Z. W. O., the Netherlands Science Foundation

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SCIENCE, according to Conant's definition, falls into the category of accumulative knowledge. If in a given period no new facts have been found and no new concepts developed, science has been at a standstill. At the same time, however, a number of facts and concepts may have been drawn from the stockpile of pure science into the field of application. Even while not standing still, science is forever feeding on its own earlier-produced results and may thereby drain its stock. This means that the question as to the scientific progress made in a given period cannot be answered simply by enumerating new facts and concepts. Scientific progress is a dynamic concept; it is essentially an increase in potentialities. It cannot, therefore, be measured in terms of simple accumulation of new and fruitful concepts but as the rate at which this accumulation increases.

So we see that promoting scientific progress is not only a matter of preserving the *status quo* in effort, number of scientists, and financial and material resources. Even if today comparable results could be reached with the same number of men and quantity of apparatus as yesterday—which is impossible as long as the complexity of problems on hand is growing—real progress would demand ever-increasing supplies of competent personnel and of funds. Disregarding for the moment the question of personnel, it is already obvious that, even in the most prosperous of times, there is a limit to the amount of money that can be spent on scientific research. Consequently progress as defined above is essentially discontinuous. In its ideal form it can only be approached in times of heavy pressure, such as when the public suddenly realizes the danger to itself from cancer or other threats, or during a war.

Science—pure science—is like a beautiful woman, wooed by many suitors for her enchanting charms; and like other delicate ladies, she is apt to swoon when courtship grows too vehement. In time of war or other emergency that is what happens, even though it is not really she who is courted, but her more practical sister (or is it daughter?), applied science, who actually thrives under the many attempts to win her favor.

Nevertheless, in situations like these, when stress is laid on applicability and technology, there are some bright spots for pure science. Young people are drawn toward a scientific career; large-scale facilities are made available that can eventually be used for basic research. Public attention is drawn toward science; inertia, if nothing else, will leave the purses open for some time after the emergency has ceased to exist. Either so much fundamental knowledge will be used up, or, in certain fields, lack of basic knowledge will become so evident, that not only the scientists but perhaps even the general public and a number of the responsible authorities may become apprehensive. And so, after the heyday of science seems to be over, a flourishing of a somewhat different kind may begin.

Continually growing resources being impossible to realize, the assumption will have to be made that there are other ways of creating persistent stimuli. Farsighted marshaling and ingenious switching about of limited means may result in a constant tackling of new problems. If it is true that in this way a first approximation can be reached of what is needed, even small and impoverished nations may hope to bring about some scientific progress if they are prepared to shoulder the necessary—substantial but finite—financial burden, and if they have the men who can find the ways to be followed.

Wartime fertility in the family of scientific organizations, as witnessed in the United States during earlier wars by the birth of the National Academy of Sciences and the National Research Council, seems to be a universal phenomenon. In a record number of countries World War II has been responsible for the creation of councils for scientific research and science foundations. Just now the happy event has taken place in the Netherlands. The newborn Organization for Pure Scientific Research will be described here, but, before going into its history and aims, mention must be made of its elder sister the (Netherlands) Central Organization for Applied Scientific Research.

This, too, had its origins in wartime. During the first world war the Royal Netherlands Academy of Sciences took the initiative in creating an agency to coordinate the national effort in applied science. The government was haphazardly catering to its own research needs, often without really understanding them; and industry, lacking research-mindedness and, to a large extent, too small to finance separate laboratories, was—with a few notable exceptions—doing very little or nothing at all. It took many years for the idea, first suggested by the academy led by Lorentz, to crystallize. Not until 1931 was final agreement reached, and a law was adopted setting up the organization which is now generally known as "T. N. O."

Two decades after its creation, T.N.O. is now a closely knit network of some fifty institutes, laboratories, field stations, and research groups. The Central Organization itself is divided into a number of special organizations for, e.g., industrial, agricultural, defense, and—the newest addition—health research. Each special organization has its council, consisting of both scientists and industrialists or others concerned with the application of science in the economic or social life of the nation. The chairmen of these councils sit together on the board of the Central Organization T.N.O., where they again can rely on the advice of a council made up of citizens prominent in either science or industry and economy.

