ISSUES IN SCIENCE POLICY

PROMOTING SCIENCE, EDUCATION AND SOCIETY: THE ACADEMY–GOVERNMENT CHALLENGE

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PROMOTING SCIENCE, EDUCATION AND SOCIETY: THE ACADEMY–GOVERNMENT CHALLENGE

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edited by

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Foreword

Irvin Asher and Meir Zadok

Science is constantly expanding both its contributions to national competitiveness and its share of national budgets. What is the role of national academies of sciences in this rapidly changing environment? What do government, industry and society as a whole now expect from national academies, and how can these expectations be met while balancing academic freedom, public funding and pressure for societal feedback? How do these new opportunities affect the national academy–government relationship, and how, at the highest levels of national science policy, can the unique long-term contributions of a fully autonomous, objective body of scholars be protected from the clamor of short-term political interests? How have various countries, large and small, faced such pressing issues, and with what results?

As part of its ongoing series of international workshops on science policy, the Israel Academy of Sciences and Humanities invited Prof. Bruce Alberts, President of the U.S. National Academy of Sciences; Prof. Emile-Etienne Baulieu, President of the Academy of France; Prof. Pieter J.D. Drenth, President of ALLEA (All European Academies); and Prof. Janne Carlsson, Former President of the Royal Swedish Academies of Sciences to join with Israel Academy President Prof. Jacob Ziv and other distinguished Israeli scientists and science decision-makers to discuss these and related issues. The resulting workshop, “Promoting Science, Education and Society: The Academy–Government Challenge” was held at the Israel Academy in Jerusalem on May 17–18, 2004.

The workshop was distinguished by the seniority of its participants, the lively and frank nature of its presentations and the broad range of allied topics covered. Taken together, the edited presentations and discussions comprising these proceedings provide a valuable glimpse of the joint challenges national academies and governments face as they promote science, education, industrial competitiveness and social equity in an increasingly interconnected world. Their success is our future.

We wish to thank the many dedicated staff members of the Israel Academy, particularly Mr. Bob Lapidot and Ms. Avital Baer, who made the workshop such a success, and Ms. Deborah Greniman of the Israel Academy and Ms. Aliza Berger for their editorial assistance. We also wish to thank the President of Israel, Mr. Moshe Katsav, for hosting a reception in honor of our guests, and Minister Tzipi Livni for her fascinating after-dinner presentation on the unique role of scientific immigration in Israel (not reported here).

The Academy–Government Relationship:
Differing Models of Cooperation

Welcome

Jacob Ziv

I am pleased to open the first session of this meeting, "Promoting Science, Education and Society: The Academy–Government Challenge." This is the third meeting of its kind. The first one, "Strategies for the National Support of Basic Research: An International Comparison" was held exactly ten years ago. The second, "The Future of the Research University" was held in 1999.

National academies are expected, and sometimes even required by law, to advise their governments and the public on scientific issues of national importance, a task carried out with different degrees of success. It is not only difficult to come up with the right advice. It is, perhaps, more difficult to convince governments that they really need such advice and to educate them to seek it. Nevertheless, many academies undertake this quite enthusiastically. An international InterAcademy Council (IAC) was recently established to provide such advice both to local governments and to international bodies such as the U.N. The InterAcademy Council was the brainchild and creation of the InterAcademy Panel on International Issues (IAP), an umbrella organization for all national academies. We are gratified that its 15-member Executive Committee includes Israel. The IAC's first major report, *Inventing a Better Future: A Strategy for Building Worldwide Capacities in Science and Technology*, was recently (January 2004) submitted to all world governments.

Our goal at this meeting is not to preach, but rather to listen and to learn from the experience of the prominent past and current presidents of the national academies represented here. I particularly want to thank them and Professor Ephraim Katzir, the fourth president of Israel for joining us here on such short notice. I see that as an expression of faith in Israeli science and its position on the map of world science.

Introduction:
Personal Reflections on Science Advice in Israel

Ephraim Katzir

During my long life, I have met with many presidents; but to find so many presidents who are also distinguished scientists makes this a rare occasion. I also have some experience in trying to persuade the government, in this case the Israeli government, that science is something useful and that technology can even help the state. Even during the pre-state years (1946-1948) I dealt with defense-related research – then probably illegal. I was also very much interested in basic science. When my friends asked me, "Why are you wasting your time on defense?" I told them, "Just look at all the terrorist activity around you (alas, not much has changed). As biologists we all know that, if you are interested in science and want to carry out research, you had better stay alive. And if you want to stay alive, you had better do something about it."

At that time, David Ben-Gurion, not yet prime minister but an elected leader of the Jewish population, was also very much impressed with that idea. One day, while I was in the United States, my late brother wrote me: "I went to the 'Old Man' [Ben-Gurion] and told him that science is something worthwhile and that it can even help protect a country. He was so excited that finally he asked, 'What can I do?' I told him, 'I need money.' Ben-Gurion replied, 'Don't worry, I'll give you money, but only to carry out truly long-range research.' He took fifteen Israeli pounds out of his pocket and gave it to me. 'Here's your money!' Then Aharon asked me, 'Still, for the first time in my life I got money for scientific research. What should I do with it?'"

That fifteen pounds eventually developed into Israel's extraordinarily innovative Authority for Defense Research and Development. Ben-Gurion helped, and other prime ministers helped, although it was often difficult to convince them. But the electronics developed by these authorities is now being sold for hundreds of millions of dollars.

Later, when Levi Eshkol became prime minister, I told him, “Look, we were successful in pushing forward research and development in defense. Why don’t we do the same thing in other ministries? And you know our ministers, so let’s have every minister push research for himself. Let’s put a chief scientist in every ministry interested in research and development.” I then persuaded Eshkol to nominate me as chairman of a national committee to examine and recommend just that. We now have about ten chief scientists, who get research money from their ministers. They need to find out what ministry problems can be mitigated by science and technology, and to be able to tell their ministers, “Look, in University X they have something important that would be very worthwhile for us to develop.”

The effect of *all* ministries pushing science has often been dramatic. For example, when Bar-Lev, both a wonderful general and a wonderful man, was Minister of Industry and Trade, he realized that Israel didn’t have big companies to invest sufficient money in new high-tech startup companies. So he had the government, acting as a “big company,” implement various techniques for supporting startups and technology incubators, supplying about thirty percent of the money invested in such new companies. Israel’s incredible rate of high-tech industry development ultimately flows from that decision. According to my colleague Nathan Sharon, between the 1970s and the 1990s about two-thirds of our exports were based on high-tech developments and industry. More recently, the high-tech sector has produced up to about $10 billion per year. Even the biotechnology sector, my favorite, is producing almost $1 billion per year. Although in Israel we are so used to miracles, I never believed that one could happen!

So, it was initially not easy to persuade the government that science and technology are worthwhile. Now they are more convinced, despite all our national skepticism, that one has to support science and the high-tech sector, at least in such important areas as education, health, industry, electronics and the environment. That always warms my heart, and to warm the heart of an old man can be very difficult.

Yet, in the area of academy-state relations, the topic of this workshop, much still remains to be done. Compare our situation with that of the Royal Society of London, which recently noted:

> In its long history the Society has discharged a range of public responsibilities and developed many links of mutual interest with parliaments, with governments and with other public offices. Governments have sought the advice of the Society on many occasions and the council has been able to draw upon the wisdom of leading scientists in providing independent advice. The Society enjoys close relations with individual governmental departments and … its president's advice is sought in relation to a wide range of appointments, in both the governmental and non-governmental spheres.

This is an admirable record, and we can only hope that the Israel Academy will also reach this same state, so effectively utilized by one of the oldest academies of science in the world.

The French Academy of Sciences: Action, Angst and Mediation in the Public Arena

Emile-Etienne Baulieu

When I was elected President of the French Academy of Sciences, I was soon presented with an opportunity to put my principles into practice. We are at a crucial point in the evolution of science and its relationship to society. The progress of science is extraordinary. That we now live one year longer for every four years of additional research is one of the best measures of this evolution. However, in spite of this progress, in developed societies – particularly in France – there are doubts about the benefits of science for human beings, in terms not of longevity but of happiness. After all, one lives to be happy if possible. So we need to make the essence of science understandable, not only to the minds of people, but also to their hearts.

In our case, we have created a special channel for communication on scientific progress to give our media and public the best information we can. That is one important duty of a national academy. We also have a series of more profound *Reports on Science and Technology*. These longer books are sold to the public and will soon appear in English translation on our website. The information they contain comes not only from a few Academy scientists, but also from a broader spectrum of competent people. For each report, we have a committee, a super-committee and then a critique committee, followed by an Academy vote. We have produced – with some influence – reports on genetically modified organisms (GMO), nanotechnology, energy, water and so on. These reports are well received and highly respected throughout French society. We only regret that we do not have enough money to make them even more accessible to the public at large.

Such activities allowed the Academy to play a major role in the recent crisis in French government-science relations. That, in turn, provided an exceptionally clear demonstration that society indeed needs the Academy.

It is not that French government ministers ignore the existence of science or how the products of scientific research contribute to the economy, defense and so on. But there is a widespread irrational metaphysical fear that our trying to master nature is perhaps somehow wrong and can get us into unforeseeable trouble. As a Darwinist, I actually prefer that the problem is something so subtle.

The lack of strong political and social support for science has led to budgetary neglect in a period of French economic difficulty; the government's budget cuts have hit scientific research funding particularly hard. I can speak from personal experience, as my laboratory was one of the many whose budget was cut 15% and then another 15% during the same six-month period. Such a sudden 30% cut barely leaves enough money to repair machines, pay telephone bills and that sort of thing. So spontaneously, outside of any sort of unions, about 60,000 French researchers, many but not all young, signed an email petition demanding change. This precipitated a national crisis. The symbol and practical point of the crisis was the protestors' demand that the government offer the same number of posts to students in 2004 as in previous years. The government had wanted both to reduce the number and funding of posts and to change their permanent tenure. (My own desire to see such conservative sinecures replaced with something more flexible and more in accordance with the development of science led me not to sign the petition – the two issues are both quite complex and they were combined unnecessarily.)

Anyway, the protesting researchers gave a press conference, and I accepted their invitation to speak, in my personal, not presidential, capacity. I supported both more financial support and institutional change as being very important to science. After negotiations with the minister in charge of research, the government offered a small concession, which was flatly refused by the researchers. The newspapers said that the situation was deadlocked. By chance, I was scheduled to speak on a radio program ("French Culture") the next afternoon. I called my vice president, Edouard Brézin, a renowned physicist, and said that since the Academy, due to our uniquely respected position, could have the confidence of both the protestors and the government, perhaps we should do something. So the next day I publicly announced that the two of us were ready to act as an intermediaries between the government and the researchers. Our offer was rapidly accepted by both sides.

Interestingly enough, in terms of the theme of this session, at a subsequent vote of the Academy, some people frankly and honestly objected that it was not the role of the French Academy of Sciences to participate in such potentially risky interventions. Still, the vast majority of the Academy's members accepted the initiative, and everyone soon agreed that we could constitute and chair a national committee to reform French science and help the government construct a new law. That law is due to be formulated before the end of this year. We also have an earlier deadline, at the end of June, for the 2005 budget, which should include an additional billion Euros for urgent additions to the present budget. [This report, submitted on June 29, may be found at http://cip-etas-generaux.apinc.org/IMG/pdf/cip29juin.pdf.]

I really believe that the universal prestige of our 350-year-old Academy is largely responsible for this progress. Of course, we now face the difficulty of putting together an appropriate Committee for Initiative and Proposition (CIP) to reform the French science system. It has to represent everyone from graduate students to Nobel Prize winners and Academy presidents – the 32 people will be quite different. It is not easy to address the needs and dreams of our colleagues of all levels and generations.

It is quite remarkable that all this is possible even in such an old, conventional and somewhat *petit bourgeois* country such as ours (we didn't even elect Marie Curie to the Academy!). Achieving such progress requires speaking out, explaining to the public the benefits that science can give human beings, explaining that it is possible to master nature respectfully and responsibly, in a way everyone can understand and feel.

The French Academy is also, of course, very involved in formal education, a more classical aspect of academy activity. We persuaded the Minister of Education – and it worked – to teach science even to the very young, and we encourage new methodology. You know, in

French, when you say something is “academic,” you mean that it is conventional. So far we have been everything but conventional. Science represents change.

The U.S. National Academy of Sciences: Telling the Truth to Power

Bruce Alberts

I would first like to explain what the U.S. National Academy of Sciences (NAS) does, how it operates and why that works so well for us. Giving advice to government the way we do is almost an art form, and we have been doing it since 1863 when our Academy was created. We have made a lot of mistakes, but, like any individual scientist, we have learned from them. One early mistake was not having a formal anonymous review process for every report issued. That was finally instituted in 1970, as a critical element, because an Academy's reputation, like a scientist's, is based on its weakest paper – often the one longest remembered. Quality is very important.

We are not a government organization but rather a private one, chartered by Abraham Lincoln in 1863 as an "honorary society of scientists." Our charter requires us to "advise the government on any matter of scientific technology" but then explicitly denies us pay for our services! In practice, that means that the government reimburses us for the actual costs of staff and logistics, but the people who do most of the work, our expert committee members, receive no compensation (they do get travel and housing expenses). We sign a separate contract with each government agency for each study or task they request. We have no annual government appropriation, but that is actually quite fortunate, because it has kept us independent. If a member of Congress doesn't like the results of an Academy report and wants to penalize us, it simply cannot be done, because we have two thousand different contracts with widely different parts of the government, none easily controlled by political acts. That is a very important feature, one that helps us maintain truly independent judgment.

Later, the same charter was used to form two other academies – the National Academy of Engineering (NAE) and the Institute of Medicine (IOM). The National Research Council (NRC), formed during World War I, is the operating arm of the Academy. These institutions allow us to use many people on our committees besides scientists – important, because our government needs a wider range of expertise than the members of our three academies can provide. These four organizations, working as one – called the National Academies – are enormously active, producing more than one report every working day!

Although 85% of our reports are requested and reimbursed by the U.S. government, we retain our crucial independence. How? Once government officials participate in our first committee meeting, they go away. We do not even *show* them our draft report, much less "negotiate" results. Instead, once ready, we release our reports simultaneously to the government and to the public, via the press and our website. Anyone can read them. This gives our reports unique credibility and value. There are plenty of organizations that work jointly with the government, but that is a very different kind of advice.

It is very important for the United States to have this independent voice. Congress might approach us because they don't trust the administration, or one government department may approach us because they don't trust another, but all can trust us as an objective, independent voice that represents the best science. Government may call us when they think they are right and need objective evidence to prove it, or when they are uncertain and simply need more data than they have. They often come to us because they realize that, in the long run, without autonomous and objective input they would only be cheating themselves.

In brief, we construct the relevant *science consensus* as input for government decision-making. For example, in 1997 there was a scare regarding weak electromagnetic fields. People were afraid of their refrigerators and power lines. We produced a major report on the possible public health effects of residential electromagnetic fields. After reviewing 500 scientific studies done in the previous 17 years, our committee concluded that there was no evidence for adverse health effects due to the electric fields that accompany power lines and appliances. That report seemed to stop the whole business, and the problem went away. The real problem was public panic that pushed politicians to "do something about it."

Another report reached an opposite conclusion. When President Bush refused to accept former president Clinton's proposed standards for arsenic in drinking water, his own Environmental Protection Agency (EPA) head asked us to study this issue. Our committee concluded that arsenic was even more dangerous than previously thought, and the EPA immediately accepted the previously proposed standard. Our report allowed them to do the rational thing: get the issue out of politics and base their decision on science. The pressure is always there, but a government that really wants to make the right decision will consider it a patriotic act to heed science advice, because that's best for the country's future, even if not for one's immediate political predicament.

Just before President Bush left for his first trip to Europe in June 2001, the White House finally asked us to provide advice on the controversial issue of climate change. We had just a month to answer fourteen major questions, and the President gave a very good speech in which he accepted the underlying science that we provided. That did not, however, ensure that the policies he undertook in response were appropriate.

These examples raise an important distinction. Our reports normally do not recommend what the government should *do* about carbon-dioxide emissions or arsenic in drinking water. That is a political decision, based (hopefully) on a cost-benefit analysis. What we say is, "If you allow arsenic concentrations of five parts per billion, these are the health effects you will see many years hence." We provide options, but then the government has to make some tough decisions. We don't try to take over their role. We simply tell the truth – the scientific truth – to power. Our advocating a particular political intervention would not necessarily help either the government or us. Finding a balance between competing needs is their area of expertise, not ours.

Why do our policymakers care about the science? Because modern science has provided us with such a deep understanding of the natural world that we can often – almost like magicians – pretty well predict what's going to happen. Why does our system work so well? First, unlike the situation in parts of Europe, everyone in the American government, on both sides of the argument, believes in science. We are fortunate in that regard. Second, our review process efficiently removes all non-scientific statements from our reports, so we can't be discredited for going beyond the science. Finally, the U.S. press pays attention to us, so the public knows what's going on. In America, when the public knows, Congress knows, and the other politicians know. So, because we're front-page news and people hear about us on the radio and television, the government tends to respond to our advice.

Of course, the National Academies also try to make sure that our national science base is strong, but that is a much smaller part of our effort: "policy for science" rather than "science for policy." For example, we publish books for graduate students on being a scientist, and we publish reports on how best to maintain excellence and integrity in scientific research and on scientific priorities. We must keep our own shop in order if the scientific enterprise is to work. Our recent report on biology education for undergraduate biology majors found that major changes are needed, in part because biology itself has become much more quantitative. A movement called Bio-2010 has developed from this report to help implement such changes at U.S. universities.

Last but not least, we help review America's own science institutions, such as the National Institutes of Health (NIH) and the National Institute of Standards and Technology. One of the most successful things we do is an annual review of multi-agency science and technology (S&T) programs. These programs can get off- track very easily, because each agency tends to go its own way, and a prearranged, public annual review can help keep things moving forward together. There is a lot more we could and should be doing using this mechanism.

