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Suggestions for reorganization of basic research work in biochemistry in Poland

Summary

Listed below is a series of suggestions for increasing the changes of making Polish biochemistry world class. The main themes are to make the science much more international, to make it far more competitive and cooperative, to engage group leaders more in scientific research, and to make research economically sound by recognizing the very low price of labor and the very high price of equipment and of foreign chemicals and supplies.

The specific suggestions are:

Education:

a. Strongly increase emphasis on English, e.g., require Ph.D. theses to be in English.

b. Add important, difficult and cheap–to–teach–in–Poland requirements, my suggestions, mathematics, physics, physical chemistry.

c. Make sure that **all** Ph.D. students are very familiar with computers.

Accountability and Selection of Leaders:

a. Abolish **all** Polish biochemical journals. Do not list and do not count biochemical publications in journals put out by Polish Universities, Academies, etc.

b. In all promotions and elections to academies emphasize **direct** contributions to **international science** not administrative or educational achievements.

c. In all promotions seek extensive foreign advice about the candidates and make that the major or decisive factor. Announce that this system will be followed.

Doing of Science:

a. Introduce a system of grants where about 50% of the serious applicants get meaningful grants. Use international advice in awarding these grants.

b. Sharply constrain the number of fields for research in biochemistry. Choose fields appropriate for Poland.

c. Develop better systems for the sharing and utilization of equipment. When funds are requested for equipment ask for realistic plans for using the equipment 24 hours a day.

d. Enforce a system whereby all research groups spend 1 day a week doing what they can do best for other research groups.

e. Provide a great deal of secretarial and technical assistance so the professors can be engaged more in research. These positions should not increase the number of people who will compete for research grants in the future.

Implementation of some of these changes is discussed.

This advice is offered with two premises in mind. The first is that the only important reason for doing really basic research is to contribute to **the world's** storehouse of knowledge, to aid the human condition, to improve the **world's** culture. It, therefore follows that only science which is world class is worth pursuing. Statements such as "our laboratory is the best in Poland at doing this" are misplaced pride, both in Poland and in any other country.

The second premise is that Poland is capable of contributing to biochemistry at the world level. It might be easier to say that because of the history of wars, of brutal oppression, as well as of the deplorable economic conditions, this goal may be impossible. It is only because I believe otherwise that I offer this relatively harsh and critical advice.

Most foreign colleagues say that Poland is doing well in biochemistry "under the difficult circumstances". They are kind but they do not expect Polish biochemistry to be world class. Poland has what matters most, a large corps of capable, relatively well trained, relatively enthusiastic young biochemists. It would seem a pity not to use the best of these for world class research since if this is not done soon this supply will vanish.

It would be quite easy in making suggestions simply to ask for improvement in economic or socio–economic conditions. It is obvious that Polish biochemists could be more effective if their shamefully low salaries were increased in real terms by a factor of 10, or even more, thus greatly lessening their burdens of daily life. Possibly even more important would be a better supply of apartments which would allow for some movement of scientists among the various academic centers. A somewhat less obvious, but major problem, is that Poles marry young, and children (or the first child) follow marriage more rapidly than in Western Europe and America. This, coupled with bad economic conditions, places a heavy burden of responsibility on young scientists, who would be most likely to devote themselves only to research. I can offer no advice on how to deal with these problems even though they maybe among the most critical. The last of these might possibly be attacked by widely available advice: "If you want to be a good scientist wait a long time to get married".

My background for making these suggestions is as follows: I was born and educated in Poland. I left at age 17, one year before matura. My Polish education was first rate and far superior to that of my American cohorts. The only reservation I have is that I was taught too many foreign languages (Latin, German and English) and none of them well. My feeling was then, and is now, that teaching of foreign languages (in spite of the Pope's virtuosity) is not a Polish strong point. Since corning to the US I was educated here and I have achieved some modest success as a biochemist. In the last 15 years I have had 7 Polish coworkers in my group, many of whom stayed for a long time (up to 10 years). Over the same period my University (Purdue) attracted many Polish postdocs and my laboratory became a bit of a social center for them. Thus, I got to know about 30 or 40 Polish postdocs well. I have also visited Poland a few times. I have received Acta Biochimica Polonica for a long time and (unfortunately) I read it. I have published in it once. I have looked at several issues of "Postępy Biochemii" and I was occasionally consulted by some authors of the reviews. Finally, my father was a prominent Polish Biochemist, and my uncle, while not a biochemist, was rector of Wyższa Szkoła Rolnicza in Olsztyn. Thus, family conversations have strengthened my knowledge. However, this is strictly an outsider's view and I believe that if I knew much about detailed conditions in Poland, I might become coopted and thus no longer be able to make strong suggestions for change.

