stress, we will be handicapped in our efforts at diagnosis and prevention.

Regional variations: Although the basic characteristics of the kwashiorkor syndrome have been fairly well agreed upon, there remain baffling differences in the signs associated with the disease in different areas. While some of these differences may be due to genetic differences in skin pigmentation and in texture and color of hair, others seem more likely to be the result of variations in deficiencies of specific amino acids or of concomitant deficiencies of other nutrients. Elucidation of these differences should yield valuable information about the relationship of specific nutrients to those clinical signs which are inconstant accompaniments of the syndrome and about the interrelationships between a deficiency of protein and a deficiency of other nutrients. Particularly intriguing is the concept that kwashiorkor-producing diets differ in deficiencies of specific amino acids and that these differences account for some of the regional variations in clinical signs, even though a deficiency of any essential amino acid may produce the interference with protein anabolism which results in kwashiorkor.

Adverse Consequences and Sequelae

Thus far, attempts to demonstrate permanent sequelae from protein malnutrition alone have failed. There have been no sufficiently prolonged follow-up studies in which permanent sequelae have been sought. The effect of protein malnutrition in a child on the development of degenerative disease in an adult will, of course, be exceedingly difficult to determine. The recent demonstration of impaired intellectual capacity in malnourished children (*38*) is of tremendous importance and needs further investigation.

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Why Did Daedalus Leave?

Underdeveloped countries are aiding the developed by exporting one of their most precious commodities: talent.

Stevan Dedijer

The study of the social behavior of scientists is one of the least developed branches of one of the youngest of the social sciences: the sociology of science. Even the belles-lettres, as C. P. Snow recently pointed out, have practically ignored scientists. The rare and tenuous tracks back through time, marking an awareness of this type of human behavior, stop in Greek mythology. In the legend about Daedalus (*1*), the first mortal inventor in their mythology, the Greeks described the behavior of a man passionately devoted to what today would be called the solution of problems in applied research and completely free of any social and ethical norms.

Daedalus starts his career with murder: he kills from professional jealousy his colleague Talos and flees to the court of king Minos of Crete. There, by appropriate inventions, Daedalus solves a series of problems of questionable moral and political worth: he constructs a machine enabling Minos' wife to copulate with a bull, he devises the labyrinth so that Minos can hide the shameful monster born as the result of the previous invention, and finally he invents a device for

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solving the puzzle of the labyrinth, with the result that the subversive Athenian Theseus kills his employers' monster son and steals their daughter. Deciding suddenly to quit his post in Crete, and refused by Minos the permission to leave and the means of transport, Daedalus invents the flying machine (made famous by the death of Icarus) and takes off to a new post, in Sicily. Minos, who seems to have valued highly the services of Daedalus, sails with a fleet to find him and bring him back, and using the knowledge that the inventor cannot resist the challenge of a difficult problem, does find him. Daedalus then promptly solves the problem posed to him by his new employer: he constructs a bath such that when Minos pulls the shower handle he is scalded to death.

In this obviously tendentious legend one point remains obscure: if, as is evident, Minos did not want to lose him, why did Daedalus leave?

The migration—temporary and permanent—of individual researchers across state boundaries is as old as the history of science itself. And in puzzling, from today's perspective, over what prompted the flight of Daedalus from Crete, we can ask certain questions.

Did Daedalus leave because he felt that elsewhere he could work better on problems he was interested in, as scientists often feel today, and as for example the German Johannes Kepler felt in the year 1600 when he went to work in Prague with the Danish astronomer Tycho Brahe? Or did Daedalus emigrate because he felt about his colleagues in Crete just as the astronomer Ruggier Boshkovich felt about the scientific community in Rome in the 18th century, when he wrote home to Yugoslavia: "There is nothing more that I desire right now than to run away to Constantinople. For indeed, I expect that I shall find the Turks to be better than the Christians." Or did Daedalus leave because he felt that "it cannot be said that society provides good conditions for the proper growth of science" (*2*).