It is hard to overestimate the importance of effective national institutions for science. In many developing countries, it is very sad to see talented scientific and technical people without adequate scientific institutions to support them. National academies of sciences around the world have been working together to help build effective S&T institutions everywhere. As emphasized in a recent IAC report, "Building a Better Future," every nation needs such a central national focus for S&T. Although that institution can take different forms, national academies consisting of merit-selected members chosen by peer evaluation have great potential. Membership must be determined by the academy's members rather than by external governmental forces. The resulting autonomy has many inherent advantages, including long-term stability.

Such an academy must be broadminded and inclusive of all the science in the country. It must support every person and program that is excellent. It should try to improve these and not compete with them. The national academy cannot be just another player in science. Rather, it must provide an umbrella that brings all such institutions together. Any problem you look at in the United States has, perhaps, ten terrific organizations working on it, but they don't cooperate very well, partly because they are all competing for the same funding sources. So our academy's job – perhaps our most important job – is to try to bring the best efforts together, to be above the crowd, to get people to work together and to provide a convening function. Our academy has to be very careful to remain special in that way.

Politicians tend to cater to those with special interests and to focus on short-term gains. Jack Gibbons, President Clinton's first science advisor, once told me, "For me, long-term is three days." Academies have to force governments to take longer-term views. Governments usually don't do that well. This can be particularly true in stressed or less-developed countries. Consider what happened in South Africa with AIDS or in Zambia with genetically engineered corn – they simply wouldn't take advice from the outside. So every nation needs an effective voice for scientific advice on the inside. The IAP and IAC try to help build that kind of capacity everywhere.

Israel is way ahead of most countries in harnessing S&T for national development. In fact, you set an example. It was very impressive when, in 2000, the IAP elected the president of your academy as one of the fifteen academy presidents on the IAC board. Professor Ziv has served with great wisdom. In addition to helping your own country, the Israel Academy and Israel's scientific community have a lot to offer to other countries as well. In many ways, you are a model for other small nations. In about two weeks I am going to Estonia; they would very much like to be like you!

The Israel Academy of Sciences and Humanities: Proactive and Effective, but Not Always Heard

Jacob Ziv

I would just like to compare and contrast Bruce Albert's comments regarding the United States with the local scene here in Israel. The typical Israeli minister usually does respect science and may well talk about it every day. What he often does not respect is the independent advice of scientists, and, as Bruce says, that is the crucial point.

If the U.S. Academy gets 300 governmental requests for such advice annually, and if I divide that by twenty to come up with a proportional figure for Israel, the Israel Academy should expect fifteen governmental requests for advice per year. Well, the facts here are quite different. In the last nine years we have been approached only four times by a ministry for advice. In fact, in the cases of the Ministry of Health and the Ministry of Education, we actually precipitated the situations that finally led to their formal requests for our advice! That speaks for itself.

Instead, the Israel Academy has had to be unusually proactive. We did publish thirty reports over the last ten years, which proportionally is equal to or even better than the U.S. record. However, as is typical in Israel, the government ignored more of our reports, although the two or three that it didn't ignore really raised a storm. For example, the government didn't like our publishing a report that publicly evaluated the success of Israel's chief scientist system, mentioned previously by Professor Katzir. We had a day-long discussion, involving all of the chief scientists, and then published a formal report with recommendations. That raised hell within at least one ministry.

Interestingly, my complaints about lack of collaboration and synergy with the government do not apply to many other public institutions. We have good synergy with the Planning and Budgeting Committee (PBC) of the Israel Council for Higher Education, the autonomous public (but non-governmental) agency that funds Israeli higher education. Through the Forum for National Research and Development Infrastructure (TELEM), Israel's independent and highly effective *ad hoc* interagency coordinating group (nobody ever actually appointed it!). We also have good relations, in terms of joint funding initiatives, with several ministries. By pooling resources, TELEM can orchestrate big investments in infrastructure, build bridges between academia and industry, and so on. We were highly proactive in initiating, organizing and operating TELEM. We have also dealt with issues important to industry, such as intellectual property rights.

However, all this activity is largely limited to the working level. It doesn't include the ministers themselves. We have a real problem there. For example, Israel still does not have an independent national research council – and independence, as Bruce just mentioned, is very important to such a body. Our Academy did initiate a law to establish an Israeli national research council, which was finally accepted by the Knesset (Israel's Parliament) eight years later! The reason for the delay? We insisted on that body being independent – even from us. Implementation is still beset with delays.

As Bruce also noted, although we would expect government to seek our advice on science, our job is not to give advice on governmental policies and decisions or, for example, on the relationship between academic and industrial R&D. We should, instead, be a catalyst to help the council supply such advice, based in part on our contributions regarding the basic research. Although the law is now here, the Council still is not. The problem at the ministerial implementation level, again lies with the difficulty our government has in fully accepting the idea that, if it really want good advice, that advice will have to be independent advice.

Our best-known proactive initiative was founding the Israel Science Foundation (ISF), the main source of support for basic research in Israel. It is now an independent non-profit organization with Academy members, PBC members and important scientific and public figures on its board. Israel's innovative FIRST (Focal Initiatives in Research in Science and Technology) program was another unsolicited proactive initiative of the Academy. After an initial trial period, funded by the C.H. Revson Foundation and other donors, it has now become an integral but independent part of the ISF. That decision was taken only after an independent board of evaluators, including Professor Pieter Drenth, judged FIRST to be important and successful.

So much for "science for policy," it's an uphill battle, but one in which considerable success can follow persistence. What Bruce calls "policy for science" is a more recent Academy interest. We are now establishing a Center for the Advancement of Basic Science in Israel, which is somewhat of a cross between the U.S. Academy's Frontiers of Science program and the Berlin Brandenburg Academy's Young Academy program. The idea is to build bridges between senior and newer scientists and to listen to what younger scientists, who are not yet academy members, have to say when it comes to future directions and policy for Israeli science. This is yet another proactive, self-generated activity. In Israel, waiting for external requests is as good as inaction.

The Swedish Academies: Covering the R&D Spectrum

Janne Carlsson

We have seven national royal academies in Sweden. The oldest is the Royal Swedish Academy of Sciences, created in 1739, and the youngest is the Royal Swedish Academy of Engineering Sciences (IVA). I am active in both academies, as former president of the first and former vice-president of the second. These two academies have quite different scopes, but both are of interest in the context of this workshop. The Royal Academy of Sciences was chartered to "promote and further science" and that is actually its only duty to the government. The IVA was founded to "benefit society by promoting technical and economical sciences and industrial development." In brief, the two academies address different parts of the overall R&D spectrum, and it is interesting to see how they work together.

Israel is known for its pioneering devotion to planting trees for future generations. That also describes Sweden in 1739, when the Royal Academy was created to promote "forestry, agriculture and mining" at the start of eighteenth-century industrialization. Now the tree serves as a very important symbol of the relationship of science to society: support basic science, the roots in order to produce fruits and provide resources for coming generations.

The membership of the Royal Swedish Academy of Sciences is divided into sectors: basic sciences, medical sciences, engineering sciences – a very small class in this science academy – the humanities and other areas of scientific research and services. Ninety percent, are scientists. The IVA has more members and its sectors represent technical areas, such as economics, educational research policy and information technology. Only about half of its members are university-based researchers; the rest are industrial researchers and organizational representatives. This gives a different flavor to their discussions with, and their influence on the Swedish government.

The Royal Academy of Sciences, like other national academies of science, provides a national forum for Sweden's scientists. As the only Swedish academy with research institutes, albeit relatively small ones, it also offers some unique research environments for supporting outstanding research by young scientists. The Academy's Nobel Prize awards are obviously its most important and visible activity, in terms of promoting science throughout the world and acting as a voice for science in the broader community. The Academy also edits scientific journals directed towards the research community, as well as fact sheets, similar to the reports Bruce Alberts mentioned, for a broader audience. We have published reports on the greenhouse effect, gene technology, radiation from mobile telephones, energy and other topics.

The Academy, sometimes alone and sometimes together with others, also produces documents written specifically for and sent directly to the government. For example, when a new government comes in, the Academy traditionally writes a report on the current state of Swedish science and proposes needed changes. Many of these changes have actually been made – usually the least expensive ones.

The evaluation of Swedish science foundations is carried out jointly by the Royal Academy of Sciences and the Royal Academy of Engineering Sciences. These foundations are among the biggest supporters of Swedish research, providing more direct support than the government itself. The academies also review government proposals affecting Sweden's scientific system, science education and research. They carry out similar reviews of European Union research activities and science policy in Europe, especially concerning the need for more basic science. The Royal Academy of Sciences, for example, has long argued for the creation of a pan-European Science Foundation.

The IVA has a more applied approach. In education and research, it works to increase the participation of Swedish universities and industry in the European Union Framework Programme. Together with government, it also carries out studies on topics such as "The Engineer of Tomorrow," how to reform engineering education, and how to improve interactions with industry and society. Concerning technology transfer and entrepreneurship, the Academy connects researchers, innovators, venture capitalists, industrial people and so on, covering the whole chain from basic research to beyond startups. The staff of its program on technology and society produces reports on topics such as gene technology, energy and environmental and communications technology for the government and for technological/economic foresight exercises.

Finally, returning to the Nobel Prize, I think that it is a great privilege for the Royal Academy of Sciences to select the Nobel laureates in physics, chemistry and economics. This is our most important activity: to make science, and the Academy, visible in Sweden and the world. The amount of international contact this generates is breathtaking. The Academy sends out about two thousand letters of invitation for each of the three prizes and receives six hundred to one thousand proposals in reply. The various review committees work together with some of the most prominent scientists in the world. Hundreds of living laureates are permanently in contact with the Academy and visit often, taking part in activities, seminars and lectures in Sweden. It is a tremendous asset for our Academy and for Sweden as a whole. We are quite lucky to have this rather special possibility

ALLEA: An All-European Approach to Academic Independence, Cooperation and Science

Pieter Drenth

In a recent address to the World Science Forum in Budapest, I started with the observation of Dixie Lee Ray that the general public has long been divided into two parts: those who think science can do anything, and those who are afraid it will. Either way, the relevance of modern science for society and societal development now seems beyond question. In a recent issue of *Le Monde*, Henry Audier of the CNRS warned that if Europe wants to preserve its role in the world of tomorrow, it must redirect its priorities towards education, culture and research. In the same issue, Francois Jacob noted that the power of nations was long measured by the size of their armies, but today, it is measured by scientific potential. Such messages help drive us, as academics, to reinforce the centrality and salience of science.

The European Federation of National Academies of Science, ALL European Academies (ALLEA), of which I am president, represents Europe in the greater sense, from the Atlantic to the Urals, not just the European Union. From the very beginning, we have included Israel, because we feel – and there was no dissension about this – that, in terms of cultural tradition and scientific orientation, the Israel Academy belongs within the European academic family. More generally, our members form a quite varied, multifarious conglomerate. Some academies include only the natural and life sciences; others include only the humanities and social sciences; many, indeed most, include both. Some academies restrict themselves to organizing meetings and debates, while others also have a very important advisory role *vis-à-vis* government. Some member academies promote science only through advice, evaluation and promotional activities, while others run their own – occasionally quite large – research institutes. The latter was particularly common in Central and Eastern Europe, where the best research was long done within academy institutes (in many East European countries, that is still the case). Yet it may be more interesting to see what all these academies have in common, rather than to focus on the many differences between them.

Whatever their structure and tradition, academies in Europe have three common objectives: furthering critical scientific thinking in society, advancing top-level scientific and scholarly research, and promoting the independence and freedom of science. Autonomy is a crucial precondition for all academies. Indeed, as Bruce Alberts wisely noted, full independence is a precondition for being truly useful as an advisor.

The emperor Justinian cut off a vital source of political life when he closed Plato's Academy, a millennium after its founding, because its views were not in line with his own. That is a dangerous approach, even for present-day governments. They do not realize how much they wrong themselves by packing advisory committees with scientists who share the administration's political outlook and who become comparatively useless "yes men." *Nature* recently (January 2003) expressed its concern that "the current U.S. administration has so politicized the provision of scientific advice that it could permanently undermine public trust." Conversely, we should be proud to serve on bodies that consider independence a primary criterion for operation. Without this independence and freedom, science will sooner or later become stagnant, irrelevant and useless.

In Europe, we have gone beyond the level of individual national academies and are also concerned with higher levels of aggregation. In 1990 ALLEA was started as an umbrella organization for all the national academies of Europe. This was a logical consequence of the ever-growing internationalization of research and scientific collaboration, and of an increasing tendency to lift discussions and decision-making about science and science policy from the national to the supranational (e.g., European Union) level. The latter level will not replace the former – there is a good case for subsidiarity and the preservation of separate national traditions and identities – but there has been a noticeable shift in balance towards the supranational level.

Since the academy is an important actor at the national level – together with science foundations, universities and research institutes – we felt the need for a similar interplay of actors at the European level. There already was a European Science Foundation (ESF), albeit one that could be better funded or even replaced by a European Research Council. There already was a European University Association (EUA). A pan-European association of academies would complete the triad. Such a tripartite structure operating at *both* the national and the European levels could prove advantageous.

In passing, I might don my other hat and describe how that tripartite structure works at the national level in the Netherlands. Every six weeks two representatives each from the Royal Netherlands Academy, the National Research Council and the Union of Universities meet to discuss and react to developments in Europe and abroad. We try to be on the same wavelength and reach a consensus before our ministries think of something "interesting." We have to resist outside (e.g., political and economic) influences. Scientists know best how to advance science. The best way to protect scientific autonomy and objectivity from potentially disastrous interferences is to unite.

Scientific collaboration in Europe is increasing sharply, not only because of European Framework Programme funding for cooperative projects – although that is a strong incentive – but also because science itself has developed into a truly collaborative and international activity. One cannot readily do good scientific work any more in a remote place without regular contact with colleagues, wherever they may be. New communication technologies make international cooperation much easier, and research proposals and activities have become increasingly international in nature.

There are several reasons why we *should* collaborate more than ever before. First, many of our highest-priority subjects are themselves international in character. One cannot study environment, infectious diseases, transportation, trade, migration or economic recession from a purely national perspective in Europe. We have to cooperate to get a full picture. Second, many meta-programs are too expensive to be funded by any one country and we need to combine resources in order to fund the necessary infrastructure and research.

Third, Europe needs to strengthen its competitive position relative to the U.S. and Japan. A few years ago, a "green book" was published that gave Europe high marks for the quality of its education and research, which are indeed competitive with those of the United States. However, Europe falls short when you look at how effectively all that human intellectual capital is translated into industrial applications, patents and other forms of technological utilization. That critical transition is really lacking in Europe. There are lots of reasons for this disparity. Patent laws are different in different European countries, venture capital is difficult to raise in Europe, and Europe tends to be more risk-adverse than the U.S. and Japan. Still, the difference in output, in terms of industrial development, is uncomfortably large and still growing; and increased cooperation and harmonization are needed.

Last but not least, there is a moral obligation for Western, economically more advanced countries to strengthen the R&D capabilities of economically less-developed countries including a number of European nations. The fulfillment of that obligation may often take the form of aid, but eventually that can lead to collaborations of mutual benefit. In the long run, such collaboration is the best precondition for peaceful coexistence and economic balance in the world as a whole. For all these reasons, national academies in Europe must cooperate.

European transnational science budgets and decisions have now reached major proportions. The Sixth European Framework Programme budget is about 16 billion Euros ($18 billion). The proposed budget of the Seventh Framework Programme is almost double that, about 27 billion Euros. So it is serious money. Who decides where all this money goes? Ultimately the Council of Ministers, but in practice, decisions are proposed by the commissioner and staff of the European Commission DGXII. They, of course, should listen to "the field," but not all Commissioners and DGs have been good listeners. Fortunately, the present Commissioner and directorate have been responsive to feedback from the field. I think that is quite wise. Although incorporating input from the "workfloor" may require a bit more time and discussion in the preparatory phase, joint decisions are easier to implement successfully. That seems to be the basic attitude in the European Directorate right now, and I think that is an effective, efficient approach.

ALLEA has become increasingly involved in research funding developments in Europe. We provided feedback on proposals for FP6 and hope to do the same for FP7. We are an active discussion partner in the preparation of a European Research Council (ERC), as proposed by a working group chaired by Frederico Mayor, which, for the first time, will make scientific quality the *sole* criterion for European Union research grants. Until now, "European added-value" implied cooperation between two or (usually) more member countries. If this new ERC concept is accepted, whoever proposes the best research, as judged by objective peer review, will get the funding. If two Estonians or only one Portuguese author the best proposal, that's fine. If it's a whole distributed network – Cambridge, Amsterdam, Paris, Berlin – that's also fine. Decisions will be based solely on quality.

Recently, I wrote a paper on two almost incompatible objectives of the "Mayo Report." On the one hand, one can promote top-quality research only by taking quality as the sole criterion. Attempts to be "representative" and to distribute grants more equally among countries will result in sub-optimal usage of available funds. The situation in the U.S. is different from that in Europe. People in Montana don't complain (that much) about science grants going to Silicon Valley or the Boston area, because they believe that Montana will also eventually benefit, as part of a stronger United States. Eventually we will also have to think that way in Europe. An excellent research project in Cambridge or Madrid should eventually be a source of satisfaction and pride for the whole of Europe, including those countries that did not get funded. That necessitates developing a new "European citizen" mindset.

On the other hand, such an approach could lock a great many struggling research groups into a very unfortunate position. A great many parts of Europe could be deprived of European financial support for research, creating a "science divide" between the haves and the have-nots. The latter will receive little money for improving their research capacity and infrastructure or for attracting scientists from abroad, and their own top students will move elsewhere. There will be a "Matthew effect": He who has will get more. He who has not, even the little he has will be taken and given to him who has. We will have to do something to avoid this.

In my paper, I suggest using *other* European funds – structural funds, social funds, developmental funds – to support infrastructure development and retain bright young students and scientists in European countries with a less developed status. Incentives could include travel grants, stipends, temporary salaries for young researchers returning to their countries, computer and equipment grants, and so on.