Even though I believe that Poland can have world–class biochemistry in some selected areas, the economic conditions will make it harder than in some of the wealthier countries of the world. I would like to note, however, that wealth does not guarantee a country good biochemistry (e.g. Arab countries, France, Italy) and a realatively low level of economy does not prevent it (China before the cultural revolution, Chechoslovakia before 1968, Hungary). It is clear that the scientists in a country, where econonic conditions are hard will have to work much harder, organize their science better, and give up some of their scientific freedom in order to make comparable achievements.

Specific suggestions

Education

Judging by the postdoctorals I have met, young Polish scientists have a solid educational background. Most American group leaders like having Polish postdocs and view them as average of slightly better than other postdocs who join their groups. Ihis is a great tribute to what Polish biochemistry has accomplished under very difficult conditions. However, I believe that even this excellent could be better in a few respects.

English. The die is cast. English is the only language in which world biochemistry is done. The choice of a **single** language is excellent for the science, but very unfair. The British and Americans know English as an accident of birth. Others need to study it. The ability to read, write, and speak English, and especially to think in English is an absolute requirement for a world–class biochemist. In my opinion the English of Polish postdocs is **much** poorer than that of postdocs from Western Europe (Germany, France, Scandinavia), but also sometimes poorer than that of especially well prepared Chinese, during the period when graduate students and postdocs sent to the US were highly selected. In general, typical Poles are not highly fluent in foreign languages. Furthermore the requirement of Russian in early school severely complicated the problem. I understand that now the requirement is removed and a choice of English, French, German and Russian is offered. It is essential to inform the children making the choice, their parents, and the school counselors that for science **the onl language worth stud ing is English** and any other choice will be quite harmful to anyone who would become a scientist. If fluency in English is not acquired in secondary school then it should be acquired at the university. I believe that the faculty in biochemistry should urge the students to do this far more strongly than they do now. I strongly recommend that a difficult English requirement be imposed and widely announced. The choice that occurs to me is requiring that all Ph.D. theses be submitted in English or that the thesis defense be in oral English. Such a change should be phased in, so that students who are not expecting it should not be subjected to it, but the time which it will be absolutely required should be widely publicized. It would be most worthwhile to notify secondary schools of this requirement in order to allow the students to study English where it really helps. Requiring that Ph.D. theses (and by extension habilitation theses) be in English has another advantage. It would symbolize again the commitment that biochemistry is international, that Ph.D. theses are for the world and must be written in a language the world understands. It may also aid in obtaining outside evaluations.

Many Polish scientists react to the Ph.D.–theses–in–English suggestion as especially punitive. It is not. While I made no strict survey, Ph.D. theses in biochemistry are now written in English in many groups in Japan and in West Germany. As a visiting professor at Osaka University I served in 1984 on a Ph.D. committee where both the thesis and the defense were in English.

Mathematics. Poland has a truly proud tradition of world–class accomplishments in mathematics. Teaching of a great deal of mathematics at the University level should not be very expensive. Additional demand for such teaching should be helpful to the mathematics faculties.

Yet the mathematical foundations of Polish postdocs (I include here physics and physical chemistry as well) seems somewhat weaker than the world average. This may be because biochemistry is classed as a biological rather than as an exact science in Polish universities. I think this is a major error.

All sciences become more quantitative with time. Those who can deal with the quantitation become leaders; those who can not fall by the wayside. Since mathematics (and simple but rigorous physics and physical chemistry) are relatively easy and cheap to teach I suggest a

grand gesture. Make the mathematics, physics, physical chemistry requirements for Polish biochemists higher than anywhere in the world. This might give Polish biochemistry style and a unique flavor. It might decrease the number of successful Ph.D. students, but this might be desirable, provided that the remaining ones are better trained.