Such questions, bearing on the nature of the scientific work, on human relations existing within a scientific community, on the influence of social environment on creative research work, and on the effect of all these factors on the migration of scientists, are ceasing to be purely academic. For never before has there existed such an opportunity for the migration of Daedali, and never before have there been so many of them migrating across state boundaries as today. Until recently, the world scientific community was mostly concentrated in the more developed Western countries. Now the interaction of the three revolutions of our age—that of the underprivileged classes, that of the underprivileged nations, and the great scientific and technological revolution (*3*)—is causing, through the socially organized diffusion of science, a veritable explosion of the boundaries of the scientific community to include every corner of our globe. Almost every country today is helping to expand the world scientific community by efforts to detect and develop its own scientific talent. The Minoses of the world are beginning to count avariciously and to guard jealously their scientists and engineers and are becoming concerned over the propensity of these scientists and engineers to take off across the border.

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Daedali in Flight

This can be seen from a series of signals about Daedali leaving and Minoses trying to find them and bring them back, picked up in a sweep from the northwestern tip of Europe to the southeastern tip of Asia.

The Advisory Council on Scientific Policy of the British Government was the first to worry publicly, in its 1953–54 report, about "the loss of scientists abroad" and, in its 1956–57 report, about the "emigration of scientists and engineers."

Moving to the continent, we find a study group formed by the Science Committee of the North Atlantic Treaty Organization concerned in 1960: "It is noteworthy," states the committee, "that even some of the nations in Europe which are technically advanced and pay good salaries are steadily losing highly qualified young scientists through emigration. Some permanent exchange of scientists is inevitable and desirable: however, any country which suffers large and continuous losses should examine its policies with great care" (*4*).

In November 1959 I submitted to the newly formed Research Council of Yugoslavia a list of questions I suggested should be looked into. Under the leading "How many scientists are we losing abroad and why," I in part said: "The urgency of this problem is suggested among other [things] by the fact that a private enquiry reveals that in the last few years just our three nuclear institutes have lost some 20 scientists who are now working abroad."

From the home of the first Daedalus we hear of further flights: "The delegate from Switzerland said that his country has (and welcomes) about 300 Greek students and that the best of them do not want to return to Greece when they have qualified" (*5*).

Considering the state of science in the land of the Sphinx, a wise American says: "We should avoid weakening the intention of those of our visitors who come to study in the USA to return to teaching and research in the UAR. This is a delicate point and cannot be sharply defined, but I think that enticing UAR personnel in training in the USA to remain in the USA through offers of positions or other inducements would be bad" (*6*).

India became concerned with this problem a year or so after gaining independence and has recently been devoting serious attention to it. In July

1959, the Indian Council for Scientific and Industrial Research took practical measures in response to the following question: "There are also persons from India who are employed in the countries in which they have received postgraduate training in special fields. Is it possible to get them back and utilize their talent for furthering various projects under the national plan?" (*7*).

And from southeastern Asia, an international expert on the development of research and education wrote in November 1960: "too many of the able young men who have gone abroad for postgraduate study are remaining there or returning after a short period at home, because they have not received due recognition or have been unable to find a suitable position with adequate salary and facilities. In some countries, the loss of young qualified men has reached an alarming number. There is a growing discontent on the part of this young cadre of scientists and many governments are coming to the realization that means have to be found to put a stop to this drift of talent" (*8*).

Sociology of Science and Research Policy

The Daedalus of the Greek myth is a cleverly devised image of the ivory-tower inventor—a being all curiosity, all problem-formulating and problem-solving, and little else. At one time there was a strong tendency to consider science as the exclusive concern of such ivory-tower Daedali. Today, however, there is a fairly general agreement everywhere on two points: first, that "science like technology is a creation of societies, not races: its precepts and results are transmitted by social tradition" (*9*); and second, that society must provide good conditions for the growth of science through the appropriate set of decisions, called "research policy," whose one important component consists of "the social and political measures needed to make the scientific potential of a country both scientifically and socially productive" (*10*).