In conclusion, Europe will not become one country like the United States, and it probably should not. Its linguistic, historical and cultural variety is an asset to be preserved rather than an impediment to be removed. Politically, Europe will become a hopefully strong federation in which individual nations retain their autonomy and independence. Thus, in Europe, centralized decisions will never suffice. Such decisions must ultimately be translated and filtered down to national decision-making bodies. ALLEA is in a very special position, because it can help its member academies filter and pass information from the national level up the line to the European Commission. It can also function as an intermediate organization to help take information from the top level and spread it through Europe's national academies to national scientific communities. It can also help sanctify the cultural or geographical contextualization needed to adapt a central policy to each particular country. ALLEA can play a pivotal "linchpin" role in the complex world of European scientific decision-making.

Science, Education and Society:
Meeting New Challenges

Bringing Science to Society: Essential but Not Easy

Haim Harari

Literally every day, the Israeli government ministers who were invited to join our discussion – but who are not with us here today – deal with, or are supposed to deal with, questions of a scientific and technological nature. These are of obvious concern not only to the Minister of Industry, who deals with high-tech industry, but also to the Minister of Communications, the Minister of Agriculture and the Ministers of Health, Environment and Energy, not to mention the Minister of Defense. Even a Minister of Justice, these days, would have to deal with laws touching upon scientific and technological issues. If this is true for the ministers, it is equally true for their deputies and assistants, the assistants of their assistants, the lobbies that try to influence them, the members of our Knesset and anyone who wishes to be a member thereof.

This brings up an issue that has never been faced by mankind before, in all its history. How can almost every decision-maker in society, whether elected or appointed, cope with all these scientific and technological issues, when they can't possibly all be scientists, engineers or people with a technical background? This makes bringing science to the public more important than ever. When we say "the public," we don't mean only children, we mean literally everyone between the ages of 5 and 120. Anyone who needs to consult a physician about a medical problem, indeed anyone who is doing almost anything today, needs a certain elementary level of understanding of science and technology. They also need a certain level of quantitative thinking, which must rely on understanding the language of mathematics, if not mathematics itself.

In my opinion, the government does not have to participate directly in this science dissemination business, except to learn. The scientific community, the universities, research institutes, national academies and other scientific organizations have the duty to share their knowledge with the public. Although 30 to 50 years ago it may have sufficed to share knowledge only with that part of the public that was particularly talented or interested in science, today it is imperative to share information with the entire public. Similarly, emphasis on science and technology education in our schools today should not be only for physics majors or those taking the highest level of matriculation exams. The emphasis should be on bringing scientific issues – including the social and ethical issues of science and technology – to the public, at all levels of society. This is much more difficult than what we used to face with brilliant 14-year-olds. The latter may be more brilliant than us, but not so the general public.

There are very few countries with more academic activity in this area than Israel. Such activity usually carried out not by the national academy, but by academic institutions such as the research universities. For example, at the Weizmann Institute, for 41 years now, we have been contributing to curriculum development in mathematics, physics and chemistry for our national school system, and to the training of teachers, in-service training, the writing of textbooks and the implementation of new science education programs in our schools. We have run an extraordinary number of different extracurricular, after-school activities, such as science competitions (Olympiads), science clubs, school visits to science museums, and other activities that help bring science to the public. Now we are taking the next step, by establishing programs aimed specifically at various groups of children who are already disconnected from society – for example, those in street gangs, who are neither working nor studying. We still provide enrichment for the brightest kids, who are the future of our high-tech industries and research, but we also involve the other extreme and everybody in between.

It is absolutely essential for all practicing scientists and researchers in all fields of engineering, mathematics, natural science, agriculture and medicine to contribute some of their talent, time and effort to this goal, to the extent that they are able. Although not everyone may have the talent to make such a contribution, the future of any civilized society depends on it. Later we will hear about the new report of Israel’s Task Force on Education; it also must address how to bring science education to everyone in Israel.

Science Education: No Bigger Challenge for Science and Scientists Everywhere

Bruce Alberts

I quite agree with Professor Harari about the obligations of scientists. We cannot continue simply to do our own research and hide from society. Some of our members confess to wanting to do the opposite: "I became a scientist *because* I can't stand society. It is too complicated. I just want a simple life in the laboratory, in a rational world." That, in my view, is a self-defeating attitude for the future of our planet.

I didn't want to be president of my academy. In early 1992 I told their nominating committee that I wasn't interested. I was, however, very interested in science education. As a professor at the University of California in San Francisco, I had been deeply involved with the local public school system. In August they phoned again to say, "Come and talk to us anyway." Soon I felt guilty; if I didn't accept, would any other president push the Academy in the directions I wanted? So in the end I said yes, and my wife and I moved to Washington. I've been there almost twelve years now. I took the job because I felt that, through the Academy, we had a chance to help expand the role of scientists in society.

The idea that a nation's best scientists need to pay attention to science education for children is becoming an international movement, with the French Academy being particularly active. They have a wonderful program for effectively spreading inquiry-based science education throughout their country. The Swedish Academy has also been very active – as have the Chileans and the Chinese. Our Academy is collaborating with India now. In all these cases, it is the academies, and some of the top scientists in the country, who are involved.

In most countries, including ours, what we often call science education has little to do with real science education; it's just memorizing words. We don't produce scientists that way. Worse, we get people upset at science, whereas they should be pleased and excited by it. Young children come to school eager to do science. Most kindergartens in the United States provide that to five-year-olds. They investigate everything. That's a real science class; but we beat it out of them by the time they are in fifth grade, and by then they hate science. All we have to do to succeed is to maintain their curiosity, but that won't happen without the deliberate, continual attention of the scientific community. Our pictures of happy children climbing all over the Academy's Einstein statue – you have a smaller replica – is the image we want for science: something accessible, friendly, a warm place. All the schools in Washington end up taking their classes there for a photograph.

To spread science and scientific values effectively throughout society we will have to change our own scientific culture, which often does not respect applying scientific aptitudes and talent elsewhere. If our best students want to do something besides being just like us, we tell them that they are "wasting their lives." They should be professors or researchers instead. They shouldn't work in science policy in government, or be science journalists or a leaders in science education. Early in my career as Academy president, graduate students, even at my own university, would approach me, since they knew I was sympathetic. They couldn't tell their professors that they really wanted to do something besides scientific research, because then they would be discounted. They would be out of the game.

We have been working – and it's hard indeed – to change our narrow academic culture, to help create a much broader pipeline for taking scientifically trained young people and spreading them all around our society. Otherwise, we are never going to make it. We need to have people who understand science, who can be "science adapters," everywhere.

Nowhere is this more obvious than in the U.S. Congress. Congress works only because of its legislative staff, mostly younger people, terribly energetic, who work for a hundred hours a week. Just one scientifically trained person on a staff could make all the difference for a senator, representative or committee. The American Association for the Advancement of Science (AAAS) has been a pioneer in creating fellowship programs that allow young scientists to spend one year in government agencies. There are now about a hundred AAAS Fellows every year. Many of them become legislative aides; others are spread throughout government. My own academy now has a new internship program that brings graduate students and postdoctoral fellows to do science policy work with us for four months, in three groups of 20 interns per year. We are trying to seed our country with talented people who really want to be the critical adapters between science and society.

You want the best people in these roles. Your worst students can't do this kind of work, at least not well. So we have to change the way we talk to our young scientists and their advisors. To help, the Academy published *Careers in Science and Engineering: A Student Planning Guide to Grad School and Beyond*, which promotes a very broad range of careers for those with an education in science. But then we started to hear from the students, "I know all this, but now you have to talk to my professors." So, with their guidance, we produced a second small book for the professors, called *Advisor, Teacher, Role Model, Friend: On Being a Mentor to Students in Science and Engineering*. We encourage students to buy this book from our website – it is very inexpensive – and to put it on their professor's chair in the middle of the night! This is a cultural change that is going to take a long time to achieve. I find many of my colleagues incredibly narrow-minded about what scientists are good for and what their students should do.

We also try to spread science throughout society by making everything we publish freely available on our website – more than two hundred reports a year. We now have three thousand books, of all kinds, accessible on our website. We sell printed versions, of course; but PDF files of these books are provided free of charge to 146 developing countries. We are still working to make these reports even more accessible. We have tried to make our scientific journal, *Proceedings of the National Academy of Sciences (PNAS)*, as "open access" as possible without going broke. The electronic version of PNAS is now free to everyone six months after publication, and immediately free for 146 developing countries. We originally tried a one-month delay, but U.S. librarians said that they would not subscribe, so we have to titrate this very carefully. We just barely break even, but this model works for us.

We have also started posting some wonderful, out-of-print science textbooks, all still quite good, on our website. The first was *Heredity and Development* (1972), the late John Moore's history of genetics from Mendel to Watson and Crick. We are trying to create a free science library so that a student, anywhere in the world, who wants to read something really good about science can do so, in many different fields. If you know of other books like this, please let us know, and we will try to get the necessary rights.

We have also been very active in formulating standards (guidelines) for science and mathematics education for students aged 5 to 18 in the United States. "National Science Education Standards" was probably the hardest report we ever prepared. After three years of intense effort, we formulated a draft and sent out 40,000 free copies; it then had 18,000 reviewers. It turned out well, emphasizing "science as inquiry," a revolution in how we teach science. We then published a special supplement for teachers, because one major problem is that most of today's science teachers never had an inquiry-based education in science themselves. So now we are also focusing on introductory college science courses.

We also produced a booklet for parents, to help them understand their childrens' science classes. Parents often say, "I can't help my children with technical terms, so how am I supposed to help them get a good grade in science?" Our booklet's title, *Every Child a Scientist*, is also a good motto for the program itself. Even in France and other countries where things are moving in this direction, one finds similar reactions. So this movement needs the scientific community's involvement.

The good news is that a standards-based science education can provide the workforce skills needed (and requested) by American business and industry: the ability to solve problems, to work in collaborative work-groups, and so on. The bad news is that U.S. industry doesn't adequately recognize this contribution of science education. They remain politically neutral in most of our "education wars" and tend to support more testing and accountability, rather than inquiry-based change. We need to reach them more effectively, so that they can be advocates for their own long-term interests. To quote Robert Gavin, former CEO of Motorola, "Memorized facts, which are the basis for most testing in schools today, are of little use in an age in which information is doubling every two to three years. Computerized expert systems and the internet can provide facts we need when we need them. Our workforce needs to know how to *utilize* facts to assist in developing solutions to problems." Yet most industrialists don't understand what kind of science education gets you there. They haven't spent enough time trying to figure it out.

To convince them and others, we need evidence. We haven't spent enough time and effort studying what we are doing in education, using scientific tools. We need hard evidence that what we are talking about actually does work. We need to understand exactly why it works, and how we can make it work on a massive scale. We must take education as seriously as we take science, and try to translate scientific evidence about it into a form that school systems can use. The National Academies' first major effort was a very popular book, *How People Learn*. We took what has been gained from research on human learning over the last thirty years and explored its implications for our schools. Strangely enough, that had never decisively been done before.

One critical issue is to test for science *understanding* rather than mere knowledge of scientific facts. It is a real challenge, and not inexpensive, to make good tests for that, but it is essential. The wrong kinds of tests trivialize science teaching and drive most students away from science. Science education is not memorizing facts about thirty kinds of whales and then taking an exam on a ditto sheet. Most American schools still emphasize what science has already discovered, over taking part in the process of discovery.

Conversely, testing for the right things drives the right kind of education. One of our reports suggests combining computational tools with what we know about assessment to develop tests that are both good and inexpensive. The U.S. is doing a lot of work on that, but we all need to share what we are learning about science assessments, because this is an international problem. We also need more really high-quality people trained as scientists to do this kind of work, a new generation of educational researchers. Without this, our nation's schools will continue to be driven by politics. New leaders come in, and they want their own system. Everybody thinks that they understand education, and too many have a magic bullet to "fix" it. So we need to accumulate an objective, common body of educational knowledge, based on confirmed evidence, the way we do in science, to move forward in an orderly, continuous way.

Another recent National Academies' report explores what constitutes good scientific research in education, as a step towards a much more vigorous and effective U.S. educational research establishment. We all have to work together on this. It takes much more energy to prepare teachers to teach science as inquiry than it does to teach memorization of "facts." So we have to demonstrate the added value. We propose more multi-country collaboration to get evidence on what works. The good news is that good science education in Israel should be good science education anywhere. Scientists around the world tend to agree on what they want for science education. So, unlike the situation in history education, we should be able to work together quite effectively on this problem, of such crucial importance to us all.

Comments

Haim Harari: The enormous variety of activities that Bruce described seems reminiscent of trying to teach a language. What we are trying to do, basically, is to teach the language of science, at all its different levels, to all the different levels of the public. One can learn a language in many different ways, and one can understand it in many different ways. Although one can also understand science in many different ways, there are several specific, basic ideas that underlie all scientific thinking: the scientific method, quantitative thinking and logical thinking. It is difficult to design successful methods for teaching teachers how to do this. This is indeed the core problem everywhere. There are many different approaches and many different reports, and all of them are moving us one step at a time towards this goal. In fact, the recent realization, all around the world, that this is an absolutely essential issue has already taken us a long step forward.

The Israeli Public Education System: Recommendations for Major Reform

Victor Lavy

I would like to thank the Israel Academy for this opportunity to present publicly the findings, released just yesterday, of Israel's special task force on educational reform. Appointed in September 2003, the task force was asked to assess the current state of the public educational system in Israel and to suggest a comprehensive plan for change involving all elements of the system. Our agenda resembled that of *A Nation at Risk*, a U.S. report from the early 1980s, but our mandate went beyond providing detailed recommendations; we were also asked to provide a detailed roadmap for implementation. There was only one restriction. We had to do all this without increasing the educational system's budget! We actually accomplished all this, except for asking for more resources during a transition period of a few years. Thereafter, the system should converge to a steady-state budget at the present level.

Our task force was headed by Mr. Shlomo Dovrat, a prominent high-tech business leader. It included eighteen members, from such diverse fields as education, economics and law. It also included working-level educators, school principals and three prominent businessmen. Eight committees, chaired by task force members, were appointed to carry out detailed work in specific areas. Their reports were later woven into the overall task force report.

We divided our work into several phases. The first phase included a critical assessment of Israel's present educational system, its points of failure, etc. Israel has not undertaken any major reforms since the 1950s. Elsewhere, education has been very dynamic. Since the mid-1980s, most member countries of the Organisation for Economic Co-operation and Development (OECD) have been intensively engaged in reforming their elementary, middle and high-school systems. So there was no need to reinvent the wheel. We carefully reviewed the considerable research results, policy work and evaluations available elsewhere, and we identified elements that we judged to be successful and capable of adaptation or replication within our own national system and context. In the next phase, we drafted a new vision for our educational system and translated it into a set of nine principles that guided the design of our reforms.

Our interim report, submitted to the government last week, was accepted yesterday by a unanimous vote of the Cabinet. We have outlined the main elements of our proposed new structure, which is quite different from the current one, but our plans still need more detail and refinement. For example, we need to provide the Knesset with a complete body of proposed legislation for the new system. By this October, we hope to submit a final report with more details about implementation and to negotiate with the national teachers' unions regarding the new programs we are suggesting. We promised the interim report by the end of April and met that target, and we hope to meet our October deadline as well.

The first, assessment phase was not an easy one. Previous committees had written reports on different segments or issues within the education system, but we needed to pull all that information together. The result was evidence of a severe, multidimensional crisis in Israel's educational system, with bad elements in almost every part of the system. Educational achievement is declining in such widely different subjects as reading, writing, mathematics and science. This is accompanied by other problems such as student dropping out and drug addiction. There are large gaps between socioeconomic groups: the poor and the rich, the educated and the less educated, Jews and Arabs, etc. There are also large gaps in achievement and competency by geographical location, for example, between the center and the periphery. Our conclusions were based on a wide variety of evidence: Ministry of Education data collected over time, international test scores over the last 10 to 15 years, and – the nail in the coffin – a very sharp decline in the language skills of Israeli military recruits from the 1980s to the present. Current competency in writing and reading really puts the nation at risk.

Equally worrisome were the deteriorating status of the teaching profession and declines in the quality of teaching, in the training and credentials of teachers, in teacher motivation and work habits, and so on. These deficiencies have led to a fragmented, weakened public education system. Many segments of the public are finding their way out to religious, private or quasi-private schooling.

Israel suffers from anachronistic legislation. Sensible, comprehensive legislation for the Israeli public education system was last enacted in the early years of the State. There are also large inefficiencies and inequalities in the use and distribution of resources, partly because of discrimination in allocation. There is considerable rank-seeking in the system, and many schools and localities get resources without providing corresponding results in the form of educational achievement. Management is excessive and excessively centralized, lines of responsibility are unclear and accountability is almost totally absent. The teacher is not accountable to the principal, and the principal is not accountable to anyone else. Schools virtually run themselves without being required to report to anyone.

There is also no modern information system. We were amazed to see how little modern informational capacity the Ministry of Education could provide to assist us in putting together our dataset, even on such basic issues as the budget. How much is spent on education in Israel? What is its distribution by educational elements, different social groups, etc.? Our first recommendation to the government was to build a modern information system, starting tomorrow.

Yesterday, after the cabinet meeting, we had a press conference with the Prime Minister, the Minister of Education and the Minister of Finance. All three pledged their full commitment to implementing all the elements of the proposed reform, without compromising on any of its principles. Although they may need to negotiate or change some details of implementation as things progress, they declared their willingness to confront those who oppose implementation of the basic principles of the proposed reform.

Our plan is based on several major elements. The first and most important is school empowerment, making the school the most important structural element in the educational system. We will move Israel to a full school day, starting at 8:00 a.m. and finishing at 4:00 p.m., five days a week. All teachers will have to be present at school during those 40 hours a week, and so will most students in elementary and middle school.

The second element is reinforcing public education, something all eighteen members signed without reservation. The most important element in Israeli education is to be the public school system, and not any other sector, for example, private education. So everything in our plan reinforces the public school system, even at the expense of individuals, families and segments of society who provide private education for their children.

The third element is improving the quality and status of teaching. This is a crucial factor in the process that translates educational resources into educational outcomes. We propose a detailed program for transforming the system that now prepares teachers for their profession.

