Recruiting the younger generation to science

A Network of Youth Excellence and communication strategies for high-school student researchers

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High-school students are very susceptible to new influences from outside their familiar environment. This age, between 14 and 20 years, is the age of self-discovery, when the adolescent explores his or her abilities and limits and seeks a place in society. These students become more critical of established social and family rules, and of other things that they once more or less just accepted. In short, puberty is a challenging time for many parents and teachers, when their children and students question their 'wisdom' and set out to find answers to problems that they think their parents cannot properly address. Similarly, science explores the world beyond the current limitations of knowledge, challenges 'wisdom', and sets out to find answers. The freedom of thought enjoyed by scientists, the ability to satisfy their curiosity, and the possibility of gaining new insights into the natural world are probably the most attractive features of scientific research, and may explain why many scientists feel more committed to their work than, say, accountants or factory-line workers. Thus, science and research offer a unique and unparalleled opportunity for adolescents to quench their thirst for answers and explore their intellectual strengths and abilities. Moreover, research in a laboratory and interaction with other scientists provide a new social environment for these students, in which they can earn recognition of their abilities and find role models that they might not encounter at school, at home or with their friends.

Attracting young students to scientific research has also become a topic of growing importance from the point of view of science. Many senior scientists, economists and politicians in the USA and Western Europe have been deploring the decreasing numbers of students choosing a career in the natural sciences. They are becoming concerned about a potential bottleneck of scientists and engineers, which could hamper the growth of high-tech industries, particularly biotechnology and information technology. The issue of making science and research attractive to young people has sparked many a debate about the future of research and related technologies (Mervis, 2003; Moore, 2002). Last, but not least, as science and technology have an increasing influence on individuals and societies, it is equally important for young people to understand better the problems and challenges they create. Such insight will also help to overcome the alienation from scientific research that is taking root in significant parts of society. These problems—how to give young people a basic knowledge of science and technology and potentially awaken their interest in a research career—are clearly recognized, and have become the subject of many conferences, both in the USA and in Western Europe. But the benefits are even greater in the conflict-loaded countries of Eastern Europe. The collapse of communism, the restructuring of their societies, the spread of crime and, in particular, the economic problems that many of these countries face make it increasingly difficult for young people to find their place in society or improve their social status. Experiencing the democratic environment of a research team can transform their usual existence, and help gifted children to get their due share of opportunities and joy out of life. Many young students who have a chance to come into contact with life and work in a research laboratory are often also able to find their first real friends in this new environment.

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These are some of the reasons why, seven years ago, I initiated a programme in Hungary to help talented and motivated students between the ages of 14 and 20 to obtain first-hand experience of scientific research in Hungarian universities and research institutes (Csermely, 1999). The idea immediately gained an overwhelmingly positive response from the Hungarian scientific community. We were able to start the programme in 1996, with approximately 300 scientists willing to act as mentors and accept high-school students in their laboratories. Many of these senior scientists are of the highest scientific merit: 109 are members of the Hungarian Academy of Sciences, including Nobel Laureate George Olah. Since the beginning, we have been able to offer more than 7,000 students—not only from Hungary, but also from other Eastern European countries—a chance to work in a real research laboratory. It has been a great success so far, as many of these students become interested in pursuing a career in scientific research or teaching. But, equally important, we have also gained a great deal of experience of how to get young people, who are still open to outside influences and new challenges, interested in science.

To recruit new students, the list of mentors is sent to each Hungarian high school and to more than 600 high-school teachers who help us with the recruiting. Any interested student can apply in writing or through our website (http://kutdiak.hu) by answering two simple questions: "Why do you want to pursue research?" and "Why do you feel that you are better than other students?" We accept all answers, and this simple screen works astonishingly well in

testing students' motivation, self esteem and maturity. Registered students then receive a copy of the mentor list, including thousands of keywords about research topics ranging from 'Pope John Paul II' to 'ribozymes'. Then comes the next screen: after having made up his or her mind, the student has to approach the mentor of choice alone. Parents—dreaming of their children as future Nobel laureates—are purposefully excluded from the recruitment process. We also have no strict age limit. The youngest student we have enrolled so far was 11 years old; however, most of the students are between 17 and 19.

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There are no rules or expectations about what a research student should achieve. Some end up with only limited experience, by reading and discussing a book or scientific papers with the mentor. However, most of the students find a stimulating environment, even with their first research team. In my own laboratory, they start learning basic techniques, such as protein characterization, enzyme reactions or PCR (polymerase chain reaction), and the most diligent ones end up with a real research project. Typically, this is pursued during one of the summer breaks—we provide funds and help them to find dormitories—however, many students visit the lab each week, commuting up to 100 km, and we support them financially to cover travel expenses. If students feel uninterested or experience any trouble, they can contact the organizers and we help them to solve their problems, or to find another lab. After a year, the research results are often mature enough to present at a student conference. Often, the students' work evolves even further—some high-school research topics have developed into undergraduate or even PhD projects.