Financially, too, T.N.O. has twofold support. A large part of its expenses are met by an annual government subsidy; the smaller but still considerable part is contributed by organized industry for general support and for special research contracts. Close cooperation among government, scientists, and industry is guaranteed in this way, and many fruits have already been born, of high value in the present period of growing industrialization of the country. Even in a geographically small country like the Netherlands it has been found worth while to pay special attention to the location of many of the institutes: the leather research institute, for example, is in the region where most of the leatherworks are, etc.; and several of the laboratories are situated near, and even in, universities with parallel interests.

As already mentioned, the initiative for the Organization for Applied Scientific Research was taken by "pure" scientists, like physicist Lorentz and botanist Went, not in the first place by industrial or "applied" scientists. It is in a way highly significant that the initiative for the Organization for Pure Research came from application-minded men like Kruyt, present board chairman of T.N.O., and Holst, then director of Philips Research Laboratories.

As in many other countries, after World War II the Bush report in the Netherlands met with wide response. Faced with the seemingly impossible task of mending its war-devastated economy, its altering relations with Indonesia pressing for a total reorientation in the financial and industrial sphere, the country's leaders saw only one way out: industrialization and still more industrialization. Practically without natural resources, heavy industry and mass production of semimanufactured articles fell beyond the scope of the country's possibilities. High-quality products and refining of imports seemed to be the only foundation on which recovery of the Netherlands could be based. This again could only be realized if industry had at its command the very best research facilities and the ablest scientists. Here the Bush report pointed the way: applied science can only flourish and stay flourishing if basic science is steadily feeding it with its newest results. And so the phrase was coined that only one kind of products could put Holland on its feet again: brain products.

What is the present state of the resources for these products? The past has been rather favorable. Eight Nobel prizemen is not a bad record for a country whose land area is less than that of Connecticut and Massachusetts put together, and whose rapidly growing population only a few months ago reached the ten million mark. But . . . the last of these got his award in 1929. Is it presumptuous to ask why eight in thirty years and none in the next twenty? There may, of course, be nothing in this. The occurrence of a van der Waals, a van't Hoff, or Einthoven is far too rare a phenomenon to yield to statistical computation. But let us for a moment assume that there is something symptomatic about it, what can the reasons be? Decrease in intellectual capacities? Deterioration of educational methods? Perhaps. But there are other causes that might account for the difference. The most obvious of these is the enormously increased competition. At the beginning of the century Western Europe practically held the monopoly of an activity that by now is widely practiced in every civilized country in the world. But must we not look deeper? May it not be that the days are over that a man like Kamerlingh Onnes could sit back in a dilapidated building and, with less than modest material aid, reach temperatures far lower than had ever been dreamed of? May it not be that, even if creative thinking still can only be done by the individual, individualism is no longer an advantageous attribute of the scientist but an impediment to teamwork? It certainly is true that many problems in modern science, and those the most fundamental, are so complex that the cooperative effort of many specialists is needed to solve them. As in many other phases of life, in scientific research specialization and integration must go hand in hand. May it not be that Dutch science lags behind in methods of integration, even though it may produce good specialists?

We shall not try to answer these questions. For insiders in Dutch university life it is easy to see that, if a serious attempt is made to bring science in Holland back to its former flourishing self, all these points will have to be taken into account. The financial position of the country being what it is, the most economical and efficient use must be made of available funds. This also makes coordination necessary. Here again we meet the difference between applied and pure science. Sturdy as applied science is, it may react favorably to the more coercive forms of coordination, whereas pure science, even if it is impossible to get results without cooperation and teamwork, will always be so highly dependent on the individual, free to follow his own line of thought, that coordination in pure scientific research is a tool to be used with great restraint and the utmost care. It appears that, to achieve this kind of coordination, not only is extensive knowledge of the research field in question necessary, but also a perfect understanding of the motivating forces that regulate the behavior of the scientist at work. This means that the coordinating body must preferably be made up of scientists.

Funds large enough to accomplish the desired results can at the moment be found only in the public treasury; hence a form of organization has to be found where nearly all active decisions can be made by scientists while at the same time the government can be responsible financially and politically to the people for those decisions. Before explaining how this problem has been solved in the Netherlands, one more important aspect must be brought forward.