The fourth element, closing gaps between different groups in society, translates – to borrow a catch-phrase from overseas – into "no child left behind." All children should get all the attention they needs to fulfill their potential.

The fifth element, a focus on early schooling, turns the traditional educational pyramid on its head. Evidence accumulated over the last 10 to 15 years confirms the importance of providing resources for early education, from ages 1 to 3. Gaps resulting from early educational deprivation are very difficult and costly to fill later, after ages 7 to 8. Over the last 20 to 30 years, Israel has put a lot of effort and resources into its high school and matriculation system. We suggest radically changing the allocation of resources by putting far more resources into early childhood education. We also recommend free but not compulsory schooling from age three on.

The sixth element stresses the need for measurement, evaluation, accountability and transparency, the main managerial tools for any efficient, goal-oriented system. Unfortunately, at present, we have no measurement, little evaluation, no accountability and almost no transparency. These will be introduced into every part of the school system. Each school should prepare a workplan whose implementation will be supervised by a board of parents, to help guide how the school sets its objectives and translates resources into work. This workshop's U.S. and European guests may be surprised that we don't already do this and that we consider it a reform.

The seventh element is efficiency in school productivity, and the last element, perhaps the most dramatic in terms of structural change, is decentralization. Israel's public education system is now highly centralized, with the Ministry of Education appointing principals and teachers in every school. We suggest rebuilding the Ministry and making it much, much smaller. It now has more than eight thousand employees, whereas one thousand may suffice after our program has been implemented. The Ministry will largely be replaced by school districts, to use the American term for *minhal hinukh ezori*. The districts will receive the responsibility – and the authority – to actually run the schools, while the Ministry of Education will shift its attention to broader, completely different roles.

All these elements are necessary and interdependent; and omitting any one could undermine the stability of the whole reform. This program should be implemented over the next two to three years, although some parts, especially increasing teachers' compensation, may be phased in over five years.

Next, let me review briefly the key recommendations for translating these principles into action. The current structure for junior-high and middle schools will be abolished. Students will make only one transition – from primary school to high school – between sixth and seventh grade or between eighth and ninth grade. The emphasis will be on early education, with optional preschool from age three, and on a compulsory curriculum for all parts of the system. The number of subjects taught simultaneously at any grade level will be reduced dramatically, especially in the first few grades of elementary school. Clear educational standards will tell teachers what their students should know at the end of each grade, which is commonplace abroad but not here.

Pupils aged 3–18 and teachers will have a five-day, 8:00 a.m. to 4:00 p.m. school week, with teachers not only teaching classes but also engaging in individual instruction and other activities. Teachers will work a full school year. (Currently, many public high-school teachers, and almost all twelfth grade teachers, basically stop teaching before the Passover break – three months of teaching time down the drain! School principals will have full authority over their budgets and staffs, and they, not the Ministry of Education, will appoint teachers and be managerially responsible for the quality of their performance.

Our reforms also suggest an optimal size for schools. Israel currently has about 3,000 schools, of which a third are very small. Most such schools should be closed or merged with others. Conversely, some overly large schools should be broken down into several more optimal-sized schools.

A significant increase in teachers' salaries is needed to make their careers competitive with those of other public-sector employees with possessing similar levels of education. We particularly need a dramatic salary increase for teachers just beginning their careers. Salaries will be linked to improvement in productivity and efficiency through merit increases based on performance. Breaking tradition, we boldly accept differential pay for teachers. There won't be only one, seniority-based, pay scale. Rather teachers' salaries will also be based on merit, performance and previous achievement.

Most Israeli elementary and middle-school teachers are now trained in vocationally oriented "teachers' colleges." We suggest closing all of these and doing away with the special Bachelors of Education degree they award. Those teachers already holding this degree will not need to go back to school, but all new teachers will need a B.A. from a university or college accredited by the Israel Council for Higher Education. In practice, more than half of today's teachers' colleges will be closed, while the others, after a transition period, will raise their standards and apply for accreditation and the authority to award bachelor's degrees in specific academic disciplines. To further assure teacher quality, we also suggest licensing exams, similar to those for lawyers and accountants. Finally, there will be a one-year internship period, followed by an assessment, before an applicant gets a teaching license. Other recommendations concern school principals.

In our new model, a streamlined Ministry of Education would set policies and goals, undertake long-term planning and suggest a core curriculum and standards. It will budget and supervise the school districts and maintain overall responsibility for the educational system. Direct authority over field activities will be transferred to independent school districts, thereby transforming a centralized system into a local one. Jerusalem, for example, will be an independent school district, responsible for its own schools. This concept has been implemented successfully elsewhere, and it is time to try it here.

The school district, headed by its own educational council, will set its own implementation policy, design its own long-term plans, and be responsible for the teaching methods in its schools. Teachers will report to their principals, who will report to the head of the school district, who will report to the local educational council (in large cities, probably headed by the mayor). Only the latter will report to the Ministry of Education. In smaller areas, several localities will unite to form a school district of sufficient scale to implement this concept efficiently. School choices will be made by parents and their children; and schools will no longer be able to choose their students. That practice currently leads to discrimination in the form of unequal access to quality education. Under our reform, no school in the country will have the right to select students based on their academic records. We also suggest creating a national evaluation unit, outside of the Ministry.

Finally, let me say a few words about the transition period. There is always a cost to transition. For example, we want to increase teachers' salaries and status, while (and by) phasing many teachers out of the system. We have far too many teachers, sharing too small a load of weekly teaching. However, synchronizing these two initiatives will be very difficult. We have asked the Minister of Finance to provide a special budget of several billion shekels over the first five years to allow teachers to be phased out at a different pace than that set down for increasing teachers' salaries. The latter should be almost immediate. Further transitional resources will be needed to help equalize existing schools in terms of their infrastructure. There are currently big gaps in the quality of the facilities available to Israel's schools. This transition may not be easy, but we hope that it will be worthwhile.

Comments

Haim Harari: We should all thank Professor Lavy for sharing his colleagues' conclusions with us, regardless of whether we agree with all of them or not. The task force certainly worked hard and invested an enormous amount of life experience and energy in drafting their recommendations. Of course, before discussing or criticizing this report, we first have to read it, which is only now possible. There will probably be quite an extensive public debate in the coming months, because this report touches on one of the most important issues in our life, education for a better future. Still, I cannot avoid asking: If our current system is indeed so devastatingly bad, with no accountability or information, and with enormous chaos and disorganization, why isn't your report's first recommendation to have whoever was responsible for this mess step down immediately, rather than leaving the implementation of your proposed reforms up to them? I would also suggest removing the previous ministers, but they have already been removed, including the one who sat on your committee and criticized the dire situation for which he is also, presumably, partly responsible. Surely any other country, adopting such a report and its initial evaluation, would change the entire leadership of its educational system, starting with the responsible minister.

Dan Shechtman: Like most such reports, the proposed reforms sound great; but they bring to mind a story. When Gandhi came from South Africa to England, they took him on a tour of London. At the end of the day somebody asked him, "Now, Mr. Gandhi, what do you think of Western civilization?" To which Gandhi replied, "Ah, Western civilization? That sounds like a good idea." I hope educational reform will not similarly remain just a good idea. I hope it can be implemented.

In this spirit, may I ask this distinguished audience a simple question: Who here represents the Ministry of Education? Is the Minister here? A deputy? Any member of the Ministry? Any member of the Knesset's Education Committee? Of our entire parliament? [No hands are raised.] So this will all be kept a great secret! This is wonderful! Perhaps this lack of government interest and cooperation explains something of our doubts, frustration and current situation. Our apologies to the presidents of the United States, French and Swedish academies and of ALLEA who *were* able to find time to attend.

Participant: Professor Lavy, where are we going to find the new breed of teachers you propose?

Victor Lavy: That will require a combination of several elements. Paying much better salaries, providing a much better teaching environment and facilities, and reducing school crime and violence all will help pull teachers into the profession. Paying differential wages for excellence will attract people who like a more competitive environment, who are motivated professionals and expect to be paid for it. This should eventually lead to a better teaching force. The teachers currently trained in teachers' colleges predominantly come from our lower-ability high school graduates, those who could not get into universities. On the average, their score on the national psychometric test is less than 450! Our aim is to attract much more able individuals.

Also, at present, almost 95% of all teachers in elementary and middle schools, and in many high schools, are women. Of course, they can do a fine job; but many of them are working only very part-time. On the average, those paid "full-time" actually do only about 70% of a full-time job; the average teacher does only about 55% of a full-time job. To be a regular profession like any other, teaching cannot be combined with major amounts of work at home or elsewhere. Requiring full-time teaching would also automatically give the profession a more balanced gender composition. This would be helpful, not because of the gender element *per se*, but because of the special attributes of those attracted in the past to become teachers.

Participant: Wouldn't the inability of schools to select students based on merit, actually harm Israel's few existing academically excellent schools, such as the *Shevach Mofet* schools?

Victor Lavy: *Shevach Mofet* schooling attracts many high-school-age immigrants from Russia by emphasizing science and mathematics. Having the privilege largely to select their own students, and largely to be exempted from undue bureaucracy, they resemble the "charter schools" of the United States. Research by economists specializing in education systems show that charter schools are indeed a good technology for producing more quality education with fixed resources. We would like to introduce something similar in Israel, but without the achievement-based methods such schools now use to choose their students. We think that is unfair, since it crowds out many children who are able but come from poor backgrounds and did not attend good elementary schools. Good schools can do well with any level of students and not only with the very able ones.

For example, there are five charter schools in Boston – in science, music and other areas – and yet they don't select their students. Admission is based purely on demand, and in the event of excessive demand, there is a lottery. When you propose that in Jerusalem, people think you are crazy; however, our committee agreed that schools should not select their students. It is up to the parents and the children to select where they want to study.

Adi Shamir: Every reform movement is proposed by well-meaning people; but the future is too complicated to fully predict, and all kinds of unintentional consequences crop up. So, first of all, why don't you try out your more radical proposals on a small scale to see whether they work or do not work, in practice, before plunging the entire country into such a sweeping reform? Second, if there is a failure, what checks and balances do you propose in order to detect and prevent impending disaster? Do you have some way of changing direction three to five years down the road, if things don't work out as planned?

Victor Lavy: The Dovrat Committee did not start from scratch; other committees, for example, the Casaraea Conference (July 2003), have suggested similar reforms. So we have the accumulated experience of other committees and investigations. Also, we are perhaps, the last, not the first, of the advanced, Western OECD countries to go in this direction. Sweden, for example, moved in one month, in 1991, from a centralized to a very decentralized system. That socialist country took its teachers, who were all government employees, and told them from tomorrow on you are employees of the municipality, and there are no more central contracts for teachers' salaries. So these elements have worked in other countries.

Ontario, Canada, for example, did poorly meeting their standards in 1995 international tests. Within five years they completely reformed their system, and in 1999 their test scores were tops. Holland, Belgium, Denmark and New Zealand have decentralized. Similarly, in England, there are no more teachers' colleges. They were phased out completely, because they could not provide the needed quality. We are not really that innovative; we only put all these pieces – previously suggested or tried abroad together in one comprehensive program.

Of course, there should be serious public debate. Yesterday, the newspapers and television carried only a very shallow discussion of our reports. We claim no overarching wisdom. We have proposed a program and it should be reviewed seriously and, if necessary, criticized. It should be scrutinized by experts, the public, parents, etc., and in the end it could be modified. The public deserves to discuss this proposal thoroughly and then pass decision on it.

Haim Harari: We must exercise modesty in dealing with education, just *because* all of our speakers express their views with such great confidence. Education may indeed be too important to be left in the hands of educators, but it also cannot be left only to physicists, chemists, economists, business-people and the like, who also think in terms of their own experiences. All of us can and should be involved in thinking and in arguing about it, but we do not all have personal experience with fighting our way daily through real educational problems.

Reality always constrains theory. We all would love to see all Israeli teachers well-educated, well-mannered, brilliant and well-paid. But we now have 150,000 teachers; and even under the Dovrat recommendations we would have 130,000 teachers. In practice, we simply don't have 130,000 geniuses in this country, especially if we need seventy of them to sit in the Academy! Not all of our teachers can, or will, be on that level. Reality will create problems that we will have to face.

The Israel Academy: Gearing Up for an Applied Research Study in Education

Dan Shechtman

I am part of an Israel Academy-sponsored initiative to organize and undertake applied research in education. Unlike the Dovrat Committee, described in the previous presentation, we are just beginning. Our initiative began with discussions between the Israeli and French national academies regarding education. The U.S. National Academy of Sciences was also of great help, particularly via Michael Feuer of the U.S. National Research Council, who has been doing this kind of work for many years. We are also interested in learning from the Netherlands, Sweden and others who are doing a good job in education.

Our steering committee consists of educators, scientists and a representative from the Israel Ministry of Education. This is a joint initiative of the Israel Academy of Sciences and Humanities, the Ministry of Education and the Rothschild Foundation, which both funds this activity and is a very active participant. Although the initiative started only a few months ago, we have already held many meetings with representatives of different aspects of education in Israel, including quite a few people from the field: teachers, principals, inspectors, etc. We are still trying to select the questions we will study over the next two years, largely through sponsored research.

Our first, broad list comprised twenty subjects, which was far too many. We narrowed this down to a shorter interim list. For example, what does a teacher need to know, and what constitutes a good teacher in Israel? Unlike the Ministry of Education, Israel's Central Bureau of Statistics (CBS) collects and provides good information, year after year, about a wide variety of topics. For example, what do Israel's high-school students do after graduation? If they choose further study, where do they go to learn? How does this correlate with their socioeconomic status? The CBS found, not surprisingly, that students from higher socioeconomic backgrounds go on to universities, the middle-class go on to colleges, and the lower-middle class go to teachers' colleges to become teachers! So most teachers in Israeli public schools today come from a low socioeconomic background and never attended a university. That's a fact. Are they talented? Surely some are, but in purely statistical terms the predominantly lower socioeconomic standing of Israel's teachers is not promising. We may study that.

What do students study in public school and what do they study out of school, at home or in other frameworks? Principals are to be given enormous power and responsibility under the new Dovrat Commission recommendations, but what constitutes a good principal? Do we even know when we have one? Is the principal the best educator in the school? Does the principal have the broad knowledge-base needed to run a school educationally, economically and socially? Maybe we should study that.

How do people study? What in an educational system enables people to study well? Is it primarily the teacher who motivates, or the overall school framework, or the educational program? Graduates of the school system who later succeed in society, how did they study? Is their public school background important, or is it only their higher education that matters?

In Israel as elsewhere, higher education always complains about the educational level of incoming students. I second that. We face a slow decline at the Technion year after year. What can we do about it? My children in primary school can readily operate my laptop computer and their own laptop. Can their primary school teacher do that? We talk about the status of the teacher; but, both with children and in society, you *earn* status. When my child was in second grade he once came home and told me that his teacher was so "retarded" that she didn't even know anything about computers. All his seven-year-old friends knew all about computers. What did they think about her status?

Is a second language important? Are tutoring and peer teaching something we should learn more about? What do we mean by "catering to the needs of the pupils"? I love that term. In Israel, "catering to the needs of the pupils" means that they can choose among 309 different final matriculation exams. Just imagine a war in which we "catered to the needs of the soldiers" by giving each one 309 choices of weapons, so they could select whichever suits their personal tastes. One would choose a pistol, another a tank, and so on! Can you imagine the results of that? Why is our war on ignorance different?

My own short list of five or so subjects is as follows: First, let's look at a school as a complex production-function. What makes a school run? Taking into account the teachers, principal, money, building, environment and counselors, what makes a good school? Let's try to understand what makes a school tick. Some schools do tick and others fail every step of the way. Why?

Second, how can we deal with gifted children, not the top 1%, as it is defined today, but the top 20%? These are the people we need to lead our country, socially, economically and scientifically. After all, as Israel's Academy of Sciences, we should be interested in educating future scientists. We are justifiably proud of the means we invest in supporting problematic children, and we have an enormously developed special education system helping tens of thousands of children with all kinds of problems. I am not cynical about all this; I truly think it is wonderful. Still, what about our gifted children? Do we have a "special education" system for gifted children and their teachers? Thousands of Israeli teachers and hundreds of counselors are trained in special education for the disadvantaged. Should we not also give equal attention to our national future, to our future scientists, poets and leaders in all fields of endeavor? How wonderful it would be if we also undertook a major effort to properly educate the achievers, the ones with the bright eyes. We have many of them. And we should also properly educate our teachers with bright eyes. Gifted teachers for gifted children. Maybe we should look at that.

Third, what makes a good teacher? Is it background, education, salary, the number of children waiting at home? Do we provide our teachers with enough tools to make them good educators? Do they even know the material? A first-grade teacher who tells her students that "subtraction is much more difficult than addition" can kill a whole class of future scientists. A teacher must be confident, and that requires a good background in the subjects taught.

Fourth, the Dovrat Report recommends starting education at a very early age. That is great, but we first need to build a cadre of teachers who know how to make three-year-olds curious and motivated. Let's give them the best. We could also study what effect early education has on the future success of children.

Finally, how do we evaluate what we do? How would we evaluate the results of the Dovrat Report, if and when it is implemented? Everything we do in education should be followed by impartial evaluation, just as it is in science. That means that the Ministry of Education must have a good mobile database, year after year. Can you imagine a profit-oriented private company without a public quarterly report?

So these are some of the questions we have been asking ourselves. After a final selection, we will set up "professional" (peer review) committees to broaden each question and then we will issue a call for educational research proposals. Hopefully, these will include joint multidisciplinary teams. We need people who see the whole picture from different points of view. Research should start next year. We can then look forward to objective evidence-based answers to some of these questions that are so crucial to our national education system.

Promoting the Entire R&D Spectrum:
The Roles of Academies,
Governments and Industry

The R&D Spectrum: The Swedish Experience

Janne Carlsson

I will try to describe how the entire R&D spectrum functions in Sweden and our national academies' role in it. This may provide an interesting comparison, because Israel and Sweden are quite similar in many ways.