This is not to say that it is easy for every interested student to get his or her own research project, as mentors also have the right to set tests. For example, high-school students applying for my own research group must first pass a test on my book (Csermely, 2001). During a written examination, they have to define 14 expressions from the book in two sentences each in order to test their accuracy and clear thinking. If they score more than 50%, they have to face an oral test, explaining three topics from the book without any time to prepare their answers. For a proper answer, they have to combine the knowledge they have gained from various chapters of the book. If they pass the exam, they have to participate in the weekly lab meetings, held in English, engage in the discussions, study research articles and prepare short presentations. After a few months, the members of my lab then cast a vote as to whether to accept the student to work with one of the senior members as supervisor. The student must draft a summary of his or her plans and defend it during a lecture in English. If accepted, they can start their own project, and quickly become full members of the lab, eligible to vote on the next student. After such preparation, it is not surprising that the best students become co-authors of scientific publications during their high-school years: Akos Vermes studied the nucleotide-binding sites of the 90-kDa heat-shock protein, Hsp90 (Soti *et al*., 2003). Bálint Pató (Fig. 1) contributed to the identification of a novel mechanism in the anticancer action of Hsp90 inhibitors (Sreedhar *et al*., 2003). Vermes spent the summer of 2003 in the laboratory of Professor Louis Hue in Brussels, Belgium, and Pató started a mathematical modelling project.

More than half (59%) of recruited students work in life-science laboratories such as mine, and 27% and 16% pursue research in other natural sciences and social sciences/humanities, respectively. These ratios, which have been fairly stable over the past four years, show the popularity of the life sciences among the younger generation, especially the fields of environmental and medical research. Importantly, 50% of the high-school students registered on the programme have always been girls, which shows an equal interest in scientific research from both genders. Among the Hungarian students, a quarter have come from Budapest, 29% from Hungarian towns with a population of more than 100,000, another quarter from smaller towns and 21% from villages. We are particularly glad about this last fraction, because our initiative gives them a unique chance to change their life and break out of the closed and often depressing environment of these less developed regions. We have also had many student researchers from Roma families and from state orphanages, who are probably the real successes of our initiative. "You completely changed my life!" is a remark we often hear from participants. "I met a new world here. I learned perseverance and endurance during my years of research. The friendly atmosphere helped me to overcome my shyness, and the wide variety of topics in the mentor database made me realize what am I really interested in in life and pursue it with full devotion," explained 17-year-old Brigitta Sipocz, emphasizing the effect it has had on her life. Indeed, many of the first high-school research students are now about to finish their PhDs, or have returned to their schools as teachers and are now helping to recruit the next generation of student researchers.

The programme has grown beyond our initial expectations, as well as beyond the borders of Hungary. The number of mentors has more than doubled from the initial 300 scientists with whom we started. In 1998, we established a Research Student Foundation to manage finances, and the

Fig. 1 | The 2002 student president, Bálint Pató, with Crown Princess Victoria of Sweden, in Stockholm, at the 2001 Nobel Ceremonies. He was a final-year student of the St Stephen High School of the Cistertian Order in Szekesfehervar, Hungary, and commuted 100 km to the laboratory, where he carried out a research project on stress proteins. Pató received second prize in the European Union Contest of Science and Innovation and presented his results at several international scientific meetings (Pató *et al*., 2001). At present, he is studying chemistry at Eötvös University in Budapest, Hungary.

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annual budget of the Foundation grew to approximately €100,000 by 2002. Twenty-five per cent of these funds come from the Hungarian Ministry of Education, another 25% from foreign institutions, including UNESCO (the United Nations Educational, Scientific and Cultural Organization), FEBS (the Federation of European Biochemical Societies) and EUREKA International, 30% is received from grant applications and 20% is donated by Hungarian firms. In 1999, students, mentors, high-school teachers and scientific research clubs also formed a Research Student Association (Csermely *et al*., 2000). All decisions, including those about finances, are made by the student president, at present Mate Szalay, and their two deputy presidents, who are elected each year by the best 80 student researchers during a one-week research camp. After the Research Student Foundation announced in 1999 that it would help to establish science clubs in high schools (Csermely *et al*., 2000), more than 200 such clubs have been founded in Croatia, Hungary, Romania, Slovakia and Serbia. Members of these clubs cooperate in larger research projects and inform each other regularly of their progress. Most of the research clubs invite established scientists to speak about their lives in research, or to talk about recent advances in their field. Now, a whole series of conferences has also started to help high-school research students acquire communication skills, give feedback on their research and to meet the same 'odd' people: other research students.