There exists one clear world example of making it in biochemistry by emphasizing mathematics and physics. This is the Soviet Union. In my opinion Soviet biochemistry is quite poor, probably poorer overall than Polish, in spite of the size of the country, with a conspicuous exception. Those who deal with areas with a large mathematic content (eg. Volkenstein, Privalov, Pitsin, etc.) are well known and respected throughout the world.

It might be quite useful to search for some other field that would be relatively easy to teach under Polish conditions, which could also be required in large excess over that required in the rest of the world. Unfortunately no such field comes to my mind.

Computers. With the exception of the biophysics institutes, computer literacy of young Polish biochemists is low. This may be a huge error since relatively soon lack of knowledge of computers will be equivalent to illiteracy for a scientist. I realize that computers cost hard currency, but they are much cheaper than other scientific equipment. Used properly they can augment and automate equipment and thus save money. Most of all they can give students an opportunity to learn. I would require computer literacy of **all** biochemistry Ph.D.s.

Interactions Abroad. While a very large number of young Polish scientists go abroad, few seem to be well advised about where to go and what to learn (few institutes are a strong exception to this statement). It seems to me that opportunities for learning precisely what is needed or wanted or opportunities to join really top groups are wasted. People go where there is a contact rather than to the optimal place, yet the worldwide demand for postdoctorals is so high that the optimal place could often be realized simply by asking.

Accountability, advice, choice of leaders

The heavily bureaucratic aspects of organizations everywhere in the world, but particularly in Poland, lead to the fact that group leaders, professors and institute directors spend relatively little time on direct scientific activities. Furthermore, the history of an imposed political system has heavily shaken the confidence of the younger scientists in the procedures by which their leaders were selected. Therefore, in order to 1) focus most scientific leaders' attention on science not just on administrative concerns; 2) to select the best people for leadership positions and; 3) to convince young workers that the promotion process is fair and that it encourages scientific merit, the promotion process to professor, institute director, member of National Academy, etc., should be made as open as possible and heavily influenced by input from other Polish and more importantly foreign scientists.

Outside Opinions for Promotion. To the best of my knowledge all major US universities seek broad-based outside opinions for promotions, appointments as head or dean, awards or elections to National Academy of Science. Many of these opinions are from the US but many others come from outside of the US as well. Several small countries (eg. Israel, India) follow this lead. Poland lags behind. Yet the advice is free and should allow for much better assessment of what really matters, which is the contribution of the various candidates to world science.

Abolishing Polish Journals. It is a world trend that national or even regional journals are replaced by international ones. In some cases national journals that were lucky enough not to have a country's name in their title become international by adding foreigners as members of their editorial boards (examples; Journal of Biological Chemistry, and Biochemistry).

There are several reasons for eliminating Polish journals.

1. "Acta Biochimica Polonica" is consistently ranked very near the bottom of biochemical journals of the world. This is not a proper reflection of Polish biochemistry and thus gives Polish biochemistry a bad name. The best papers are in fact published in international journals.

2. Out of a burst of nationalistic pride or because of festschrifts dedicated to important elder statesmen and stateswomen occasionally good papers are submitted. These papers are seldom quoted and thus are a loss to the world's and to Polish biochemistry.

The argument for keeping "Postępy Biochemii" is even poorer. As pointed out in the section on English, writing about biochemistry in any other language is a waste of time and effort. It is a wrong symbol. Poland has too small a scientific enterprise to be able to generate top quality reviews in all fields. I view this journal as positively harmful.

In the normal drive for accountability Polish biochemists publish and later count as publications papers in various bulletins, university, academy and institute publications. This is terribly harmful and distorting as the authors and their institutions are convinced that a lot of work is being done when sometimes little is done. As these publications are not read outside Poland, and probably not even in Poland, publishing in them has no risk of possible harsh criticism from the outside. It is all benefit to careerists and all wrong. I cannot suggest that all universities and institutes close their private journals; they may be needed in other fields such as humanities. What I propose instead is that biochemists are strongly discouraged from publishing biochemistry in such journals. Such publications should not be listed in curriculum vitae, in grant proposals and what may be most important in institute and departmental reports.

The standard rejoinder is, "we do not pay any attention to domestic publications, we do not count them". Then I was told, by the same person, with great pride how many papers an institute published in a year. It turns out that half of them were published in Poland. Several postdoctoral applications to the US list long lists of Polish publications and no others. This is taken as very negative by American professors who examine such applications.