As in most countries, Sweden's major R&D performers are universities and research institutes, industry as a whole and individual enterprises. Our universities create new knowledge, and our research institutes transform it into new methods and technology that can then be used by individual industries. Industry uses its new tools to create new products for consumers and profits for its investors. Our universities, supported mainly by society, provide the common scientific platform required for national R&D development. The work that follows contributes to industrial competitiveness: from individual research results to applications to startups to competitive enterprises. All three sectors, like links in a chain, make unique contributions to this process.

How R&D-intense is Sweden? Comparing R&D in different countries on a *per capita* or per gross national product (GNP) basis, Israel is at the very top. Israel's R&D expenditures are 4.8% of its GNP, Sweden (4.3%) comes next and so on. Here too, Sweden and Israel are quite close to each other.

Who carries out R&D in Sweden? Mostly industry (60%) and universities (20%). As in Israel, national research institutes are very few and small in Sweden. Industrial research is not broadly distributed. The twenty largest companies undertake a very large part (40%) of all Swedish R&D. This concentration is rather extreme, even for a small country. Finland is even more extreme; there just one company (Nokia) contributes 40% of the total. In other European countries, and perhaps in Israel, public sector (university) R&D has decreased as a percentage of the national total. In Sweden it has increased.

In brief, we have a lot of R&D activity which is good, but our biggest companies dominate the national R&D scene, which is not so good, particularly since many of them have been bought by foreign interests, and top management and decision-making have moved out. Astra Medical Company is now owned by English interests; Saab Automobile is owned by General Motors; Volvo Cars is owned by Ford; Saab Aerospace is owned by British Airspace; the owner of Ikea has moved outside Sweden and so on. All are multinational companies on that seem to be their way out. Most of the reasons Swedish companies go abroad are political, industrial and economical, and there is nothing that Swedish universities can do to stop it. Our politicians and industrialists must do that.

Interestingly enough, however, these large "leaving" companies have mostly kept their R&D work in Sweden – due to our good R&D reputation, workforce and educational system. So, perhaps their shift in management doesn't matter to Swedish R&D that much after all. The only difference is that now, to *keep* the R&D of these companies in Sweden, we have to maintain our good research environment and the high educational quality of our universities. Swedish academia recognizes this responsibility and takes it seriously.

We also want to keep our brightest young scientists in Sweden, although we do have a brain drain, mainly to the U.S. The Swedish Royal Academy of Sciences has created very attractive stipends to help keep young scientists in Sweden during the first five years following their Ph.D. Unfortunately, although we get 200 to 400 applicants, we can award only about eight such stipends a year. Even so, we do get to support some exceptionally good scientists and help them stay at Swedish universities. The stipend supports the investigator's salary, laboratory and equipment costs, graduate student assistance and so on, so it is quite attractive. The Royal Academy also gives four similar stipends to older researchers, mainly professors. Both types of stipends last for five years, so there are 40 or so scientists in this program at any one time.

The Swedish Royal Academy of Engineering Sciences has a program called Connect to help promote the development of startups, based on a similar program in California. The idea is to connect researchers, innovators, entrepreneurs and venture capitalists (if there are any in Sweden). Started only three or four years ago, Connect now has fourteen regional offices. They have ten member companies, all old and established, 2,000 volunteers and some paid staff in their regional offices. Now Connect is being extended to the Baltic states and discussions are underway with our fellow Scandanavian countries. This initiative has been very effective, although I can't give the exact number of startups. Connect also supports work in our universities, the technology incubators, science parks and industrial parks affiliated with our universities. So it doesn't work alone. Rather, it operates in cooperation with many other Swedish institutions and activities to help promote and integrate the entire R&D spectrum.

What Indusry Really Wants from Academia

Amir Elstein

I am the general manager of Intel Israel Ltd. We employ several thousand people and are the tenth-largest business entity in Israel. I will briefly describe Intel's mode of operation, to provide insight into how foreign companies can work successfully here and elsewhere. Intel's policy is to establish fully owned subsidiaries that function much like independent companies. They need to develop their own personnel and infrastructure, including scientific infrastructure. They promote a sense that "you own your own future," a future that is neither regulated nor guaranteed by corporate headquarters, which only provides broad direction. This is a critical element for general managers in industry, they must control all parts of the pipeline required to develop their business. Thus, Intel Israel must support basic research not simply because it likes basic research people, but as a vital means for expanding its business capability. One cannot survive in the long-term without owning the whole pipeline, and that starts with basic research. We provide funds, collaboration and direction to basic research in our area. We can't just stand by and watch things happen. We have an obligation to participate, and that is why I am here.

To put Professor Carlsson's useful R&D spectrum into an industrial perspective, in the end, we are looking for breakthroughs that represent an ability to sell a lot of content. We need to sell millions of things that originally started at a basic research level; that is our job. Moving such research through subsequent technology, application and commercialization stages also requires a great deal of technological capability and development; but that is not basic research.

The investment needed in a unit of R&D is also very different in each phase. The basic research required to create big generic blocks of technology, such as biotechnology or nanocomputing, could demand billions of dollars. However, such powerful, highly generalizable new knowledge could eventually develop into *thousands* of different applications. In contrast, each single application is highly specific and needs a far smaller investment in order to be developed and launched into the market.

Basic research remains a very profitable engine for growth – for society as a whole – only because each of its many multiple applications can create big markets, driving billions of dollars back into the pipeline of the national innovation engine, the original billions are then multiplied by the massive *enabling* capabilities added by industry. So, when an industry makes profits of billions, they had better invest ten percent in basic research. Even in Israel, basic research investments at the billion-dollar level are quite relevant, not a poor business decision, but a good business decision.

We now have a bigger need for R&D investment than in the past, not because we are eager to spend more money, but because we face yet another technology transition. We had one in the last decade, when we moved into a "post-industrial age," a transition from a macro-world based on steel and oil applications to a micro-world based on carbon, hydrogen and microorganism-based applications. Today we are facing a nanotechnology-based transition. Intel is already manufacturing fifty nanometer devices in high volume, and that is only harvesting the "old" nanosciences research of the last decade. More recent R&D has brought us to a real inflection point, because our knowledge of the micro-world cannot readily be extended into the nano-world, in which quantum mechanical effects introduce a different physics. To understand and harness this different physics, we need to reinvest in knowledge development and infrastructure at a startup level, not just a maintenance level.

What new kind of research engine will be required to drive this new innovation engine? The application (industrial) side is now driving integration at the research level. We industries are asking academia and the basic research community to start integrating at the basic research level, because we need platforms that are already totally integrated. It is not the end result that must be integrated; the basic research itself must be integrated.

National academies of science must take the lead in enabling this, through a whole set of innovative organizational and policy changes. This is definitely not the traditional way things have been done. It may be the first time in recent science history that information, computing, sensing, biology, health and social research capabilities must be linked together. This is coming very soon, but we are not there yet, and people should realize that it requires a different cycle of investment.

Geographically, today there are three big, extended R&D entities: the U.S., Europe and the Far East. Each spends about $280 to 300 billion annually on the overall R&D spectrum, from basic research to commercialization. However, the R and D portions show quite different patterns of growth. Since the 1980s, basic and applied research budgets have been increasing steadily but quite slowly, while development budgets having been growing rapidly. These differential trends have been very steady for two decades. The gap between basic research and applied R&D spending is thus growing ever wider. To me, this simply means that we now know how to utilize basic research better, not that we need more money to do it.

The gap between governmental and industrial R&D funding is also growing. In the 1970s and 1980s they were comparable, but today industry funds three times more R&D than government. Between 1990 and 2000, government investment stayed about the same, while industry experienced a major breakthrough in R&D investment. Universities and colleges account only for a small part (3%) of direct R&D investment, and they need government and industry, not because they are incapable, but because of their unique intrinsic business structure. If we don't understand that and invest more money in them, basic research in academia will die.

In general, industry largely serves a very broad-based "consumer society," the masses, not a narrower national defense environment (often the government's main R&D concern). If industry and society hold about 85% of the R&D ownership and provide about 65% of the R&D budget, we need to understand what made us rich and capable: basic research. So we should come back and support basic research.

National styles in science and technology investment vary greatly. U.S. R&D, for example, is very focused. Figure X shows, Comparing cumulative R&D investments per major topic, in the U.S. and European Union's (EU), there is a prominent gap in two domains of my personal concern: information technology and computing infrastructure. In these domains, the U.S. wins with a well-led effort from basic development all the way to commercialization, but the EU wins (albeit more narrowly) in all the other fields.

The EU works in quite a different mode than the U.S. They invest heavily in multidisciplinary research, which should make them more capable in the long-term, more ready for the coming new world order. The necessary innovation cycle, involving integrated technologies and the ability to work together in multidisciplinary teams from basic research onwards, is already embedded in the research culture in the EU, but not in the U.S. This should be a "wake-up call" for the U.S. research investment mechanism. China, with its huge and growing R&D budget, is following the EU, not the U.S., model. In Japan, the main drivers are the computing environment and the multidisciplinary environment.

In terms of computing companies, the EU approach means, "We are not about computing. We are about serving the largest cycles of society's needs, and we are about integrating to do it better." A good example is the Interuniversity MicroElectronics Center (IMEC) environment in Belgium; I think they got it right. Conventional integration at the last stages of the spectrum can still add value for society, but maximizing added value requires integrating fields from the basic research phase on, not only at the business phase.

So how can national academies help promote innovation and national growth? As Lackey once said, "Innovation is a locally driven process succeeding wherever organizational conditions foster the transformation." Organizational conditions are what our national academies can really help us with. Any other body, including one involved in R&D funding, inevitably has its own narrow, short-term interests. So, even if they think right, they will often make serious longer-term mistakes. We need a sane, independent and far-seeing consultant in this process. We call on our national academies to help us with this longer-term process of knowledge creation through technology transfer.

What about the national government? We all know the research/commercialization cycle. It is a cycle that *makes* money rather than losing it. So there is no reason for the Israeli government to have been investing decreasing amounts of money in basic research over the past few years. This is jeopardizing our future. We may be doing well or even leading in some broad R&D investment indicators, but most Israeli R&D funding is industrial funding for applied and industrial R&D, not governmental funding for basic research. Israel's government has reduced its R&D spending (largely basic research) by about 60% over the last four years alone! The overall system is holding up: venture capitalists are coming back, industry is not bailing out and international cooperation is increasing. But that represents the culture and commitment of the private sector; the governmental side is sinking fast. This is alarming, because of the direction that leaders in industry and academia will have to take. This crisis is not only about money, but about leadership – namely, its lack of it in government and its flow from industry, because Israel's research money is increasingly industrial.

Things are also speeding up worldwide. Innovation time has been slashed by a factor of about five over the last century. It took 100 years for the world to issue its first six million patents. By 2000, the world was issuing about 150,000 patents a year, and by 2003 over 220,000. We probably will get our next six million intellectual property (IP) elements, such as patents, within twenty years. This is an incredible IP engine, but unless you fill it with money, it is meaningless. The potential benefit of all this IP is so big that it is a stupid decision not to invest money in it – and that includes governments, which need to maintain long-term national prosperity.

There is always some conflict between academia, with its eagerness to create and disseminate knowledge, and industry, with its eagerness to make profits. The latter is what I get bonuses for. Despite this culture clash, we must learn how to share our respective and joint ownerships, because the innovation process is circular. What goes in will eventually come out; we need to invest in both domains. Intel understands that the mission of universities will expand and that industry will increasingly depend on utilizing that expansion of research-based knowledge. We will collaborate and co-invest more with universities, at least with those faculties that have a somewhat entrepreneurial view of academic research. That doesn't mean that they should chase IP or make money for their investors – that's our job – but they should look around for research opportunities, gaps, places where research should be headed if someone can put the money there. Just to hold such a discussion, we need proactive faculty members with broad horizons.

The sources of research funding will continue to change. The guys giving out big basic research money today will not necessarily be doing so tomorrow. Academia needs to invest its talents and efforts in collaborating not only with the Intels, but also with the numerous small, innovative startup companies, some of which may eventually be as big as Intel. It is a lot of work for academia to develop this broad-based kind of collaboration. It will take a lot of organizational and networking skills. This is probably another place where national academies can help.

We often tell universities, all around the world, "Don't bother selling us IP, just bother creating it. This is not because we begrudge your making money; it is just because we can do that much better than you can." Our approach is really quite straightforward and sane. Just look at the facts. Out of 230 universities recently studied, only six made enough money to justify their major research engine through IP creation and sales. In fact, only 10% of the companies studied could point to any detailed product lines that emerged from university research. So the big issue is not whether academia will get a lot of money from IP (they won't) or whether academia and industry will create lots of products together through basic research (they won't). The few exceptions merely prove the rule. The meaningful 80% is somewhere else.

Academics should get the money they need from industry and the government – and lots of it – but they should use it to do what they do best, what nobody else can do: basic research, discovery and disclosure. That will promote development and commercialization in industry – what it does best – but it will happen largely outside of academia's domain. Of course, we must be honest if we make such a deal and actually put the dollars back into basic research; otherwise we are cheating academia. If we tell them, "Go ahead and publish, give it away for free; because we are the ones who know how to really make money," then the only way to balance the equation is to actually put significant money back into basic academic research.

Finally, there is still a real gap between investment and recommendations, even for the rich guys. Going from basic research all the way to commercialization costs a lot of money. Consider an International Technology Research Institute for Semiconductors, representing the real R&D needs of the entire field and offered as a research investment opportunity for society. I'm talking about real and ready opportunities on the level of "If you give me the money, I can innovate this for you." In 2004 we could do all of those innovations for $1.4 billion, but society invested only about $1.0 billion in such research. We are about 35% short of actually exploiting our full capabilities. So, R&D needs more money. There is no doubt about it.

What about Israel? From about 1985 to 2000, there was good collaboration between the stages of the innovation pipeline, leveraged by the government and academia. Twenty years of serious prior government investment in senior professors and faculty, from 1965 to 1985, gave us those results. The industry–government–academia triangle worked very well. Since then things on the government side have gotten worse, while R&D demands have expanded. In view of the "nano-transition" we currently face, even successfully repeating our 1985–2000 "golden age," with the same concepts and funding, would not be enough. Research on potentially commercializable phenomena at the "nano" level initially will require pumping in significantly more money than in the previous continuous funding model.

Our government is now investing 60–70% *less* in R&D than in 1998–2000. Industry has undergone serious traumas recently, but it is already getting its investment level back up. Academia is looking for governmental or national academy leadership to show the way forward. Private organizations cannot do this, because we cannot actually influence treasury decisions for what is really a public good. Our Minister of Finance is a very good friend of the concept, but not of the money flow. This is our wake-up call.

In conclusion, academia and industry cannot do it alone. Our government and national academy to must show us the direction towards greater integration, and they must show that we are financially, as well as conceptually, serious about it. Professor Ziv's pioneering work with TELEM is a good start, but we still have a very long way to go.

Comments

Participant: Why is so much industrial R&D actually located in Israeli industry?

Amir Elstein: Universities and government don't yet have a well-structured engine of innovation. They are not organized for that kind of collaboration, so much of our money actually supports in-house basic research, using only the brainpower of academia. I get academic researchers, pay them or steal them, and I do the basic research in-house, because I can't find a good, systematic, long-term collaboration mode that can support my needs within academia itself. I need to know that, in 2010, whatever R&D structures I set up in 2004 will still exist and service me.

Jacob Ziv: It is good news that industry is seeking the advice of the academy. It is news to me; but I certainly encourage it. I also buy your approach that intellectual property generated in the universities should eventually serve industry, but it must not become a major factor in the budgeting of the universities themselves. However, as you mentioned, that requires industry, like government, to invest directly in basic research with no direct correlation to a specific product.

Four years ago I, along with representatives of all seven universities and the Minister of Science, met with then-Prime Minister Benjamin Netanyahu to convince him to establish a national research council. We explained the need for well-established, objective, national-level evaluation of research needs and priorities. He listened carefully and then said, "Well, it all seems a bit fishy. First, when all of you can agree, something must be wrong! Second, why bother? High-tech industry is doing so well in Israel that, in five years, it will be able to support the universities. What do you need the government for?"

He was wrong, of course, but this supports your contention that we must not relieve the government of its duty to support basic research – which doesn't mean that universities don't have a duty to help industry as much as they can. The Israel Academy has been very proactive in that.

Academia is often blamed for being an "ivory tower." I must say that in recent years Israel's ivory tower has been the government, not the universities and not the Israel Academy. TELEM is one good example of that.

Academia–Industry Relations: An Israeli Case in Point

Irit Pinchasi

As a specific example of the issues previously discussed, I would like to share the experiences of Teva and its relationship with Israeli academia – both the successes and some of the worries we wrestle with today. Teva is the largest pharmaceutical company in Israel and the world's largest producer of active pharmaceutical ingredients for the generic drug industry. About twenty years ago, we decided to see, more or less as an experiment, if we could also develop new drugs, all the way from the basic research-based idea through clinical trials and on to the market, just like the "big guys." Our business goal was to provide Teva with an engine of growth outside its existing generic drug business, while helping patients.

Since Teva was then too small to do basic research in-house, we needed to identify and add value to appropriate, cutting-edge science from Israeli academia in selected niche areas and to transform it into marketable products. This required our adding value at many points, using knowledge, expertise and skills that exist within Teva but not within academia.

Our first new drug, Copaxone, a leading treatment for multiple sclerosis, was developed through a very successful collaboration with Israel's Weizmann Institute of Science. In 2003, after seven years on the market, it contributed about 20% of our total revenue.

We now have, by far, Israel's largest drug development group and about twelve new molecular entities in various stages of the development pipeline. About ten of these are based on licensing agreements with Israeli universities, so our basic idea worked. We also have over fifteen equity investments in Israeli startup companies with promising products or platform technologies.

We do create some new entities based on in-house research. However, we do not seek to discover totally new receptors or enzymes. Rather we try to optimize or find new uses for existing molecular structures or to combine them into novel, patentable products, with added clinical value. Finally, we sometimes collaborate with foreign pharmaceutical companies in order to share the risk, know-how and "market muscle" required to commercialize such products.