Why is public support for science justified? The community has not the *"l'art pour l'art"* interest, the scientific curiosity, the wish to understand what to many a scientist is still the prime moving force. Research is desirable to the community solely because of its services. So, the question arises, which fields of science can contribute to the public weal? Not overlooking the demonstrable fact that one field may contribute more, and certainly more directly, than another, the answer that has been given to this question in Holland is simply: "All." And this means much more than the use of the English word science implies. In Dutch, as in German, *scientia* has been translated by a word that has retained the original Latin meaning. *Wetenschap* includes the natural and social sciences, as well as the humanities. It may be that this semantic difference has something to do with an analogous difference in appreciation of the part that the *Geisteswissenschafte* play in the life of a people.

If it is important to understand nature in its physical and biological expression, isn't it of as much consequence to understand social phenomena? And isn't it even more fundamental to understand the working of the human mind? In our times social structures are rapidly changing. Man has continually to adapt himself to his surroundings. To do this in such a way that his life is dignified and worth living while the *Naturwissenschafte* aid him in making an optimal use of his material resources, he needs at the same time the help of religion, philosophy, pedagogy, sociology. The study of philology, linguistics, history, psychology, ethnology, etc., are essential in trying to get some understanding of the functioning of the human mind. All these *Wetenschappen* are at least as important to the community as the natural sciences. They deserve just as much attention when active efforts are made to stimulate science.

Obviously the humanities will have to be treated in a different way than the physical or medical sciences. Both in their financial requirements and in the need for coordination there is a large disparity. This might be thought sufficient reason for a total separation. On the other hand, there are many who think that the crucial trouble of the modern world lies exactly in the divergence between the two large fields of knowledge. Disregarding the one while trying to propagate the other will merely cause the situation to deteriorate. Only total integration of effort can ultimately result in the balance between sciences and humanities which, to many, seems so important for the future.

II

On January 5, 1950, after a long parliamentary procedure, a law was passed setting up the *Nederlandse Organisatie voor Zuiver-Wetenschappelijk Onderzoek* (abbreviation: Z.W.O.; translation: "Netherlands Organization for pure 'scientific' research"). Z.W.O. can be distinguished from the Science Foundations in several other countries, on the one hand, by the catholicity of its interest in the "sciences;" on the other hand, by its limitation to pure research where "pure" is meant as the antonym of applied.

To understand the position of government, universities, and scientists in the organization, a little must be said about all three. According to the Dutch constitution, each cabinet minister can be held accountable by Parliament for all his actions. He may have to answer for the way in which funds are spent that have been appropriated on his budget, as well as for the application of laws that have been countersigned by him or his predecessors. As the Z.W.O. Act bears the countersignature of the Minister of Education, Arts, and Sciences, and the state support to the organization appears on this minister's budget, there must be some provision that he can carry responsibility for the actions of Z.W.O. However, scientific freedom from political influences is so traditional in Holland that the possibility of placing the management of the organization in other hands than those of scientists has never even been raised. Even in the state universities of Leiden, Utrecht, and Groningen, where professors are appointed by the government, the influence of the Minister of Education, though of vast importance financially, never leads to political nominations. Recommendations by the Senate (the assembly of all full professors) carry such weight that the Board of Curators very seldom dissents—and this for purely academic reasons and only if such disagreement exists the minister will feel free to reject a recommendation. Scientists, as in most Western countries, have no union. There is a young Federation of Scientific Workers, but this has not yet reached so large a membership that it may be called representative. Science has its only official representation in the Royal Netherlands Academy of Sciences with its two divisions for *Natur-* and *Geisteswissenschaft.* In all scientific matters this venerable institution ranks highest and acts as the official government adviser.

Z.W.O. consists of four separate organs: the Council on pure scientific research, the Board of the organization, the advisory committees, and the Director and his bureau. Of these the council is the top organ. It consists of two representatives of each of the universities: one for the sciences, one for the humanities and the social sciences. In each university the Senate and the Board of Curators together draw up a list of recommendations, and, acting on the advice of the Royal Academy, the Minister of Education appoints the members in such a way that not only the universities but also, as far as possible, the different branches of learning are represented. In addition to these there are council members from nonuniversity circles (at present: two industrialists, one leader of agriculture, the president of the Supreme Court, and the president of the National Bank). The council is the general policy-making body. It decides directly only on the most important issues, but it lays down the principles along which the board can take action.