Finally cancelling Polish journals would; a) save some money, b) (more important) eliminate some administrative burdens from top Polish scientists and possibly allow them more to think about direct research and direction of their research groups.

Factors Affecting Selection of New Leaders. Scientific leaders in the world have many attributes, among them are prestige obtained by past scientific accomplishments, great desire to accomplish more and help others to accomplish more, clear vision of important problems, administrative skill, and charismatic ability to lead others. There are essentially two factors here, science and administration. I believe that in the situation in Poland science should be emphasized far more than administration. It is scientific leadership that the country is lacking. In order to infuse new vigor into the enterprise young people should be especially selected. This is a bit of a gambling procedure as mistakes in selection are more costly, but successes are more long lasting. As in other areas of Polish economy and society, I suggest gambling. In choosing young leaders, I would particularly favor those who have just returned from long and successful stays in Western laboratories, as they are much more likely to have high expectations; they will not have their expectation horizon clouded by knowing the reality of the Polish conditions. It would be best, but of course quite difficult to accomplish, if these leaders were told about their new positions while abroad. They would then be in a much better position to make plans for possible acquisition of equipment to make contacts with Western scientists and to learn the needed expertise.

Keep Group Leaders Active in Science. It is essential in Poland to keep group leaders interested and working on science rather than diverting their attention to administrative functions. The competitive grant program should be a major factor in doing that. Another factor should be a system of mandatory sabbaticals for fairly long stays in single laboratories abroad. A huge

number of young people in Poland do postdocs; many, but not all, Polish professors travel, go to meetings, give lectures, visit universities. What is needed is concentrated, direct experimental, or if need be, theorethical (but not administrative) work.

Another way to help Polish scientific group leaders is to provide them with direct assistants. However, these additional assistants should not be future scientists. They should be secretaries and technicians. The price of using future scientists for such work is too high: they all later want to have their own laboratories. However, since price of labor in Poland is low it seems foolish for professors to type their own letters or do many quite simple technical tasks.

Doing of science

Narrowing of Research Fields. In my view biochemistry in Poland is far too fragmented. It would be far more efficient to select only a few topics, and study these intensely. The problem of making a choice of topics to concentrate on will be very difficult as all strong scientists will like for their topics to be chosen. It seems to me that in the selection of topics the following criteria should be used.

a. Existing expertise in Poland.

b. Intrinsic interest of the topic and its importance to science.

c. Level of world competition. It seems to me that Poland is unlikely to be world class in the really hot areas, because (among other things) communications between Poland and the rest of the world are too slow. What is needed is an important area not now in the center of scientific fashion.

d. Moderately low equipment and operational needs. Areas such as x–ray crystallography and state–of–the–art NMR seem too expensive.

e. Ability to interact well and contribute to science in other areas selected for study in Poland.

As soon as the notion of narrowing of topics is brought up one will hear protests. The protests will be of three types: a) Narrowing of topics inhibits imagination; b) Narrowing of topics may miss the really important area of the future; c) Narrowing of topics may deprive individuals with very specialized talents of the opportunity to shine.

In my view complaint a) (see above) is groundiess for young scientists. They can be turned on to be interested in almost any valid topic, without a large body of past experience. A strong preference for nucleic acids over proteins, or enzymes over antibodies, etc., seems suspect. Older workers will need to stay with their topic to be imaginative. Therefore, the process of narrowing the topics should be fairly slow, 10 to 15 years perhaps, in order not to ruin good scientists. However, with the intention to narrow topics, a plan about how it will be accomplished and possibly the choice of topics should be widely publicized, as soon as it is practical, so that biochemists, especially the young ones, can adjust.

The advantages of narrowing the topics are:

a. Modern biochemistry requires many papers exploiting a single discovery before its impact is felt. Polish biochemistry would have bigger impact if its discoveries were exploited.

b. It would create an opportunity for competition between groups and allow the granting agencies to evaluate the accomplishments of the group.

c. It would increase a peer group of scientists with whom one could have discussions and interactions.

d. It would decrease the need for so many different items of equipment and allow for better utilization of needed equipment.

e. It would better define what collaborative activities by other groups might be helpful.