Teva's Innovative R&D Division has grown over the last twenty years from about 50 people, all in Israel, to about 500 people, about half of whom are located in Israel. This is where a lot of the core development and the interaction with the scientific community occur. Since we are the largest pharmaceutical company here, we also see ourselves as educators, hiring people from academia and training them on-the-job to do industrial pharmaceutical development. Such people do sometimes leave us to work with smaller startup companies. Either they stay and contribute successfully there, or they come back to us after a couple of years with additional skills and management experience. The overseas half of our division is spread worldwide, mainly to do clinical trials in and for our largest markets, the U.S. and Western Europe. Like the rest of our industry, we are now venturing into Eastern Europe.

How can pharmaceutical companies add value to academic research? Let us take Copaxone as an example. The first major development hurdle was that Copaxone was a mixture of amino acid copolymers with no specific sequence, whereas regulatory agencies are sticklers for batch consistency, quality and so on. So we had to take this mixture and, without losing its biological activity, standardize it so that it could pass regulatory scrutiny. Another drug of ours, Rasagiline for Parkinson's disease, was based on research done at the Technion, but their original molecule was clearly impossible to patent. In our industry, enforceable patents and sufficient patent-life to make a profit are crucial, so we isolated the active isomer and created a novel, patentable product with all the biological activities of the original preparation. There are similar examples in almost every product in our pipeline.

Each year we screen about 140 to 150 proposals for new projects. All go through a very tight sieve of evaluation, based on scientific merit, IP merit (patentability), market potential, competition, added value, etc. The basic research funnel must be very wide in order to get those very few projects that can actually succeed. In principle, we evaluate projects for all indications, but we emphasize certain niche indications where we can do the clinical trials and marketing on our own. If we do find a particularly good idea outside our strengths, we can collaborate with other pharmaceutical companies with more expertise and marketing power in that area. Of course, for us to maintain a robust, continuous product pipeline based mainly on Israeli research, Israeli science must maintain its current level of productivity and innovation. The decreasing level of government financing for basic research, which in our area takes many years to result in something practical, is thus quite alarming. The government must restore and maintain funding of basic research at high levels. Otherwise, we may be forced to start looking for innovation outside of Israel, which would be very sad for us all.

Our industry is now approaching a new technological inflection point. Our last transition moved us from simple chemicals to biological and biotechnological products; the next will involve gene, cell and stem cell therapy – areas in which Israel is really at the cutting edge. We want to help with this revolution and to have the right skills and expertise to take advantage of these new opportunities and commercialize them.

Why do scientists work with us? We do bring money – we finance continued research, pay royalties and so on – but what else do we bring? As a local company, we bring the same language, culture and networks. People know each other and are easy to work with, and we can maintain continuous contact and collaboration. We are also willing to invest in relatively early-stage ideas, whereas many other companies look for more advanced products, already in phase II clinical testing.

Our division has proven experience in all stages of drug development, with in-house skills and infrastructure in everything from chemistry, pharmacology and toxicology to statistics, clinical trials and regulatory strategy. As a generic drug leader, Teva has world-class capabilities for the commercial production of the active materials, as long as they are chemically and not biologically produced (after acquiring Sicor, we now have some in-house biotechnological capabilities as well). Finally, Teva's leadership team has a long-term track record of success in everything that it has done. We hope to become a leader in developing innovative medicines as well.

Comments

Ada Yonath: The issue of patents affecting, driving or even stifling research is something we have recently been struggling with in our own research group, which studies ribosomes, molecular assemblages that translate genetic codes into proteins. Since ribosomes are very abundant and universally imperative, they are potent, widely utilized therapeutic targets. Minute variations among ribosomes from different organisms permit the widespread use of antibiotics that specifically target pathogen ribosomes but do not affect human ribosomes. One important ribosomal target is a pocket within the molecular tunnel through which newly assembled proteins must pass. Some important antibiotics, such as erythromycin, work by blocking this tunnel.

In 2001 our group published the structures of tunnel-blocked complexes of antibiotics with the large ribosomal subunit of a eubacteria that resembles human pathogens. However, in 2000, a group at Yale University determined the structure of the same ribosomal particle from *Archaea*. Since their ribosomes differed at the most important antibiotic binding site (nucleotide 2058), it took them two more years to construct complexes, even using concentrations 2000 times higher than our clinically relevant conditions. Furthermore, their antibiotics do not block the tunnel of Archaeal ribosomes very well.

In brief, the structure of the *Archaea* binding site does not seem useful, either theoretically or practically, for developing improved antibiotics. Back in 2000, however, the Yale group successfully patented the structure of the empty Archaeal large ribosomal subunit and extended their patent beyond *Archaea* to all ribosomes. Unaware of this, we filed our patent in 2001, specifying clinically relevant ribosomes and antibiotics. We have already been approached by almost all the major drug companies suggesting collaboration; but our patent is still waiting, perhaps because of the Yale patent. Although the lawyers we consulted claim that the Yale patent is unlikely to be useable, it took a lot of time and effort to determine this.

This is the new environment in which scientists work. The drive to patent is intense, and the drive to profit from intellectual property sometimes seems unlimited. We have to set reasonable bounds and improve our patenting of science-based knowledge, so that we don't waste huge amounts of our time fighting patents that are unusable or unreasonable. The Yale group, by the way, has now founded their own company for developing ribosome-targeting antibiotics and hired our senior biochemist.

Technology Transfer and the Academia–Industry Relationship

Hanoch Gutfreund

Much of my talk grows out of my involvement with the Dead Sea Forum, first convened a few years ago by Professor Jacob Ziv, President of the Israel Academy, and the late Professor Nehemiah Levtzion, then the Chairman of the Planning and Budgeting Committee of the Israel Council for Higher Education. The Forum met to discuss the changing role and environment of Israel's research universities, and university–industry relations was deemed such an important element that a special committee was formed to focus on those issues. Our final report will be discussed by the committee next week and should soon be made public. As the committee's chairperson, I shall share some of the highlights with you now.

In brief, we fully concur with Amir Elstein's statement that there is a very significant role for academies of science and improved government policy in this area. There was once a belief that, since university–industry collaboration is a win-win situation, perhaps market forces alone could drive and smooth the process. However, the associated dilemmas, constraints and problems are so severe that, as Amir noted, industry and universities simply cannot do it alone. There is also cultural incompatibility between the university's pursuit of knowledge for its own sake and industry's management of knowledge for profit. This leads to many differences in governance, timescale, criteria for success and so on. Still, there are many compelling arguments, both institutional and national, for entering into such a partnership.

Proactive searching for joint opportunities and contractual university–industry agreements to collaborate on specific projects are a fairly recent phenomenon. In the 1960s and 1970s there was still a bitter debate about this in the universities. In his delightful book, *Beyond the Ivory Tower*, Derek Bok, former president of Harvard, devotes two chapters to those internal debates about what collaboration with industry would do to university culture.

We are far beyond that stage. Universities, in times of diminishing resources, have discovered the potential benefits of industry-generated income, and industry wants direct, immediate access to the results of university research. Governments recognize that such cooperation is the main fuel for academic and economic growth.

Several countries, such as Sweden and Australia, have produced very instructive reports on the turning of science into a business. A comprehensive OECD report reviews all the issues involved in the commercialization of academic research results. It is interesting, of course, to look for a common denominator, because this is a global phenomenon and we all face many of the same issues, but there are very significant national differences as well.

In the United States, since 1984, there has been a government–university–industry research roundtable, sponsored by all three U.S. academies. This forum has played an important role in bringing national science policy issues, particularly those at the interface of these three elements, to the attention of the public and decision-makers. The roundtable continuously produces reports, and in 1995 its members revised and redefined their mission. Since September 11th they have focused mainly on issues connecting research, science and national security. Our report must be seen in the context of all these others.

There is a definite need for more supportive government policies in this area. There are intellectual property issues that must be carefully regulated by legislation, with all due care for the consequences. There are issues of how best to encourage the technology transfer process, whether through direct subsidies and tax exemptions or by other means. The OECD report describes how, in several countries, the government is directly involved in smoothing that process. There are issues of local versus foreign industry, and places with preferential incentives for the former.

I will leave aside these details to address two basic questions that face today's universities: "Who owns IP?" and "Is the transfer of knowledge a legal obligation?" The Bayh–Dole Act, adopted by the U.S. in 1980, was a landmark decision with worldwide consequences. Designed to promote investment by the private sector, it stated that IP arising from publicly (governmentally) funded university research was still owned by the university itself – an incentive that greatly smoothes the technology transfer process. It also said that the universities are legally *obliged* to engage in such technology transfer. Israel has no specific legislation on that. There is no need for it, since IP arising from academic research automatically belongs to the universities as a consequence of our patent laws. Although there are no external legal obligations, all Israeli universities have internal rules obliging their researchers to inform them about discoveries with commercial potential. The results here, compared to other countries, are quite good.

What are the instruments of technology transfer? In the United States, almost every university has a technology transfer office, a department within the university responsible for promoting that process. In contrast, since the 1960s, all Israeli universities have had external but fully owned, subsidiary companies for technology transfer. Because of Israel's standard, uniform academic salary agreements and bureaucratic restrictions, generating and launching a business-like activity is best done outside the university. Still, our universities should develop a technology transfer policy that better defines their goals. The Australian report we mentioned recommends that all universities develop mission statements for their technology transfer processes, taking into account public benefit and other goals in addition to maximizing profits. Although Harvard's mission statement instructs its transfer department simply to maximize profits, M.I.T. takes a completely different, almost opposite, tack.

If the technology transfer goals of Israeli universities go beyond maximizing profits, such goals will be difficult to achieve via an external entity whose board of directors is instructed only to do that. This issue will become a new, required element in university policy.

The number of relevant issues and problems is large, and the Israel Academy is a highly appropriate arena in which to discuss them and bring them to public awareness. I hope that our report, once it is made public, will generate public debate and promote this process.

Governments and Academies:
Facing the Challenges of the Future Together

The Government–Science Relationship: Changes for Changing Times

Eliezer Sandberg

Maybe I should start by apologizing, I am a lawyer, not a scientist. I am, however, Israel's Minister of Science and Technology for two reasons. One is that Israeli ministers are political officers, appointed in accordance with political decisions. The other is that I asked for the position, following my experience heading a new Knesset subcommittee dealing with high-tech issues. I have learned many things – positive and negative – since then, but, in all, mine is one of the most optimistic and pleasurable ministries in the State. You who are people of science know what science means and you know the capabilities of Israeli science. For eight years I headed Israel's delegation to the Council of Europe, where I had to struggle again and again with anti-Israel decisions involving the peace process and the Palestinians. Now, as Minister of Science and Technology, I go to different places and feel how science can really bring people together, even those who come from places of dispute, and how science gives inspiration and hope to the world.

I would like to emphasize a few points about the relations, as I see them, between the government of a state and its national academy of sciences. There is an ongoing and longstanding contradiction between the desire of the academy to enjoy freedom of research and its need to receive support, mainly financial support, from the government. Governments usually want results. As the voice of science and scientists within the Israeli government, I sometimes find it very difficult to explain to the Ministry of Finance how the money that is going into science will improve life in Israel, in the short and long term. Sometimes being a lawyer can be a virtue and in this case I was able to make a strong case for the connection between science and social benefit here in Israel, and not only in Israel. Everywhere I go, I have the same dialogue. The government finance people say, "If we invest in science, what will be the outcome?"

The Intel and Teva presentations before mine – although I was not here – presumably reflected some of the changes that have been occurring in the world of science and research. Increasingly strong ties between industry and academia are changing what was, in the past, a clearer separation between basic science, applied science and technology. Today things are more blurred.

I will not go into all the evidence for this change, although I might mention one United Nations health report noting that most medical and pharmaceutical research focuses on illnesses that are problems in the rich countries of the Western world. Little is done for poor countries or for poor populations that are unlikely future clients for the medicines developed. Similarly, consider the numbers of academic people and scientists who file patents to protect their IP. I don’t think that was the case in the past. Things are changing, and, so in my view, the state also needs to reconsider the relationships between basic research and academic freedom. This is particularly true of state sponsorship of research and the economic benefits that these scientific activities can bring.

In Israel, perhaps unlike other places, our parliament raised this issue many years ago. In 1961 it enacted the Law of the Academy of Sciences and Humanities, which clearly delineates the contributions of the Academy to the State of Israel and its society. As is the case all over the world, there has often been tension between the administration, our ministry and the Academy. But a new initiative, introduced by the Israel Academy itself, should help address that problem.

A new law, enacted a year or so ago, mandates the creation of a National Council for Civil Research and Development. Professor Ziv, the President of the Israel Academy, was strongly involved in the enactment of this law, and I can say only good things about his involvement. This law will create a new order, a new relationship between the scientific organs that already exist in Israel and the government. For the first time, our law states explicitly whom our government is to consult regarding research, technology and development (RTD). The council (which I have already nominated) will look into all the different organizations, statutory and private, universities, research institutions and ministries that deal with RTD, and make recommendations with reference to all of them. It is the first time that we are concentrating so many recommending powers in one organization.

That mandate will include the Israel Academy in its purview. Professor Ziv made a very brave decision in accepting the establishment of a council that will examine the Academy, monitor its activity, and give advice to or instruct it in some fields. That might sometimes seem like a contradiction of the freedom of the Academy, but it does go together very well with the new, changing world in which the government, academia and other research institutions need to be brought together. I think that this council will initiate a new era in the connections between the Academy and government in Israel.

The law explicitly states that the government can solicit opinions from this council. I look forward to cooperating with it. All the various organizations in Israel that deal with science in one way or another will have to affiliate with it, take part in it, be examined by it. Setting aside this advisory role for the council, I believe that there are still many other roles left for the Israel Academy in its dialogue with the government.

I can list several issues regarding which I expect, hope and believe that, in the future, we will be in direct contact with the Israel Academy. They include the current debate about reenacting our law prohibiting cloning and Israel's proposed new educational program, particularly those parts that touch on science teaching. I once asked Professor Ziv, "What do you think Israeli teachers should teach their ninth-grade pupils in order to prepare them for future research in nanotechnology?" I thought that the answer to such questions was always mathematics; but Professor Ziv told me, "No. Physics, biology, chemistry – they all have to be there for nano." We are going to need a revolutionary new educational program. What part of it will be connected to those subjects that deal with the substance of science? How much science is going to be there? The Academy has a very important role to play in these decisions. Other decisions, like budget cuts for the universities, are a matter for the government, although the voice of the Academy is still extremely important.

The absorption of new immigrant scientists raises other issues. How strict should we be with them about their titles? Should we accept a full professor, doctor or Ph.D. from the former Soviet Union at face value, although an Israeli of similar training or experience might have a lesser title or degree? How much are we going to compromise on that? These are important issues on the Israeli agenda, and I believe that a dialogue on them with the Academy could be very fruitful. I hope that next year, when some of these issues emerge again, we will be able to consult with and hear the views of the Academy.

Our new Council for Civil R&D will be making recommendations to the government's Interministerial Committee on Science and Technology. As Minister of Science, I am also the chairperson of that committee. In that capacity I am very interested in investigating the possibilities for change. I have many thoughts and ideas on this subject, which I am not going to describe here; but I do believe that we need to look into different legal constructs for dealing with scientific innovation than those that exist today. We may need to create some new organizations and institutions, and to change some existing ones. We need to discuss ideas about involving more young scientists in new types of activity, ideas about combining the old and the new, and, of course, about how we can maintain basic and applied research in these times, when industry so intensively influences the everyday life of every scientist.

I have briefly described both the needs and the challenges in the relationship between government and science in the State of Israel. Above all, we should do as much as we can to promote science, to assist scientists, to help alleviate their everyday worries, and to let them do their research freely. I am ready to do that. In fact, one of the reasons I must leave exactly on time is that my next meeting is with the Minister of Finance, following a meeting yesterday with the Prime Minister. Both meetings are about how to do more for science.

A European Approach to Science, Intellectual Property and Ethics

Pieter Drenth

Yesterday I addressed the overall role and function of All European Academies (ALLEA), the European umbrella organization of national Academies. Today, in discussing salient problems of the future, I will limit myself to two particularly important issues: intellectual property (IP) rights and ethical issues related to science. ALLEA has standing advisory committees for both. The committee on intellectual property rights is chaired by Roger Elliot, and the committee on science and ethics, which I formerly chaired before becoming President of ALLEA, is now chaired by Gerald Toulouse. My observations on IP rights in Europe will rely heavily on the opinions of the IP committee and its chairman Elliot.

Regarding IP rights, I am the mirror image of your science minister, who introduced himself as a lawyer talking about science. I am a scientist talking about law. IP rights in the context of academic research mainly involves patents and copyrights. These are meant to maximize the public good derived from inventions and creativity by granting and protecting monopoly rights for a given period, to allow adequate rewards for inventors and to ensure that the applications of their research pass into the public domain. However, in certain circumstances, these rights can be overridden by other aspects of the public good, such as national security and – of more importance to scientists – limited use for teaching and research purposes. The latter exemption promotes free communication and the further development of research.

Some recent, radical changes in European attitudes towards IP may have a harmful effect on this balance. First, research institutes and universities increasingly encourage their researchers to consider the potential financial rewards of their research, on account of the increasing privatization of universities and decreasing public support. Universities tend to encourage more contract research and to diminish open communication, especially if patents seem likely. There is also more pressure on researchers from universities (and their boards) to select research topics that can lead to patents. Both trends tend to harm science-driven research and the free flow of information.

Second, there is an important difference between discoveries and inventions, and patents should be issued only to the latter. In practice, however, this crucial distinction is increasingly blurred, particularly in the computer sciences and medical biology (human genomics). In the past, a patent submission had to meet clear requirements for invention, but nowadays even a vague, quite unsubstantiated suggestion of potential medical utility can lead to patents on a DNA sequence.

Third, enhanced protection for IP rights, particularly through international agreements, has a disproportionate effect on economically less-privileged and developing countries, *de facto* denying them access to vital information and patented products. Drugs against AIDS are a case in point.