A research policy to be realistic has to be based on a thorough study of the interaction of science and society, which constitutes the field of the sociology of science. Yet, it can be safely said that, until quite recently, with few notable exceptions so far (*11*) the sociologists of science have been in general of little, if any, help to the policy makers on any of the principal components of the research policy. This is certainly true as regards the loss of the scientific talent through emigration. On the other hand, practical-minded decision makers are often inclined to find little that is useful in academic studies, which do not seem to have an immediate practical bearing on bothersome research-policy problems.

With the growth of efforts to make research become one division of labor within every society and a part of the culture of every people, and as the boundaries everywhere in the world become (let us hope) more open, one can expect that the migration of scientific talent will become a problem of international concern (it is surprising that it has not already become so, especially in the case of the new countries). The sociologists of science, by studying the flying Daedali as individuals of given mentalities doing a specific kind of work and migrating from one given professional environment and one given wider social environment to another, could not only advance their branch of inquiry but could also greatly aid the policy makers to find their way in the intricacies of the problem of migration of scientists, on both a national and an international scale.

Aiding the Developed Countries

The first and the obvious step in approaching this problem would be to attempt to collect, systematize, and classify (even roughly) on a world scale data on the migration of research talent. This could be done by giving, for each particular country, the number of emigrating or immigrating scientists and engineers, the direction of their flight, and their level of development.

In spite of the evident concern—public but even more private—of Minoses everywhere, very little of this is known, even for the most developed countries. Thus, from Britain we hear (*12*) that "there are no comprehensive statistics to show the extent of the movement," of scientists and engineers out of the United Kingdom, and from the United States (*13*) that "no one knows the precise number, or the nationality of foreign students who take up permanent residence in the United States."

In the absence of more precise data, for the purpose of this article, all countries could be roughly classified into three categories: (i) the current "sink" country for migrating research talent; (ii) the "sink-source" countries; and (iii) the current "source" countries.

And with respect to the level of development, the migrating research talent could be classified into: (i) the undetected scientific talent, leaving the country through general economic or political emigration; (ii) the raw talent (the undergraduate students); (iii) the semirealized talent (the graduate students); and (iv) the accomplished Daedali.

The United States seems to be the only sink country; scientists and engineers from all the countries of the presently open part of the world, especially from Europe, are emigrating to the United States, while there seems to be very little permanent migration from the United States.

Countries like Britain, Germany, France, and so on lose scientists, mostly to the United States, but gain them through immigration from other countries.

In general, countries just starting to develop in science are source countries. Scientists and engineers from such countries are emigrating not only to the United States, just as those from Britain, Italy and Germany are doing, but also to these latter countries. Generally, it is from new countries that the Daedali are migrating in one direction only: out.

And while the countries of the second category lose their scientists mainly on one—the postgraduate—level, the countries just starting in science lose them on all four levels of development to *all* the more advanced countries. In this way, one could say, the underdeveloped countries are aiding the developed ones by supplying them with one of their most precious commodities: creative talent.

Importing Research; Exporting Researchers

For a number of reasons, the problem of migration of research talent will be considered here from the point of view of source countries. This means that the very interesting ques-

tion of migration of scientists from "sink-source" countries, which have a tradition in science and as a rule a relatively vigorous research policy, will be considered only indirectly.

In the past, the underdeveloped regions of the world contributed to world science without having a scientific potential of their own. In this respect their position in relation to the world scientific community was somewhat similar to their position in the world commodity market: to both of them they exported raw and semifinished goods—in one case, agricultural and industrial products and in the other, their scientific talent. For example, of 12 scientists born in Yugoslavia and recently chosen in a survey by Yugoslav university professors as having contributed most to world science from the 16th to the middle of the 20th century, eight emigrated as boys and became scientists of world renown. Since 1945 my country has started a vigorous policy of developing its own resources and of creating for everyone an opportunity to improve his living conditions. As a result of this, the loss of the unidentified scientific talent through economic emigration can be said to have practically ceased. This kind of export of scientific talent can be expected to diminish in other cases to the degree that a vigorous policy of development is started, aiming to increase the well-being of the population.