There should be little worry that the chosen topics will be too narrow. Widening of topics is a normal social process. It occours spontaneously.

Utilizing of Equipment. One of the important complaints that one hears from Polish biochemists is the lack of equipment. Surprisingly, when I looked I often found a relatively large amount of relatively good equipment. Certainly, more equipment and better equipment would help. However, in contrast to the US and West Germany, the equipment on hand is not very extensively utilized. A visit to the lab generally shows that most items are not used right now. Considering the staggering price of equipment (in dollars) and the low price of labor (in dollars) in Poland this is grossly wrong. It would economically pay to utilize the equipment much better than it is being utilized now and much more than it is utilized in the West. Several suggestions can be made to improve this equipment utilization.

1. Decrease the number of research topics; this will increase the demand for some instruments and eliminate the need for others, e.g., very different equipment is used to study proteins vs. DNA.

2. Significantly increase the availability of supplies and the budgets for supplies. It is close to ridiculous, but common, for centrifuges to be idle, because there is no money for CsCl to form gradient, or for amino acids analyzers to be idle because there is no ninhydrin, etc. Do not give money for equipment unless you intend to follow up with supplies. I hear a common figure in the US of at least 10% of the price of equipment per year is needed to keep it up.

3. Budget a good deal for equipment repair and for qualified technicians to repair it. It would be a good trade–off to reduce the number of biochemists and increase the technical support personnel.

4. (This of course has advantages beyond just savings on eguipment). Improve the work ethic in research work. It is no excuse that one has to teach, talk to visitors or attend committee meetings and equipment is unused. Someone should be using it. A real push is needed here. Of course, the hard living conditions in Poland oppose this.

5. There should be a major extension of working hours in the laboratories. This can be done in two ways; the simplest is to encourage voluntary after–hours work in the labs around the clock and make the labs easily accessible to the working personnel around the clock (this is not so in many labs now). The second way would be to introduce a significant number of operations on the 3–shifts–per–day system. It can be argued that this is not done in the West. First of all, expensive equipment such as supercomputers, high field NMR etc., is routinely utilized 24 hours a day in the West. Second, simply by proclivities of some graduate students and postdocs an informal shift system develops in most good American labs with a large part (25–30%) of the groups doing their work late at night. However, the most compelling reason is the completely different relation between the price of equipment and labor in Poland.

Instrumentation Centers. Some instruments lend themselves superbly to multiple–user applications. An example of this is an amino acid analyzer. I was told that in the whole city of Wroclaw there are 8 amino acid analyzers and none of them work well. At Purdue University there is currently only one, but it works superbly. The difference lies in: a) a technician and a supervising Ph.D. among whose major responsibilities is amino acid analysis; b) a relatively good system whereby outside users can reimburse us for the costs of the analysis. It is much cheaper for most groups to pay several thousands of dollars a year for amino acid analyses than to own their own amino acid analyzer and to operate it well.

Many American universities now operate Biotechnology Centers providing colleagues with a) amino acid analysis; b) protein and peptide microsequencing; c) peptide synthesis; d) nucleotide synthesizer; e) high MW mass spectrometry. Not all of this works superbly, but it is a model that might well be adopted in Poland. Surprisingly many scientists enjoy running such support facilities. Many, who are faced with oblivion as their fields of research are eliminated, might find an outlet here.

It is absolutely clear that some fields of research do not do well with shared instrumentation.

Work in physical chemistry and in analytical chemistry where new instrumental methods are being developed **requires** complete control over the equipment in order to use it to the limits. It is very difficult for me to believe that many biochemists require individually owned equipment. Every proper head of a research team **likes** to control his equipment and, therefore, is likely to provide reasons why shared equipment is poor. In fact, I believe that shared equipment, operated by very competent and dedicated people will generally yield better results than individually owned equipment in biochemical laboratories, since such equipment is often not operated by experts. The strength of this opinion increases with how far the field is from physics toward biology.

In order to have good shared equipment facilities, entirely new infrastructure is needed. Scientists have to be recruited to run them, but the other reforms should produce surplus scientists; sizeable budgets should be given to them for supplies and a method of sharing costs.

Cooperation. In discussions with Polish biochemists, one theme recurs. They would like to have, and need, rare enzymes or rare substrates, which are available in the Western countries at very high prices (high even to Western scientists). Several American colleagues try to arrange for such aid and many Polish visitors to the US buy these things for their own with very limited US currency. The need is very real and almost impossible to satisfy in Poland. Yet the situation seems anomalous.