Fourth, new copying and dissemination technologies have opened a new chapter in scientific communication, with more speed, better cross-referencing and often some cost reduction. All of this is not much of a concern for most researchers or scientific authors – unless their textbooks are widely sold – but it is a very important issue for scientific publishers. Consequently, they are attempting to tighten copyright laws and to dilute the traditional "fair use" exemption, which allowed making copies for research and teaching. Even the old law used to be a bit tight. In my country, one was not permitted to make more than 15 copies. If you had a class of 25 students, you had to give them the master copy and ask each of them to go to the copier and make his own single copy! Even this will no longer be possible if the laws are tightened. No one will be allowed to copy anything for teaching or research. This could be disastrous.

Fifth, legislative pressure to protect databases has led to a new European directive that will provide intellectual copyright protection to the raw data itself, which is not covered by traditional copyright legislation. Since the quality of science depends on the repetition and verification of results by others, denying access to such data could be a serious impediment for science. Such legislation could also apply, for example, to meteorological and oceanographic data essential for research. So decreased access to data can be a real threat to science.

Europe's existing "patchwork" system of patenting is very complicated, expensive and inefficient. ALLEA's intellectual property rights committee recently formulated a number of specific recommendations for pan-European patent law, including:

- The creation of a single uniform set of patent regulations for Europe, administered by the European Patent Office (EPO);
- English as the one uniform language for patent applications;
- Community-wide jurisdiction to enforce patent law;
- The introduction of a grace period, to avoid disadvantaging European researchers *vis-à-vis* the U.S. and the rest of the world;
- The separation of individual projects and medical treatments into separate or derivative registrations.

These proposals are now being forwarded to the European Commission. ALLEA will continue to lead a concerted and collaborative approach towards the EU. We hope that European academies will remain vigilant against the further erosion of academic norms and against the efforts of publishers, the music industry and the media to tighten IP legislative frameworks to the detriment of the academic enterprise.

As for ethical issues, my second topic, the time when science could ignore ethical constraints and public reaction is past. Scientists now realize that their responsibility does not stop at the laboratory door. They have to be concerned about the impact of science on society and the potential reactions of society that can impinge on science. Science must be properly integrated into public life, rather than isolated from it.

Discussions of ethical problems are now commonplace throughout Europe. With respect to science's "internal" ethical problems, the emphasis falls on violation of integrity and on scientifically unacceptable behaviour, such as scientific fraud, deceit and IP infringement. Less serious but still reprehensible is socially improper behavior, such as not obtaining fully informed consent, insufficient protection of privacy, careless behavior, particularly before the general public and the media. This includes being too optimistic or promising too much without sufficiently strong evidence.

"External," socio-ethical problems involve such pressing questions as: Is it really worth pursuing what we investigate? Is our research sufficiently independent from interested parties, such as sponsors and users? (Contract research does not have to go wrong, but one might well heed the Scottish saying, "He who pays the piper calls the tune.") To what extent are scientists responsible for what is done with their research? Surely, not every misuse of research is the fault of the researcher, but researchers should try to ensure that their results will be properly interpreted and used, and that abuses will be identified and counteracted.

Other ethical problems are generated by the research itself, no matter how well or responsibly done. Examples abound in medical research, where new means for diagnosis and treatment can necessitate making ethical choices for which society is not yet prepared. Should scientists take "no go" or "slow go" decisions with respect to certain research problems?

Are these problems of uniform concern throughout Europe, or are they restricted to certain countries or regions? Some issues, such as genetically modified foods (GMF), seem quite country-specific. There is extensive public discussion on the possible dangers of GMF for the consumer, although all available empirical research provides evidence to the contrary. The reactions of European countries vary from quiet acceptance to requiring frightening food labeling to discourage GMF use. As another example, stem cell research opens up major new avenues for the medical treatment of many genetically determined diseases, but there are strong differences of opinion in Europe about its ethical status. The Italian, Irish, Spanish and Portuguese governments, representing mainly Catholic populations, are largely against stem-cell research. The U.K., the Netherlands and the Scandinavian countries, representing a Protestant tradition, are largely in favour. Germany is strongly opposed having ever since World War II a strong apprehension of genetics-related issues. So one notices considerable variety, because legislation is often influenced by varying religious and traditional norms.

There may also be more general or universal criteria and concerns. It is not easy to define them, but we will give it a try. In my own view, research is unjustifiable if unacceptable damage is inflicted upon the objects of research, be they humans, animals, cultures or the environment. Research is also unacceptable, if the nature or consequences of the research are in conflict with basic human values such as dignity, autonomy, informed consent and freedom of choice. This would also preclude the commercialization of the human body. Finally, research is unacceptable if it contravenes solidarity with humankind. This includes accepting the equality of human beings and avoiding discrimination. It also includes solidarity with posterity, to whom we leave a livable, sustainable planet.

A Joint Future: Learning from Each Other

Bruce Alberts

I want to start by congratulating the Israel Academy for being such a great help to the world scientific community and for its exemplary participation in the international activities of the world's academies. This is something I knew nothing about when I became president of the U.S. National Academy of Sciences (NAS). My whole view of international science was jaded by international biochemistry congresses in faraway places, where I heard speakers whose papers I could simply have read in the library. I wanted nothing to do with it. However, in September 1993, soon after I became president, the first-ever meeting of the academies of the world was held in New Delhi. Their goal was to inject scientific input into a major U.N. population conference that was to be held in Cairo in 1994. Otherwise, we feared, the conference would proceed without any scientific input.

The New Delhi meeting was something completely different for me. It wasn't about DNA replication research; it was about how science can do something important for the world and society. It was a different kind of science. For example, how much does educating women contribute to population control? There was scientific data on that. We could tell from scientific evidence what works. That meeting was very successful; its major statement, presented by the president of the Indian National Academy of Sciences, was indeed the only science at the Cairo conference.

On our last day in New Delhi, someone organized a special meeting of all seventy academy representatives to ask whether there shouldn't be more regular meetings of this kind. As a young, somewhat naïve new academy president, I doubted the need for yet another organization. We already had the International Council of Scientific Unions (ICSU). Why did we need anything else? Then Dr. Mennen from India, a former president of ICSU, presented some very articulate reasons why we did need this new organization and everyone – including myself – became enthusiastic.

The InterAcademy Panel (IAP) on International Issues was basically established at that meeting. Its secretariat is now located at the Third World Academy of Sciences in Trieste, and it recently received a major permanent endowment from the Italian government. The InterAcademy Council (IAC), now headquartered in the Netherlands, was formed in 2000, with the help of IAP. Both are organizations in which Israel has been enormously visible and important, partly because of the quality of its leadership. At the 2000 IAP meeting, the world's academies voted on which 15 academies should represent the world scientific community on the IAC Board. China, India, the U.S., the U.K. and France were all obvious choices … but Israel? Israel's election at the time was a dramatic symbol of the world scientific community's objective recognition of what Israel has done in and for science – not only for yourselves, but for the rest of the world as well.

The IAC's first major report, *Inventing a Better Future: A Strategy for Building Worldwide Capacities in Science and Technology*, was released at a special meeting of the U.N. General Assembly in February 2004, hosted by Secretary General Kofi Annan. The second report, about how science and technology could best improve agricultural productivity in Africa, will be released by the Secretary General at a meeting of African leaders in July. (Africa is the only continent where food productivity per person is declining.) The committee's water expert is from Israel, and in general the contribution of Israelis has been noticeable. It makes good sense for a country like Israel to advise less-developed countries. In the United States, we are sometimes too far removed from that development experience to be useful.

We have worked with you trying to build up the scientific academies of the Middle East. We completed a wonderful joint study on water in the Middle East. The committee comprised three Palestinians, three Jordanians, three Israelis, a few Americans and a Canadian. Their last meeting was held in Washington, and my wife and I had them over for dinner. It was amazing; the Palestinians and the Israelis even exchanged political jokes. Although they had all earned their degrees in similar foreign universities, they hadn't known each other. Working together on this report had built new bridges between the water communities of the region. Sadly, this sense of excitement about the future has since disappeared, although we hope to do more in the future. Our new Israeli-Palestinian Foundation allows the NAS to bring together young scientists from the region in a Frontiers of Science framework. So we do hope that things will get better and return to the wonderful spirit of three to four years ago.

In our recent joint Israeli–U.S. Academy meeting in the States, we shared a concern that our best young scientists are not getting a chance to do their own independent work until they are too old. They are also too risk-adverse to be bold, in part because the major funding agencies won't fund their research until they already have a great deal of supporting data. One of your innovative solutions for this problem is your Focal Initiatives in Research in Science and Technology (FIRST) program. We were fascinated by this experiment. In fact, the director of the National Institutes of Health (NIH), Elias Zerhouni, a wonderful leader who was educated in Algeria, attended our meeting, because he is very concerned about exactly the same issues. He is now supporting a major NAS study on this, beginning with a workshop this June. Our committee is chaired by Nobel Prize-winner Tom Chech. We will recommend how the NIH might catalyze some more creativity from our best young people. I suspect that your example, FIRST, will be showcased there again. Both the U.S. and Israel have done many interesting relevant experiments, and we all need to share the results.

I am also fascinated by the massive experiment that Israel is proposing in public education, as described by Professor Lavy. I hope you will come to the United States and study the many experiments underway in our school districts. Each and every way we try to organize schools has had its own problems, and we need to learn from the experiences of others in order to avoid mistakes. For one, U.S. school systems generally do not pay attention to the wisdom of the best people in the system, that is, the best teachers and principals. They may even view them as nuisances, because they always raise ideas for change and make demands on administrators. We need more of the Japanese respect for "wisdom from the shop floor."

Any scientist would view an attempt at major social change as an experiment. As Professor Adi Shamir noted in his comment, it is absolutely impossible to figure out in advance what exactly is going to happen. The problem with major American education reform experiments, such as our new "No Child Left Behind" program, is that politicians can't admit that they ever make mistakes. Therefore, they can't really do experiments. They have to insist that they got it right the first time, even if that keeps them driving in directions that don't and never will make any sense. The U.S. "No Child Left Behind" initiative has many of the same types of rules found in the Israeli proposal: you have to be certified as a teacher, schools have to jump through certain hoops, and so on. Now they are sending letters to some of the most outstanding teachers in our public education system, stating that they are not qualified because they lack certain formal course work. This is crazy.

If the world had a more scientific spirit, everything would work better. We would be a little more humble about predicting in advance the outcomes of these great social experiments. We wouldn't take such pride in our reforms and inventions that we couldn't readily admit and adapt to their shortcomings.

My dream for the San Francisco school system – where four of my grandchildren are pupils – is to continue an experiment started there when I was the principal investigator on a federal government grant to promote "hands-on," inquiry-based science programs in elementary schools. Someone came up with a simple but great idea. From 72 elementary schools, the school district chose the 15 teachers who knew how to teach science best and put them on a special advisory committee for the entire school district's hands-on science education program. Then the same idea was extended to mathematics. This is an obvious way to get shop-floor, experience-based wisdom into the system, but it is almost never done. In fact, I understand that a new administration in San Francisco has disbanded the whole thing!

My major point is that the scientific approach needs to be brought into education. This means treating the educational system as an analyzable, evidence-based system, in which we incorporate what we *learn* from experience and experiment to build better and better systems. This is a critical issue for every country. Meanwhile, there is good evidence in the United States that huge numbers of talented people are simply being lost in our present educational system – a national tragedy as well as a personal one.

Professor Lavy mentioned Boston's charter schools. The University of California at San Diego has set up its own public charter school, right on the campus. This Preuss school only accepts children from

San Diego whose parents never went to college. Since they have many more people applying than they can take, they use a lottery to select students, who attend for seven years, from sixth grade through high school. What happens to these kids, compared to what would have happened to them in a regular school? The results have been amazing, with 98% going on to college. Schools such as these show what is possible. They also prove that we are not doing as much as we could for the vast majority of our disadvantaged children.

I will conclude with the role of academies at the national level. The following experience clearly shows their value. The U.S. House of Representatives has a committee charged with the oversight of government agencies. Recently, they challenged the NIH on conflict-of-interest issues. The Los Angeles Times published a major series of articles about NIH scientific staff consulting for private companies in potentially inappropriate ways. The Director of the NIH, Dr. Zerhouni, then had two options. He could ask the Academy to do a study on the NIH's conflict-of-interest rules, or he could set up a blue-ribbon panel to do this study under his own direction. He opted for the latter and asked me to co-chair it with Norman Augustine, a former CEO of Lockheed Martin Aircraft Company. Since it was an emergency, we had to do the whole study in only 66 days.

We had a wonderful panel, but the study was "tainted" from the beginning, because it was run under NIH auspices. When we released the report, the newspapers promptly suggested that we had "sold out." It was a very sound report, but it lacked traction. Had the Academy done this study, the outcome might have been quite different. The U.S. press really does respect the Academy as a neutral, objective body. I kept thinking, "Why did I kill myself to help produce this report, when they weren't going to pay attention to it anyway?"

The Academy doesn't lobby for legislation; we simply put out our reports. Then other people or groups, who may have strong positions, can use our reports to argue their points, pro or con, based on independent, objective science. I can't imagine that Israel doesn't need the same kind of objective advice. One problem, of course, is that it takes a while to get the necessary reputation among (and trust of) your press. That could take time, but a respected, independent voice for science is a very important feature in any society. Even when public action is not immediate, our advice is still out there on the record, ready to be used when relevant legislation arises – as much as ten years later.

We like to think that the Academy brings truth to Washington, in the spirit of the famous movie "Mr. Smith Goes to Washington." That's our role. Our panels come from the grassroots. Our educational studies involve active teachers where relevant. Most policymakers in Washington try to do the right thing, but they often don't understand the real-life complications involved. We have to help them understand what the problems are before they make their important decisions. They need the scientific and technical facts, at least. Such truth can't be bad for Israeli decision-makers, either.

Delivered as the keynote address at a special evening session (May 17, 2004).

Science and Bioethics: The Case from Stem-Cell Research

Michel Revel

Before addressing the importance of bioethics in the progress of biological research, I will try to venture a definition. Bioethics seeks to ensure that progress in and medical applications of the life sciences serves as an instrument to promote human welfare, while respecting human rights and fundamental individual freedoms. There are some general principles to be followed in bioethics, but the speed of major advances in human genetics and reproduction is now so great that new ethical reflections are continuously necessary. For this we need multidisciplinary bioethics committees at both the national and the international level.

To me, the function of bioethics is two-fold. Bioethics insists that it is legitimate to explore the beneficial potential of scientific advances, but also that we carefully define the limits of permissible application. Both are the focus of the Bioethics Advisory Committee of the Israel Academy of Sciences and Humanities, which I chair. Our reports, available on the Academy's website, address such issues as the use of human embryonic stem cells for therapeutic research and large-scale, population-based DNA collection and genetic information databases. We are now completing our report on the limits of prenatal diagnostics, including such issues as "designer baby" sex selection and other applications of modern genetics.

Because of time limitations, I will focus only on the human embryonic stem cell issue. Israel conducts a great deal of research on stem cells in a therapeutic context. This research could replace classical drug- and surgery-driven medicine with revolutionary new regenerative medicine. Stem-cell-derived, dopamine-producing nerve cells have already been used to treat and cure Parkinson's disease in mice models, and insulin-producing cells have been used in diabetic mice models to replace insulin injections. Successful experiments using other types of human embryonic stem cells strongly suggest that such techniques could be transferred to humans. We even hope in the future to be able to treat spinal cord trauma and neurodegenerative diseases with stem-cell-derived nerve cells, and to treat cardiac infarctions ("heart attacks") with new cardiomyocytes. However, to adapt and apply these therapies to patients, human embryonic stem cells are urgently needed.

Stem cells can, of course, be multiplied in tissue culture, but how are the original stem cells obtained? From the inner cell mass of five-day-old blastocysts, small balls of human embryonic cells, usually left over from in-vitro fertilization (IVF) therapy. Such "extra" IVF embryos are already outside the uterus and, if not used, are usually scheduled for eventual disposal. Unfortunately, most existing human embryonic stem cell lines are not of clinical grade and could not be used in human patients, so there is a desperate need to develop new embryonic stem cell lines. That poses the main bioethical problem.

Is it ethically permissible, even for therapeutic research, to derive cells from human embryos, thereby bringing the existence of the original embryo to an end? A highly pluralistic ethical debate is in progress, with considerable variety of opinion. As Professor Drenth mentioned, some European countries accept such research, while others reject it. The Catholic religion and the laws of many individual countries consider the embryo as person, with the right to be respected and treated as such, from the moment of conception. This would prevent any research that ended the existence of an embryo, even a blastocyst. It would also, in practice, end IVF-assisted conception, since that requires producing many embryos from which doctors can select those with the best chances of implantation (the odds aren't all that high). The Catholic Church consistently opposes both practices.

In the Jewish tradition, in case of danger, the life of the mother takes precedence over that of the embryo and later the fetus, up to the moment before birth, so the fetus obviously does not start out with *full* human rights. Rather, human status and rights are acquired progressively, with a significant landmark at 40 days after conception. The situation is similar in Islam.

Proponents of stem cell research note that at the five-day stage one blastocyst can still be divided to give rise to two distinct individuals (twins) with two quite distinct human identities and consciousnesses. Even genetically the two will not be the same; there is a lot of genetic independence, and in any case, we are not only genetically determined. How, then, can the blastocyst represent or have the rights of any single human being? The proponents further note that although every human being comes from a blastocyst, not every blastocyst becomes a human being. In nature, only half of all blastocysts actually implant themselves in the uterus and develop further. In IVF therapy, the blastocyst's future also depends on the explicit decision of the parents to initiate the pregnancy. If they don't want to use any more of their stored embryos, they are frozen and, in many countries, simply discarded after five years.

A few years ago the International Bioethics Committee of UNESCO, of which I am a member, wrote a report recognizing the plurality of ethical opinion regarding the production of human embryonic stem cells for research. Even among those countries that prohibit it, there are differences. Germany, for example, has a law prohibiting the importation of stem cells *except* from "countries where there are ethical rules." Israel is listed as one of the latter, and German scientists have actually imported human embryonic stem cells from here. In contrast, Italy recently decided to prohibit freezing *any* embryos at any stage, just to prevent stem cell research. This will seriously jeopardize Italian IVF therapy. In the U.S., you cannot create new stem cell lines with federal funding, but you can use existing cells. However, as I explained, that is not enough. American scientists can legally produce new stem cell lines with private funding.