But as such countries start to develop their research potential there is a growing tendency to lose a considerable proportion of it on all levels of its development: on undergraduate and graduate levels and on the level of full-fledged research. This seems to be a process parallel and opposite to that of the diffusion of scientific work from its birthplace in the West into social environments basically alien or unsuited organically to it.

This type of migration tends to occur, it seems, first of all on account of a trait of the research work itself: it can be learned only with difficulty from books. For "modern science is a local tradition and is not easily transmitted from one place to another . . . Scientific research . . . is an art; it is the art of making certain kinds of discoveries. Scientific research is taught by example" (*14*).

In my country, Yugoslavia, the number of university students today is at least five times greater than in 1940 and the annual university expenditure has increased even more. Contrary to the situation for some other countries, the number of Yugoslav undergraduates studying abroad is, for a number of reasons, extremely small. Yet today the university, as a social institution whose function is to develop creative talent, among its many increasingly modern traits still has many traits characteristic of the decidedly undeveloped country that was old Yugoslavia. One of them is that there is no tradition of research at the university; during the four years of study the undergraduate student as a rule still has no contact whatsoever with research or with problem-solving in general. Graduate study, the level at which a young man's research mettle is first seriously tried, is just being organized now. And after graduating, those going to the research institutes (those remaining at the university still have little opportunity for research) suddenly face the question, often heard and repeated, "How does one do research?" since up to that time they have had almost no contact with a practitioner of "the art of scientific work." So a new country without science has to import it; it has to send its promising—usually its most promising—research talent abroad, hoping that upon returning these men will act as local centers of diffusion of the art of research. That is why it is not unusual in new countries to find institutes almost empty of researchers: they are abroad learning the art.

The countries with a developed research have opened their doors to thousands of such young graduate and undergraduate students. For example, in the United States there were in 1959 over 65,000 foreign students, 18,000 of them graduate students; in the United Kingdom the figures are 11,047 and 4286; in Austria and Switzerland one-third of the total student body consists of foreigners. Most of these students are working in natural sciences, medicine, and engineering, and the majority of them come from what we called "source" countries. Quite a number of such countries have more students abroad than in their own institutions of higher learning.

And what happens is that many talented (often the most talented) citizens of, let us say, Zonia, who have gone abroad to import the art of science or engineering, become scientists or engineers and in the process cease to be Zonians; they do not return home. When the impact of such losses begins to impress the Minoses of Zonia, they begin to grumble: the open door is an open door of a trap for our Daedali (*15*).

Responsible people in the United States, the principal host country, have shown concern over this problem: "US Government agencies believe that two basic objectives of the exchange program are frustrated when students emigrate to the USA. They are the opportunity to promote international amity, which is considered the primary purpose of educational exchange, and the opportunity to help other countries' social and economic progress, which is also considered an important goal" (*13*). Such people are trying to find "what can be done on the US side to encourage students to return home?" (*16*).

There are indications that other host countries are beginning to ask such questions. The problem of the emigration not only of students but also of experienced scientists and engineers from the source countries is beginning to be considered on an interstate level. International agencies are beginning to discuss it in committees. In spite of this encouraging trend, realists must recognize that one can hardly expect government agencies, let alone private firms and institutions, "not to entice" the talented foreign scientists, young or mature, who hope to be enticed. In the end, the main burden of stopping the critical loss through emigration of scientific talent on all levels of its development falls on the Minoses of the countries from which the Daedali are emigrating; it is principally they who must bear the responsibility for transforming their source country into a source-sink country.

Information Needed for Action

In order to make the appropriate decisions, the responsible decision makers must have information on the following points: (i) How much research talent have they lost and are they losing on all levels? (ii) What has been found elsewhere about why scientists and engineers leave? (iii) Why have their own Daedali left; in other words, what factors in the domestic scientific and social environment tend to make them a source and not a source-sink country?

To obtain information about the first point it is not enough to count the number of emigrating students or full-fledged researchers. In the final sum one must include not only the quality of the research talent of the individual emigrants but also their qualities as social beings acting within a given scientific and a wider social environment. One must estimate their quality as leaders and teachers of research and science, the strength and the effectiveness (actual or potential) of their participation in the interaction between science and society—for example, as administrators of science or as persons having the not easily found ability to communicate to the decision makers the information needed for an effective research policy.