The board consists of six members chosen by and from the council, including *ex officio* its chairman and vice chairman. This board is the real governing body. Board and council chairman for the first five-year term is G. Van der Leeuw, noted theologian and philosopher, and a former Minister of Education, Arts, and Sciences; the vice chairman is H. B. Dorgelo, physicist of the Technische Hogeschool at Delft. They are appointed by the minister from binding nominations of three names made by the council.

In addition to those already mentioned, there is another member of both council and board. This is the representative of the Minister of Education, Arts, and Sciences. He has the same rights and obligations as the other members and, in addition, a kind of veto power. He may order the suspension of any decision that he thinks will be contrary to the interests of the country or the wishes of the government. This suspension is strictly limited in time. The Minister of Education must then either raise the suspension or make it permanent. He is, however, legally obliged to ask the Royal Academy to advise him. It will be clear that all possible precautions are taken to ensure the scientific standpoint a fair hearing. This right of suspension will probably only have significance as a preventive against rash or insufficiently founded decisions. It is interesting to note that a similar veto right in the organization T.N.O. has never been used since the beginning in 1931, but neither the government nor the T.N.O. board would like its abolition. The government representative and his suspension right ensure the necessary ministerial responsibility without opening the door to management of Z.W.O. by the Administration.

The director is not a member of board and council, but acts as their secretary. He is at the same time the organization's business manager and is free to make any suggestion he deems appropriate to board or council. The board appoints and removes him. He attends all meetings of the advisory committees. These have been established for the physical, biological, and medical sciences, and for the humanities and the social sciences; their number may be enlarged. No research grants may be made without consultation of one of these committees, which have liberty to make recommendations *proprio motu*. Members of these so-called fixed committees are appointed each year by the Council, with the advice of the Royal Academy. These committees, their subcommittees, and *ad hoc* advisers are the real scientific arm of Z.W.O. and its most important organ.

III

Several years lie between the original plans of 1945 and the Act of 1950 creating Z.W.O. Happily this lapse of time was not paralleled by lack of action. The impulse that set the government in motion also resulted in vigorous activity among scientists. An association of the country's nuclear physicists—in some ways comparable to "Brookhaven"—cooperatively using a cyclotron and coordinating atomic researches in the universities; and a mathematical center, combining the efforts of many mathematicians and designing and building modern electronic calculators, were among the institutions that came into being long before Z.W.O., although they were destined eventually to fall into its sphere of activity. The government, on the other hand, did not sit back to wait until organizational and legislative difficulties had been smoothed out but, immediately after it had become clear in which way plans were developing, appointed a preliminary board of the not yet existing organization and made funds available for initial activities. Although these funds were small, this made it possible to make a number of research grants as early as 1946. Appropriations have been growing; before the middle of 1950 four million guilders[1] had been used. This may not seem a large sum compared with U. S. expenditures for research, even though the size of the country is one three-hundredths and its population one fifteenth that of the U.S.A. It goes, however, to basic research exclusively.

Some of the reasons may be mentioned for the organizational separation between T.N.O. and Z.W.O. Applied research usually has definite goals; it may be planned more distinctly and accurately than pure science, which is more dependent on individual preferences and personal interest. Hence applied research may thrive in specialized institutions under managerial direction, whereas pure research will more readily prosper in the university atmosphere, or at least under carefully adapted guidance. Administratively this leads to totally different structures. Variations in approach of project reviewing and differences in general outlook of pure and applied scientists are other reasons. A lot may be said for and against these grounds. In combination with historical reasons they seem fairly conclusive. The strongest motive, however, is this: especially in times of pressure for immediately applicable results, pure science would be in a bad position if a tug of war for funds were possible. A legal guaranty of an independent annual subsidy from the treasury is included in the Z.W.O. Act. This also includes provision for representation of Z.W.O.

[1] Before the devaluation of 1949 a guilder was 38 dollar-cents, now it is a little over 26 (in 1939, 53 cents). It must be borne in mind that the standard of living in the Netherlands is very much different from that in the U.S.A. One guilder goes much farther in Amsterdam than 26 cents in New York. Without claiming that university professors, both here or there, feel that they are adequately remunerated, a comparison may be drawn from the statement that the maximum annual salary of a full professor in a state university is now 12,000 guilders, or nominally 3,160 dollars.

and T.N.O. on each other's boards. And, of course, many other interrelations have been created to ensure perfect cooperation.

