need to help the teachers learn how to do that.

So we need more training courses for teachers?

Yes, and different kinds, and with more energy going into this great need and opportunity to teach science quite differently. The scientific community should be taking this up and pushing for it, because who else is going to do it?

Your advice for Current Science?

I get *Current Science* at home. It is doing very well I think. The major issue is how to get more of what is written out to the general public and the general press. A suggestion would be to put more resources – if you could find them – into a press office. Our (*Science*) press office has a fair number of people in it; it is a major effort, and it is very successful in getting important issues out to the public. Right now, we are dealing with bird flu, for example. We have a paper in press that contains information that a special government panel in the United States, composed of outstanding scientists, thinks is too dangerous to put out to everybody. So for the first time ever, *Science* magazine is probably going to leave out some details in the scientific article that we publish. But before we can do that, the government must produce a transparent plan that allows those who need to know the missing details to get them. This is a huge issue and the public can be frightened; it is easy to be frightened because bird flu – if it spreads – is very dangerous. So it is very important to get accurate information to the public. Just today we put out a series of review articles with this aim, and we will be publishing more. This information has to get to the general press, so the general press can put out accurate information to the people. This is very important; otherwise you could have panic, you could have all kinds of things happening.

I was recently in Japan where there was a failure of the scientific community to get accurate information out to the people who live in areas that now have some radioactivity from the nuclear reactor accident. The Japanese scientists are trying to organize a new kind of mechanism so that next time this happens, they will be able to quickly provide information to mothers and families about what is and is not dangerous. In the absence of such trusted information, those who don't know anything will probably overreact; many in Japan are probably suffering from this now.

To focus on India, you have a big problem today in exploiting your own talent and resources to produce better crops for feeding people using modern biotechnology methods. You can develop *Bt* eggplant yourself and many other kinds of products that use science to address major problems for poor people, and India has lots of poor people. Africa also has large numbers of people who need access to the benefits of modern science, and yet a scientifically misinformed and frightened public might prevent both India and Africa from using these important tools. That is another example where science communication will be key.

But the authorities who are involved don't seem to take the initiative to communicate with the public...

Our Academy has played an important role in the United States on such issues, trying to examine all these questions objectively. We put out many reports that are relevant; we put out a recent report where we looked back over all the years of using genetically modified crops in the United States (which occupy huge amounts of land), and there has been no adverse effects that anybody has ever seen. It is important to use this kind of science to move forward rather than being blocked by fears that are not warranted. So this provides a great example of science communication.

What role can India play in promoting science on a global level? What steps do we need to take?

Well, you are doing lots of things already; for example, science fairs for children that help develop and identify talent across India. In the last few days, by talking to many different scientists independently, I learned that many of India's best science graduate students have come from the villages. Your people provide a great resource for India that is not being fully exploited now. I see a great opportunity and challenge for scientists working with educators to see how – by using modern tools and giving access to the Internet – they could reach many more young people across India who can contribute to the future of India.

What are the challenges facing international science in this century in terms of societal applications?

There are so many problems before us. We need to do intensive new kinds of work and new creative ideas to create new technologies for meeting energy needs – both energy saving and energy harnessing. We face a forecast of major food problems due to increasing population and wealth in the world. We have many different environmental problems, all needing scientific solutions, such as water shortages – how to use science to use water more efficiently? We also face health threats – as the world gets more crowded with people and animals, the chance of major pandemics or infections increases. There are almost limitless challenges to world science.

The challenge for scientists is to create systems that are more productive in producing good science. To take an example from India, you have a terrific start but you need a lot more university science, and you need many more outstanding institutions. There is talk of increasing funding for science, but there are barriers to making good use of money – the famous or (I would say) infamous Indian bureaucracy. The fact that, for example, scientists are distrusted and subjected to the same financial oversight as people who are building roads is not appropriate. I think India can learn a lot from the United States in producing mechanisms that remove the barriers that prevent your resources from being more effectively used. So there are lots of challenges inside the community to make science more effective and more efficient.

In your speech in 1999, you mentioned a vision for science in 2020 (ref. 5). How far have we come in realizing that vision?