The reasons for the high price of the needed chemicals in the West is in part due to the relatively small demand for them, but predominantly due to the very high price of relatively skilled labor needed to isolate them or to synthesize them. It, therefore, appears strange for Poland, with exceptionally low priced skilled labor, wanting products of pure labor from the United States. It would seem logical that countries with low skilled labor costs would supply biochemicals and speciality chemicals to those with high labor costs, but worldwide it is not so. For example, the best suppliers of the substrates or of chemicals for protein synthesis needed for my research are Switzerland, Japan and the United States, countries with the highest skilled labor costs. It is probably the case that some of these chemicals are made in lower labor cost countries and simply distributed by the Western companies (the separate manufacturing and later resale is quite a common practice). However, it seems as if a great opportunity is being missed. It seems to me very important for Polish science to enter these markets, in part to provide alternate employment to universities for (less talented) Ph.D.'s and in part to satisfy local market needs and to gain substantial hard currency from sales abroad. However, developing a successful commercial venture should take some time and may still lead to limited product base.

I believe that as a short term solution for Polish science, a system somewhat similar to a military draft might be developed. Each laboratory that is funded by grants (see separate section on this) should be required to work for other laboratories about 1 day a week. A possible way of matching needs and delivered services might be a publication with lists of desired services by the already funded groups. Groups asking for funding would be required to pick from that list or offer a more imaginative suggestion. Most biochemical groups isolate worthwhile compounds (they might have to broaden their scope to be really needed), organic chemical groups synthesize, biophysical groups measure or write computer programs or interface equipment, etc. If the incentive system were developed and helped others to produce strong grant rewards, there would be a very large number of imaginative suggestions.

A less radical method would be to encourage an environment, where groups rendering service, e.g., amino acid analysis, peptide synthesis, etc. could be paid sums which not only cover their costs (in equipment depreciation, personnel, supplies, etc.), but allow them to make a **small** but clear profit. This too would be a major incentive. It is done by the various biotechnology groups in American universities.

Grant System. All European and Japanese university systems have been developed for the pleasure of the professors, who are only minimally accountable and continue to be well (not in Poland) paid and respected independently of what they do. A grant system, such as in the United States, where only those who have been judged to be productive are funded, seems to me to be mandatory. Poland does not have enough resources to distribute them to all professors. In addition the competitive element of grants is a big incentive to get things done. A newly introduced grant system is furthermore probably the only method of introducing changes in the way things are done, with the emphasis given to various fields, etc. What I propose is a grant system built on a premise that:

1. About 50% of the grants should be funded to be competitive but not absurd. Having more than 50% funded does not generate enough competition, it carries no clout. On the other hand the American system of awarding grants finds itself in deep difficulties when asked to select only the top 10% or 15% for funding. This decision seems too hard for any committee to make.

2. Grants are not given to large units, Departments, Institutes or large teams of scientists, but to individual research groups. Grants may not be shared with other groups, but must be used directly by the relatively small group to which they were given.

The most important issue is the committee that will award such grants, because it is essential that they be given correctly. I would like to make a heretical suggestion. The grants committee should be foreign, United Nations, or FEBS or United States Committee. Obviously the international groups would be better. However, failing that one could ask the United States whether they would be willing to do this as part of aid for Poland. It would be very great aid indeed because:

a. The grant proposals would automatically be required in English (a good thing).

b. There would be much less confict of interest.

c. There would be much more likelihood of a few experts in each area.

d. International standards might be used.

e. The committees might be more sympathetic than Polish ones for using the grant system for real reform.

If you ask me to do so I could informally ask NIH and NSF whether they might consider evaluation of Polish grants as foreign aid to Poland.

Discussion

The relationship of bio hemistry to biologi al s ien es

Biochemistry is becoming increasingly central to most biological sciences. A few trends within the science itself, gene expression in various foreign organisms and the study of cellular organelles lead to a good deal of interest of biochemists in biology. Therefore, it seems logical to integrate biochemistry into the biological sciences and many countries do it more and more strongly. It appears that country wide this trend is very strong in Poland.