The decision to emigrate or stay at home is the resultant of attractions and repulsions acting on an individual from two professional and social environments; it is a choice made, through the free will of individuals, between two sets of alternatives. This is seen, for example, in the following case. Recently, a prominent scientist from a source country wrote: "The conditions for science in my country are unsupportable. Everything here tells me that both as an individual researcher and as a social being I am not needed nor wanted," and then he took off for the United States, where, as we saw, a prominent group of scientists proclaimed, "It cannot be said that society provides good conditions for the proper growth of science."

The number of researchers and engineers who have left the sink-source and the current source countries in the past ten years runs, probably, into thousands. But it seems that no exhaustive study has been published about even a small sample of this number from which one could define roughly the principal motives for emigration that influence individuals as private persons, as professionals, and as socio-political beings. All one can do at this stage is to draw up from the existing sources a list of the factors said to be influential in the decisions of individuals to emigrate. This list would include: salary; material standard of living; status in the scientific community; opportunity to advance professionally on the basis of ability; ease of obtaining the means for research; degree of development of the scientific branch the scientist has been trained in or wants to work in; status in the social community; and finally, a number of factors lumped under the general heading of socio-political factors.

The relative weight of these and other factors influencing the decision to emigrate has not as yet been published, even for a small number of cases. But from all the information available one may hazard a guess that the higher salaries offered, the higher standard of living abroad, and the purely political reasons (except under extreme circumstances) perhaps do not play as decisive a role as some decision makers from source countries are inclined to think without full examination.

In approaching studiously this problem one must not forget that this choice made by an individual one way or another is always the result of an intense inner struggle, for it involves cutting oneself off from innumerable ties strongly binding one to a particular social environment and going into a new and an alien one. Kepler, for example, deciding not to emigrate in 1615 wrote: "Am I to go overseas [to England], where Wotton invites me? I a German? I who love the firm continent and who shrink at the idea of an island in the narrow boundaries of which I feel the dangers in advance" (*17*). In 1959 one scientist who emigrated wrote: "I decided to leave the country where I was born, to which I am tied by all the joys and sufferings, by all the failures and successes of my 45 years of life. It was the most difficult decision I had to make."

The Macro and the Atomic Approach in the Sociology of Science

We shall assume that the decision makers from the source countries are aware of the problem of emigration of scientists and that they desire the necessary information to make them a source-sink country. This is quite an assumption. For, first of all, very often in such countries the ability of many of the best-intentioned decision makers to supply initiative for the collection and the evaluation of information and to act effectively upon the data meaningful for their field of responsibility is limited by their educational background and the environment to which they belong. To realize how bold this assumption is, one has only to see how little study preceded some of the big government decisions with respect to science in some source countries.

In order to obtain the necessary information, the decision makers will have to turn for help to the sociology of science. And here we come against the attitude of one category of decision makers from some source countries toward the social sciences in general and the scientific study of the micro-social relations of their society in particular.

The process of developing a country consists to a large degree in importing and grafting modern civilization onto an alien and a resisting social environment. The greater the social urge and the will to develop, the higher the goal, the shorter the time for reaching it, and the stronger the pressure of the past upon the living (including the decision makers), the more painful is the process for everyone involved. Under the best of circumstances the decision makers of such countries are human beings working under enormous pressures, which unfortunately are rarely described and are difficult to imagine from the outside. Man being an ideological animal, the pressure to get things done inclines such decision makers to accept the action philosophy —that rapid results can be obtained at the cost of the most abundant available commodity: human beings. This ideology readily finds its logical expression in the exclusive and dogmatic acceptance of theories of society which deal with man only in macro dimension, only as "masses" moving under the action of forces and according to the "laws of motion" of human matter. This macro approach treats man in bulk, in "zero approximation," as a biological and an economic being, neglecting most of his other needs and the fact that he is motivated "not by bread alone." This attitude toward the social sciences is likely to be prominent especially in the first, the hardest, phases of rapid development.