In Israel, the Academy's Bioethics Advisory Committee approved producing new stem cell lines using donated "leftover" IVF blastocysts. We did, however, insist on a clear separation between the IVF medical team and the recipient stem cell research team. Furthermore, such embryos should not be bought or sold, to respect the imperatives of justice and equality. Based on this bioethics infrastructure, two Israeli research centers, one in Jerusalem and the other in Haifa, have already produced new human embryonic stem cell lines for clinical research, with the permission of Israel's various bioethics committees, including its Helsinki Committee.

The cloning of embryonic stem cells is another hot issue. The goal is to obtain cells that are immunologically compatible with the intended recipient, so that they will not be rejected. One can make embryonic stem cells without cloning, but cloning could add very important potentials. Our committee decided that it is ethically permissible to attempt embryo cloning for stem cell production, without reproductive purpose; this is called "therapeutic cloning."

Like most other countries, Israel already has a law prohibiting the reproductive cloning of humans. This law, passed for an initial five-year period in 1998 and renewed in 2004, does not prohibit producing cloned embryos, but it prohibits implanting such an embryo into a uterus (i.e., proceeding to reproduction). This renewable approach sends the important message that something good can come from almost any good science, and that no science should be banned, *a priori*, forever. Even if one opposed creating viable embryos for research, cloned embryos are not necessarily fully viable in reproductive terms, in that they were never meant (or are no longer meant) for complete fetal development.

This has recently been a hot issue at the international level. For example, the United Nations is now considering an international convention formally prohibiting reproductive human cloning, which is already prohibited by almost all the nations, including Israel. Within this discussion, France, Germany and others are proposing a broader ban that would also affect therapeutic, not just reproductive, cloning. The U.S. administration, for example, now holds that "pending adoption of an international convention against human cloning, no state shall permit any research, experiment, development or application of any technique aimed at human cloning." That closes a complete area of research, something which I believe goes too far and should not be done, even under political pressure. This is a serious issue for national academies all over the world and for umbrella groups like ALLEA.

In contrast, the United Kingdom and Israel hold that while stem-cell cloning research should certainly be regulated, it should continue because of its exceptional medical importance. More extreme is South Korea, where a Dr. Wang recently claimed to have made embryonic stem cells from a cloned human blastocyst – if true, a first. He apparently needed 242 blastocysts from 16 donors to make his one cell line. The Korean Bioethics Committee said they didn't know anything about it, but it turns out that Dr. Wang is the president of his own ethics committee! That's obviously not the way things should be done. The science seems great; the bioethics, dreadful.

All of Israel's bioethics committees, including its Helsinki Committee, have advised the Knesset to continue limiting the validity of its human cloning law to five years. Today it is prohibited; in five years, we will examine it again. We will not completely close down a field of scientific research, ensuring that no new students or money will ever enter it. We will make improper applications illegal, but we will not demonize the science. Science is not itself a moral value; human cultural values determine whether we use the Tree of Knowledge for good or evil. I believe the Kabbalah suggests that we should have eaten from the Tree of Knowledge only together with the Tree of Life. If we put both of them together, knowledge and life, then we will use our scientific knowledge for good and not for evil.

Responsibly treading this middle road requires multidisciplinary bioethics committees involving scientists, lawyers, philosophers, religious leaders and representatives of the public. How can science and the public best interact? They have to reach a consensus, but such a consensus cannot be achieved by force, no matter how strong the logic, empirical proof or political pressure. Bioethics committees must be independent, must deliberate at length and must represent the best of what society, science and academies can contribute.

Closing Session

Parting Thoughts

Parting Thoughts

Emile-Etienne Baulieu

Clearly, the role of a national academy of science involves action in science. In this highly interesting meeting, we have dealt with such important topics as education, economy, the role of government and, finally, ethics in science. Thanks to the efforts of the Israel Academy, we have, within a day or so, covered most of the main features of scientific activity in the modern era. I thank the Israel Academy for this exceptional meeting, and I will report to my French colleagues on its great and highly deserved success. The President of the State of Israel, Moshe Katsav, recently addressed the French National Academy of Sciences, and as that Academy's president, I can testify that we had so many people attending that we added an extra day. Hopefully these two meetings signal the beginning of closer collaboration between the scientists of our two countries.

I would contribute just one more observation. Beyond all the technical and scientific aspects of our activity, we must better understand and address the difficulty most people have in understanding the path of science. Everyone has seen the rapid expansion of scientific activity, its success and, eventually, its power, but people are still largely ignorant of how scientists discover and interpret their findings. People also want reassurance that these findings will be applied responsibly and fairly to human needs. We must take great care to address their minds, intuition and hearts. People are afraid of what's going on, because they do not understand it. They are not told enough in a way that speaks to them.

With a few exceptions, the media do a poor job of explaining science and its contributions. By was of both commission and omission, they tend to set public opinion against scientific research. Public opposition, anxiety and hesitation influence governmental action, and this intensifies our difficulties in accruing the critical mass of resources that we need to make more beneficial discoveries and to maintain the freedom to explore promising new areas of research. In France, the recent difficulty in the dialogue between scientists and the elected government resulted largely from French public opinion. Because science is viewed as so unstable, the government preferred not to make potentially unpopular decisions, like budgeting sufficient funds to continue the current national pace of research.

So interaction with society is a natural and increasingly vital responsibility for a national academy of science. This new responsibility derives partly from the past progress of science, which, paradoxically, has spurred some of the current difficulties that may hinder the future progress of science. I realize that this is a rather political remark; but we scientists are used to dealing with reality, and we must now address social realities with our usual intelligence and enthusiasm.

I would close with a few words of optimism regarding the work of national academies. What happened recently in France showed that academies should not only conserve their strength, but also, when helpful, exert it. They can facilitate a "bottom-up" approach, in which suggestions from a nation's individual scientists can efficiently reach the upper, decision-making levels of the national government. On occasion, academies can even become principal players in directing the general policy of the entire nation, albeit in a limited sphere.

In France, and perhaps elsewhere, the national academy has become extremely important, it has moved beyond providing a locus for talks among specialists in an ivory tower to become an integral part of society. We are proud to submit to the judgment of our fellow citizens the best of what we can discover by studying and mastering nature.

Parting Thoughts

Bruce Alberts

Many of the problems raised in the interesting talks of this exceptional meeting serve to reiterate the importance of collaboration among national academies. Regarding patents, the U.S. Academy has been pushing back on the U.S. Patent Office for many years. We have just completed a major report, co-chaired by the President of Yale University, Rick Levin, recommending important changes in U.S. patent policies. We are in the middle of a second study, focusing on patenting in genomics and microbiology, which, as Professor Yonath noted, raises special difficulties. That report is chaired by the President of Princeton University, Shirley Tilghman, a distinguished member of the Academy. We are also addressing the database issue that Professor Drenth raised. There we have been interacting with our European counterparts, who are struggling with the same issues. This is a new but very important way to get science working better in the world. If we all work together, we can accomplish much more than by doing the same things alone.

In the United States, we recognize that we carry an extra-heavy weight in the world – perhaps more than we should – but that also implies extra responsibility. We are trying hard to protect the freedom of scientific inquiry, the freedom of information and databases, and the ability to identify real inventions, not mere discoveries. But in the end, these are issues we must work on together.

There is a major movement among scientists of the world, most recently through the InterAcademy Panel and InterAcademy Council (IAC), to promote scientific capacity building in less-developed countries. That may seem strange to many people involved in traditional international development, but we are gradually making the point, with the support of major players such as U.N. Secretary General Kofi Annan. Even the smallest, weakest countries need *local* scientific expertise and capabilities in health, environmental and agricultural science. It may be much cheaper to fly in advice than to develop local capacity, but it doesn't work. You first need capable people to give the advice to! The IAC's first report, *Inventing a Better Future*, discusses this at length. We are trying to get past the "tipping point" in the attitudes of the World Bank, the U.N. and other major players. They all must recognize that building strong scientific institutions in a nation is essential if that nation is to follow a successful development pathway.

The Israel Academy, which impresses me greatly, is particularly important to such efforts, because Israel provides a unique example of a small country that has successfully done what needs to be done in this area. Interacting with Professor Ziv for all these years has helped me appreciate the wisdom and creativity with which Israel takes action on new ideas and the degree to which your example could encourage and help others. Such international partnership is very important.

Finally, I am deeply impressed by this meeting, in which we have covered huge intellectual ground in such an interesting and stimulating way.

Parting Thoughts

Janne Carlsson

Professor Ziv began by saying that you were here to listen and learn from us, but I have also listened and learned a lot from you. We have always been impressed by Israel's achievements, particularly in creating such a well-functioning society in such a short time. Your approach seems very similar to that of Sweden in many ways, not least in science, research and education. There are so many interesting openings for further contacts and discussions in these areas.

I would only comment on Professor Lavy's presentation on Israel's proposed reform of its educational system. He described it as similar to what Sweden did in 1991, but this is the first time I have seen or heard such a rational (*post facto*) explanation of what we did. I also must say candidly that there have been many setbacks in Swedish educational reform since that time and many changes in the original plan. Private and religious schools are back in, teachers' salaries are not as high as intended, and so forth. Hopefully, the subsequent real-life experiences of the Swedish system will also be considered. I would welcome continued contacts and discussions on such issues, and would hope that I can take part in them personally. Many others in Sweden will also want to learn from your reforms and real-life experiences and to take part in your reforms in various ways.

We are also impressed with Israeli science, particularly your approach of pursuing advanced nanoscience and bioscience and then creatively integrating them with older technology.

Parting Thoughts

Pieter Drenth

Any umbrella organization is always proud when one of its members does a good job, and ALLEA is no exception. I am very happy with this interesting and stimulating meeting arranged by the Israel Academy. It is one of the things I will be mention with satisfaction and pride in my next annual report.

We have been discussing the relationship between academies and government, academies and the general public, and the advisory role of academies. Sometimes we have complained that governments or people don't listen to their national academies. An interesting question, of course, is: Why should they? How can academies legitimize themselves so that they will be heard? My answer includes three unique "selling points," if I may borrow a phrase from marketing. First, abundant scientific knowledge and expertise are readily available within the academy's walls, because of its high standards for election. That makes academies a unique national resource.

Second, academy members are not appointed (and should not be appointed) on a political basis and do not generally pursue non-scientific objectives or goals. That means that they are objective and disinterested parties, in the proper sense of the phrase. Third, academies and their members are deeply committed to science, with its free and uncontaminated nature and power to improve our lives.

Academies, however, need more than formal justification. They must also *earn* credibility in society. Credibility cannot simply be claimed; it must be earned through working advice, evaluation and other activities of the highest, most reliable caliber. Another precondition for credibility is that the national scientific community must demonstrably feel itself properly represented by the academy and would accept the academy's positions as true representations of its collective opinion. Quite a number of specific structural conditions are needed to attain this. For example, each academy member must be elected solely on the basis of scientific criteria. This is now the case in most of Europe, although historically there have been cases of political, ecclesiastical or dictatorial pressure.

Next, particularly in rapidly moving fields, creative younger scientists should also be represented in the academy, whether this is accomplished by appointing them to special young scientist academies (as in Germany's Leopoldina) or by limiting the age of regular membership. Members of the Netherlands' academy "retire" at age 65 (retaining the full rights of a member, except for board membership) leaving a vacancy for a younger scientist.

The same applies to 50% of the general population, albeit not the current scientific population, namely, women. There is, in Europe, a deplorable bias in academy membership with respect to gender. The underlying reasons may be complex, and I am not suggesting solutions now; but this problem does affect credibility. We must address the under-representation of female scientists in prestigious organizations such as academics.

Finally, every national academy of science has a restricted number of members. It should therefore acknowledge, involve and exploit the rich expertise that exists outside of the academy. This would supplement the academy's own expertise and would increase its credibility as a central national clearinghouse for scientific information and advice. Academies can capitalize on this expertise, for example, by appointing appropriate non-members to their advisory committees. Many European academies already do this, but many others still do not.

I am pleased that most of these conditions are well met at the Israel Academy, and I am very happy to have you as a member of ALLEA. Thank you for being our host at this interesting meeting.

Parting Thoughts

Jacob Ziv

In concluding this important meeting, I would like to thank all those who participated including the many distinguished and interesting speakers. Most of the Israeli speakers, by the way, were not Israel Academy members, several were even from industry, although almost all were scientists. Similarly, the current management of our Israel Science Foundation does not include a single Academy member. Most are younger scientists elected by the scientific community itself. So, in Israel, we are making a successful effort to get non-members involved. On the issue of women members, we are not yet doing well enough. My only solace is that we are doing somewhat better than the Netherlands.

My special thanks to the Israel Academy staff who did so much work on such short notice. We hope to continue our dialogues on these issues and to see you again at similar meetings in Israel.

APPENDIX 1

Conference Schedule

Promoting Science, Education and Society: The Academy–Government Challenge

An International Workshop held at the
Israel Academy of Sciences and Humanities
Jerusalem, Israel
May 17–18, 2004

As science becomes an ever-greater part of national budgets and determinant of international economic competitiveness, is the role of national academies of sciences under pressure to change? What new implications, challenges and opportunities come with the new environment, and how do these affect the academy-government relationship? How can one best balance academic freedom, public funding and the expectation of societal "payback"? Is there still a unique role for a fully autonomous, objective body of scholars at the highest levels of national science policy, and how can such autonomy be maintained? How have different countries faced such issues and with what results?

MONDAY, MAY 17 (PM)

Session 1. The Academy-Government Relationship: Differing Models of Cooperation

The Role of National Academies in the Science System and Beyond:
Relationships with Other National Actors
Balancing Autonomy, Responsibility and Responsiveness
National Experiences, Experiments and Future Challenges
Chairpersons: Pieter Drenth, Ephraim Katzir

Presentations: Bruce Alberts, Emile-Etienne Baulieu, Janne Carlsson, Jacob Ziv

Session 2. Bringing Science to Society: The Role of National Academies and Governments

Enhancing Public Appreciation of Science
Enhancing a Scientific Approach to Education
Science's Contributions and Responsibility to Society
Chairpersons: Bruce Alberts, Haim Harari
Presentations: Bruce Alberts, Victor Lavy, Dan Shechtman

Evening Session (Gala Dinner)
Welcomes and Introduction, Jacob Ziv
Invited Speaker: Minister Tzipi Livni
Scientific Immigration: A Unique Opportunity and Responsibility
Keynote Address: Bruce Alberts
A Joint Future: Learning from Each Other

TUESDAY, MAY 18 (AM)

Reception at the President's Mansion
President of the State of Israel, Mr. Moshe Katsav

Session 3. Promoting the Entire R&D Spectrum: The Roles of Academies, Governments and Industry

Basic Research, Strategic Research and Advanced Technology
Cooperation Between Academia and Industry
Society's Investment in and Payback from Research
Chairpersons: Janne Carlsson, Ada Yonath
Presentations: Amir Elstein, Irit Pinchasi

Session 4. Governments and Academies: Facing the Challenges of the Future Together

Experiences with Specific New Issues: Stem Cells and Biotechnology
Intellectual Property Rights and Scientific Cooperation

Science, Society and Ethics
Changing Roles and Modalities: Globalism and the IAC
Chairperson: Emile-Etienne Baulieu
Presentations: Minister Eliezer Sandberg, Pieter Drenth, Hanoch Gutfreund, Michel Revel

Closing Session: Parting Thoughts
Emile-Etienne Baulieu, Bruce Alberts, Janne Carlsson, Pieter Drenth, Jacob Ziv

APPENDIX 2

List of Speakers

Prof. Bruce Alberts, President, U.S. National Academy of Sciences; Co-chairperson, IAC

Prof. Emile-Etienne Baulieu, President, Academy of France

Prof. Janne Carlsson, Former President, Royal Swedish Academy of Science

Prof. Pieter J. D. Drenth, President, ALLEA; Former President, Royal Netherlands Academy of Science

Mr. Amir Elstein, General Manager, Intel Electronics, Ltd. (Israel)

Prof. Hanoch Gutfreund, Aisenstadt Professor of Theoretical Physics and Former President, Hebrew University of Jerusalem; Chairperson, Academy Committee on Academy-Industry Relations

Prof. Haim Harari, Former President, Weizmann Institute of Science; Member, Israel Academy of Sciences and Humanities

Prof. Ephraim Katzir, Former President, State of Israel; Member of the Israel Academy of Sciences and Humanities; Racoosin Chair of Biophysics, Weizmann Institute of Science

Prof. Victor Lavy, Haber Professor of Economics, Hebrew University of Jerusalem; Director, Falk Research Institute (Israel); Member, National Task Force for Education

MK Tzipi Livni, Minister of Immigrant Absorption

Dr. Irit Pinchasi, Vice President for Innovative Research and Development, Teva Pharmaceuticals (Israel)

Prof. Michel Revel, Chairperson, Israel Academy Bioethics Advisory Committee; Siegel Professor of Virology, Weizmann Institute of Science

MK Eliezer Sandberg, Minister of Science and Technology

Prof. Dan Shechtman, Chairperson, Sciences Division, the Israel Academy of Sciences and Humanities; Chairperson, Initiative for Applied Research in Education; Tobias Professor of Materials Science, Technion

Prof. Jacob Ziv, President, Israel Academy of Sciences and Humanities; Gross Professor of Electrical Engineering, Technion

APPENDIX 3

List of Abbreviations

AAAS	American Association for the Advancement of Science
ALLEA	European Federation of National Academies of Science, ALL European Academies
FIRST	Focal Initiatives in Research in Science and Technology
GMF	genetically modified foods
IAC	InterAcademy Council
IAP	InterAcademy Panel on International Issues
IP	intellectual property
ISF	Israel Science Foundation
IVA	Royal Swedish Academy of Engineering Sciences
NAS	National Academy of Sciences (U.S.)
NIH	National Institutes of Health (U.S.)
NRC	National Research Council (U.S.)
OECD	Organisation for Economic Co-operation and Development
PBC	Planning and Budgeting Committee of the Council for Higher Education (Israel)