It seems to me that this is an expensive trend. By uniting with one group of sciences one per force cuts some bridges to the other sciences. It should be noted that some of the greatest advances in biochemistry made since 1950 were made by people trained in chemistry or physics and in countries (Great Britain and United States) having the tradition of biochemistry as a method of satisfying the **physical** scientist's curiosity about life. Examples are DNA double helix (Crick – physics), genetic code (Delbruck, Crick, physics), x–ray crystallography (Perutz, Kendrew, physics), α helix and β structure of proteins (Pauling, physical chemistry sequencing of proteins (Sanger, Edman, organic chemistry) and of nucleic acids (Sanger, organic chemistry, Gilbert, physics). Of course, many contrary examples involving biologists can be listed, but it should be remembered that for its optimal development biochemistry may need

physical sciences at least as much as biological sciences. I hope that in classifying biochemistry as a biological science and then drawing plans you will not define biochemistry totally as a biological science. This would make access to mathematics teaching, to organic synthesis of substrates, nucleotide analogs, peptides etc, very difficult.

Poland has a few relatively good biophysics groups. I believe that any new plans should not diminish these groups, but instead use them as a major bridge between physical and biological sciences. What I am writing about is not a platitude. The organization of academic departments and institutes has an important influence on associations and cooperations formed between researchers and therefore, significantly affects the outcome of the research work. If you divide physical and biological sciences too strongly, biochemists will seldom talk to chemists and never to physicists and mathematicians.

The Biggest Cost of Science is Brainpower. All of this was poor assumption. I have assumed that Poland may be an exception to the world trend and that in Poland many young people of great ability are interested in careers in top flight research science. This unfortunately is not the case in most Western countries. It seems clear that the quality of young science students is now lower than before because the most able fraction of the population choose financially more rewarding careers such as computer science, but even more, business, finance, estate planning, investment banking, etc. The real cost to society of having top flight science is probably less in money than in the top brainpower of a country. In my opinion the US can afford the smartest people being diverted to science. Poland has much bigger problems; it also needs financial experts of which the US has too many. Therefore, the decision to have top–flight science carries with it a heavy price of a rather peculiar brain drain. It is you, not I, that must decide whether your country can afford it. I hope you will. However, if you do not intend to have the most able people to go into science, then you probably should not bother having basic research in experimental science at all. It will still be quite expensive and the results will be unimpressive.

Implementation of Changes. In discussing some of the above suggestions with collegues, who generally agree with the direction of the suggestions, I encounter two views. One is to implement most of the suggestions right away (the revolutionary approach), the other is slowly to trend toward the implementation (the evolutionary approach).

It is clear that a total revolutionary approach is far too brutal. Let me deal with an example. It seems too brutal to tell a student who is to write his Ph.D. thesis in 1990 and who expected to do so in Polish, that he must write it in English. It will, however, also serve little purpose to say that we encourage writing of theses in English and those who can easily do so, should do so. What I would propose is loudly to announce in 1990 that all Ph.D. theses must be in English after 1995 (arbitrary year but 2000 seems much too far). Even if you should choose 2000, announce the requirement now. This will make potential science students select English in **gimnazjum** and exert pressure on these schools to have or try to get enough competent English teachers. Many other changes can be handled in the same way. If possible make a loud, coordinated announcement that 1) Poland is serious about doing world-class basic research in experimental sciences, 2) Poland **expects** that the performance of her scientists on the world scene will dramatically improve, 3) in spite of severe economic conditions Poland is prepared to spend some serious money on basic research, 4) Poland has adopted many strong measures (some, hopefully most, of the above suggestions) to improve this research.

The competitive grant system in which a significant number of serious applicants succeed and a significant number fail is by far the best way to implement the high utilization of equipment, intergroup cooperation and narrowing of research topics. It is clear that those who have put in a lot of serious effort and many years of life into research science in Poland should be allowed to

finish their careers with dignity and respect. On the other hand, unless they have made major contributions to international science they should have as little say as possible in naming their successor. They should also lay relatively small claim to very limited resources.

Sugestie dotyczące reorganizacji badań podstawowych w polskiej biochemii

Streszczenie

W artykule zostały przedstawione sugestie zmian zmierzających do uzyskania wysokiego poziomu krajowych badań naukowych o znaczeniu międzynarodowym.

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