The Ecology of Research

This macro approach—believed by many Minoses to be sufficient—excludes the other necessary theoretical guide for action: the atomic approach, which describes society as composed of individuals and groups of individuals doing specialized kinds of work and having a variety of inherited and acquired aspirations, mentalities, and

attitudes and communicating and reacting with other individuals or groups, the totality of these interactions forming a given social environment. Whatever is the value of the macro social theories, the atomic approach is essential in considering problems of interaction of science and society. For masses never invented a machine or produced a scientific theory. Everything in science is the product of individual social beings; and the loss of one single talented Daedalus can set back a scientific institution for years.

When, either through social sciences or through the observation of the outside world, the decision makers inclined to hold macro social theories become aware of the necessity of importing and grafting research onto their own society, they are likely to be guided in their decisions by the formula:

Effective research =
[in order of importance]
machines +
buildings +
money +
research program tied closely to
political and economic goals +
a set of formal research institutions +
a quantity of problem-solving Daedali.

Through painful experience and immeasurable waste they discover that this formula does not fit the facts, that there is operating in it a hidden parameter. This is what in the developed countries is called "scientific tradition." One speaks of the scientific tradition of a scientific institution, of the whole scientific community, or in the relations between the decision makers and science. Both the history and the sociology of science have neglected the study of *how* and under what micro social conditions scientists create their work and transmit the art of research to the young talents of the new generation. Scientific tradition developed gradually in the West, unobserved and almost unfelt. It could be defined as a communication of experience by other than written means. Until recently it is only in literature, and very rarely at that, that we find mentioned the cost in men of this "rugged individualism" kind of development of social conditions for science. Thus, in his novel *The Search,* C. P. Snow has one of his characters say: "And so I had to draw young men, and having got them, see that they were not wasted. That, I thought, was where I ought to be useful: for from all the laboratories I knew, the number of men thrown away by negligence, by incompetence, by sheer ignorance of the fact that there are differences between young men, would be enough to stock a reasonable scientific society in South America. . . . There must be a certain amount of trial and error, however, and one cannot expect a career in science or anything else to be adjusted with immaculate precision. But there is altogether too little trial and too much error. Luck must play a big part; but that does not seem a good reason for letting it decide altogether."

Must the source countries develop tradition purely by "trying and erring" with their scientific talent—young and old? In the world of today, in a world becoming more and more open and where there is more and more science, this is becoming impossible.

The process of developing a country, the process from no tradition in science to a tradition in science, is very painful for scientists also. Most of them, trained abroad or not, work in a social environment which is alien to science and research, and most of them find themselves to be, as a prominent physicist put it, overdeveloped scientists in underdeveloped societies. For no social institution around them—the institute, the university, the scientific community, and the decision makers—"has a tradition for science." This lack of the proper social environment or tradition acts upon researchers as a strong pressure outwards. The flight of Daedali from source countries is only one measure of the painfulness of the process; it is only one symptom of the relatively unsound social conditions for science. For it must be kept in mind that for every Daedalus who is willing or able to fly away there are many other grounded Daedali who stagnate, succumb, and are destroyed as research talent by the unfavorable social conditions. The novel of the Soviet writer Dudintsev, *Not by Bread Alone* (not to look for further evidence from the countries which until recently grounded their Daedali) speaks eloquently of that.

As the world becomes more open and as, one hopes, peaceful coexistence becomes a reality, the Minoses of the source countries can less and less afford to ignore the missing factor of science tradition in their formula. They will have, so to speak, to manufacture rapidly this tradition. To develop an effective research potential they must alter the local environment in the direction of making it, through conscious efforts, by policy measures, favorable to scientific work, which up to now, has not had a part in the culture of their society. To be able to do this, the wise source-country Minoses will have to initiate the study of the relation of the existing micro and macro social environment and the research work. This study—which can be called the ecology of research—can contribute greatly to the transformation of an environment alien to science to one attractive for the work of individual Daedali.

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