That was largely based, as I remember, on my time in India. I have visited M.S. Swaminathan's projects, called Information Villages, about five different times. He has a vision for applying science to the majority of Indian lives – improving their lives in a way that is meaningful when thinking about world science. How can world scientists contribute more broadly to their own countries? And India is a great test case. So you could be real leaders in this area. I don't understand why more government resources are not put towards the goal of using science to improve the lives of all Indians. For example, you could have a competition across India for government money to set up institutions like Swaminathan's that focus on bringing the benefits of science to the poor. The M.S. Swaminathan Institute in Chennai is mostly funded by private money that he raises from winning prizes and things like that; not many people could do that. But his model and others could be the basis for competitions to form ten new institutions across India with the same aims. So there are great opportunities in India to do more with science for the public.

Of course, the vision has not yet been realized...

Do you think it would be realized by 2020?

I hope we will be better off. We are not going to get all the way there.

During the 99th Indian Science Congress that was held between 3 and 7 January this year, there was talk of increasing the total R&D spending...

It has to happen gradually; India cannot do it all at once and the much needed new funding has to be spent well. You have to do things like fix the bureaucratic obstacles. *Current Science* for example could do a lot, not only to try to get information from active working scientists written up about what needs to be changed – this is the kind of thing that we do in *Science* magazine all the time – but also once this information is written up, to get it to the news media and to the other people who need to know those things.

Anything that you would like to add?

I think it is an exciting time to be living in India. You have a great tradition starting with Nehru of focusing on science. In most of my talks, I talk about Nehru's statement about wanting a 'scientific temper' for India. We need a scientific temper not only for India but also for the world – rational people who are tolerant, willing to look for evidence for statements and to change their mind if they see that they were wrong before, to listen to other people's ideas and respect other people's ideas if they make sense. This is why I am putting in so much emphasis on science education for children – to actually enable them to understand and behave like scientists in their lives; not to be scientists but to be rational problem-solvers and analysts of all the kinds of confusing messages that we have in our society, people trying to get your money on the Internet, politicians trying to get your vote. It is very hard to weave your way through life without getting fooled. Also of course, these kinds of problem-solving abilities are great for being contributors to the workforce; people who work in any kind of company will need to have those skills. So there is every reason to put a huge effort into a new kind of science education for all children. The problem is of course that we need a massive effort in teacher training. We need a massive recognition by the scientific community that this is crucial to them and their countries. That takes a cultural change, which is hard.

Do you think scientists take themselves too seriously?

What do you mean 'take themselves too seriously'? You mean they are too arrogant, that they think they are too important to spend time on other things besides their own science? Yes? Okay, there is some of that!

Ray Bradbury says: 'Touch a scientist and you touch a child.'[6] He also says: 'The best scientist is open to experience and begins with romance – the idea that anything is possible.'[6] On the one hand, you have child-like behaviour in a scientist and on the other hand you have arrogance...

There was a programme at the US Academy for science education that was called 'Every Child a Scientist.' I think what Bradbury means is that every good scientist should be like a child – inquisitive and willing to explore things. There are some aspects of childhood that are not good; you have to be grown up in other ways.

I have this other quote by Charles Pierce: 'There is one thing even more vital to science than intelligent methods; and that is, the sincere desire to find out the truth, whatever it may be.'[6] But Paul Valery notes: 'The folly of mistaking a paradox for a discovery, a metaphor for a proof, a torrent of verbiage for a spring of capital truths, and oneself for an oracle, is inborn in us.'[6] How do we overcome our shortcomings in the search for truth?

A scientist must fight against a natural bias to believe one's own theories. When you do experiments, you should not be trying to prove your theory; you should be trying to test your theory. So, the inborn biases can ruin your science. You can't be a good scientist with a bias against what the truth actually is.

1. Alberts, B., http://biochemistry.ucsf.edu/labs/alberts/Editorials/Speech8.pdf
2. http://www.brainyquote.com/quotes/topics/topic_science2.html
3. Alberts, B., *Science*, 2012, **335**, 263.
4. Alberts, B., *Science*, 2012, **335**, 380.
5. In ref. 1, Alberts talks of a Really Big Idea: 'By connecting all scientists in the world to each other and by providing them with rapid access to valuable information stores, we aim to increase both the potential value of scientists to their societies and their status in the eyes of their governments and fellow citizens. As Bronowski emphasized, we will thereby also promote the worldwide diffusion of scientific values. And with scientific values we shall spread tolerance and democracy, until they encompass all of the people on this globe.'
6. http://www.brainyquote.com/quotes/topics/topic_science4.html

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