Two and a half million guilders ought to be available in 1951. Under the circumstances, while manpower is still the limiting factor in nearly every branch of science, this seems to be adequate for the present. Many plans are, however, being made, for which far larger sums may be needed. Among them an extensive fellowship program is anticipated to find and develop promising talent. The financial situation of the country makes it uncertain if these funds will be found. The present government has an open mind toward science and has done what it could without too many ill-effects on the budgetary balance, which was in view before devaluation but which now again seems a long way off. E.C.A. has already been approached on the question of whether Marshall-aid funds can be directed toward T.N.O. and Z.W.O. It seems certain that only with this help can Z.W.O. reach its more immediate goals.

The financial structure of the organization is such that money appropriated on one year's budget, contrary to governmental practice, can be transferred to the next year or later. This is based on the necessity to assure scientists beforehand that grants for work that will take more than one year will not be withdrawn solely on the grounds of nonavailability of next year's funds. Even though shortage of money has made this an empty gesture thus far, it deserves mention as a legal novelty.

It may be interesting to end this résumé with a few details on expenditures. Of the four million spent up to September 1950, 50 per cent was granted for research in physics and chemistry, mostly in fairly large amounts for well-coordinated work of (often interuniversity) teams. Mathematics got 13 per cent, nearly all of which went to the Amsterdam Mathematical Centre (which is looked on as a possible nucleus of the international mathematical institute that Unesco is planning). Astronomy, geology, and biology were given a total of 11 per cent. Medicine got 13 per cent, divided over a large number of mostly individual research grants. The social sciences had only a few projects, which took, however, 7 per cent of total expenditures; and, finally, 6 per cent went to the humanities in a large number of grants. In this last category falls nearly all the 3.5 per cent made available for publication of books and papers.

Grants vary from 250 guilders for visiting a foreign country to study some geomorphological structures, to a few hundreds or thousands to invite foreign scientists to demonstrate or participate in research from some weeks to several months; to five to ten thousand for publishing studies of history, archaeology, linguistics, ethnology, etc.; to twenty or thirty thousand for analyzing and interpreting results of psychological examinations of draftees for military service; to fifty thousand or more for crystal-structure research with electron rays; to about 150,000 a year for mathematical research and apparatus; to a total of more than a million for highly coordinated work of a large group of physicists. In 1946 two grants were made; this number has steadily risen and reached 119 in 1950. Altogether 275 yearly subsidies were directed toward 179 separate research projects.

Technical Papers

The Colloid Osmotic Pressure of Serum

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The paper "A Rational Method for Calculating Colloid Osmotic Pressure of Serum" (*1*) contains several statements that may be misleading.

One that concerns me particularly is "Scatchard attempted a theoretical derivation, but made an erroneous substitution invalidating his result." Dr. Kesselman informs me that it is our footnote 5 (*2*) that he criticizes. The equations in this footnote are correct except that the indication of a continued series (+ . . .) is omitted in two of the intermediate equations. This footnote makes no attempt at a theoretical derivation. It is merely a restatement of the well-known Donnan equilibrium relations for an ideal solution and their application to real solutions. The last equation in the main paper contains a typographical error, and should read

$$P/c = 268/[1 - (0.4 + 0.9\,\mathrm{pH})c].$$

It should, however, be replaced by the equations of our later papers (*3, 4*). The equation for the osmotic pressure of plasma in footnote 10, which contains the same error, has been found too limited in application to be recommended.

In the last paragraph Kesselman says, "It is to be noted then that, with all other factors remaining constant, a fall in serum sodium produces a rise in serum colloid osmotic pressure. . . . It is interesting in this connection that oral administration of isotonic sodium chloride has been shown to produce a fall in serum colloid osmotic pressure" (*5*). In this reference, the authors say, "In the present investigation, salt solution was administered in order to effect hemodilution and decrease of the colloid osmotic pressure." It is not impossible that this treatment leads to an increase in the concentration of serum sodium, but