> A hierarchy-free, democratic research environment, where the only credit goes to real achievement, is a must

From our seven regional conferences held in Hungary, Romania and Serbia, the best third of the student lecturers get a chance to present their results at the national conference. The best third of this national meeting—approximately 80 students each year—is then invited to a one-week summer camp in July, near Lake Balaton. Here, the best Hungarian scientists are invited to talk about their approach and devotion to science. We also invite a respected writer, a priest and a successful businessman to provide other role models and give alternative views on scientific research and progress. University undergraduate psychologists help these outstanding student researchers to cope with their loneliness and other personal problems; grant agencies present their funding programmes, teaching students how to apply for funding, and the Hungarian Patent Office demonstrates the importance of protecting intellectual property.

We have also established a network of 600 high-school teachers to recruit research students to the initiative and/or establish science clubs in their own schools. Starting in 1999, we have organized annual conferences for these teachers to exchange information on fundraising and how to establish science clubs, organize local conferences and recognize talented students. The conferences also include discussions with government officials on governmental help for enhancing research activities in high schools, and to increase the number of high-school teachers studying for PhDs.

The programme now includes hundreds of Hungarian students, high-school teachers and science clubs from Croatia, Romania, Slovakia, Slovenia, Serbia and Ukraine. Students engage in exchange programmes with the German Schülerakademie, the Weizman Institute (Rehovot, Israel), the Irish Centre for Talented Youth (Dublin, Ireland), the US National Institutes of Health and the Illinois Mathematics and Science Academy (Aurora, IL, USA). In addition, we also invite 10–15 students from all over the world to our conferences. More recently, the best Hungarian high-school research student is invited to the Nobel award ceremonies each year in Stockholm, Sweden (Fig. 2). The selection of the student is made by a special interview of the best ten students, organized jointly with the Hungarian Association for Innovation. It is our goal to extend these contacts in the future, and to improve the regional cooperation in Central and Eastern Europe. In 2002, similar movements from Belarus, Brazil, Croatia, Germany, Hungary, India, Iran, Ireland, Israel, Lithuania, Poland, Romania, Serbia, Singapore, Slovakia, Slovenia, Spain, Sweden, Ukraine and the USA formed a Network of Youth Excellence to exchange their experiences on the best practices and to help to propagate the initiative (Csermely & Lederman, 2003). The Network also established partnerships with UNESCO, Ashoka International, EUREKA International, the International Union of Biochemistry and Molecular Biology (IUBMB) and FEBS.

Fig. 2 | The best student of 2002, Livia Meszaros, with Imre Kertész, the Hungarian Nobel Laureate of Literature, at the 2002 Nobel Ceremonies in Stockholm, Sweden. Meszaros studies the expression of the Wilms' tumour 1 gene in melanomas. She won the contest of the Hungarian Association of Innovation and participated in a two-month research project at the US National Institutes of Health. At present, she is studying medicine at Semmelweis University in Budapest, Hungary.

After seven years, we have gained a lot of experience about how to attract young people to science and research. The first and most important fact that we learned is that students must be offered the possibility of doing real science, not didactic, over-organized pseudo-research or experiments with a guaranteed outcome. Students clearly appreciate the world of research with all its frustrations, uncertainties and technical troubles—and with all the joy that comes with a real discovery. As mentioned above, students between 14 and 20 are eager to try things themselves and explore their limits, so we can present them with new challenges and tasks. Schools might overload them—or rather mis-load them—but science performed in a proper environment never overwhelms their abilities.

Consequently, it is also important not to set standards: even the smallest bit of knowledge and understanding that a student gains in a laboratory is worth it.

Adolescents at this age need emotional support and personal guidance, so the scientists who serve as their mentors must therefore be willing to get involved and actually spend quite a bit of time with them. It is also important that mentors have a high level of credibility—not only as scientists, but also as role models. A hierarchy-free, democratic research environment, where the only credit goes to real achievement, is a must. Students are also eager competitors, which gives them great strength and motivation to continue, even after repeated failure. But we must not over-use their competitiveness. We do not want success-thirsty gladiators in the laboratory, we want to educate our future research colleagues.

Last, but not least, students also gain a lot of personal experience that has nothing to do with science or research. They still seek their place in society and explore their strengths and capabilities. Just by giving them a chance to spend some time in a new environment and by positively reinforcing their strengths—and showing them their limits—we can help them to gain a clearer vision of what they can expect from the future. For the vast majority of students, such an experience will create a long-lasting commitment to science and research. However, high-school students who choose a different career are not failures, and the energy we put into them is not a waste. They will keep their commitment to science, wherever they go. And if they return home with the experience of how scientific research works, they often become key opinion makers in their home environment, that is, within their age groups, their families and their local societies. As our commitment to younger students can significantly improve the credibility of scientific research in society in general, we have to mobilize all efforts to show them the joys of science. The best students deserve the best treatment. They are our future.

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