The idea is currently reiterated that research productivity has passed from individuals to teams of investigators trained in different disciplines and capable of thinking from different points of view. The assertion has been made that, like chemical reactions, "scientific progress takes place most rapidly at the interfaces between scientific disciplines." The philosophy has also developed that research productivity can be enhanced and its practical utilization multiplied by engaging many groups of scientists to work on phases of coordinated projects. As a consequence of these trends, agencies charged with support of research are perhaps inclined to make grants on the basis of experimental design rather than in consideration of research talent. As forcefully stated by Richter, "In most instances all we know about a project is what we see written on a piece of paper—the application blank—words. We do not know the man, we may never even have heard of him... This means that in most instances we must vote the way we bet on horses at the races; because we like the name, the number, or the stable."

Paul Weiss has ably stated the reason why project research appeals to many investigators:

"The well-channeled roads of mass traffic are also the ways of least effort and resistance, offering the security that lies in numbers, and the comfort that comes with conformance. To travel them does not call for the vision and daring and fanatical devotion of the pioneer. Procedures are neatly mapped out, equipment ready-made, and tangible results are the more certainly assured, the more narrowly circumscribed the task... The risk is small, and the reward assured. And this, of course, appeals to those who crave security. Coincidentally, our prevailing system of research support by project grants plays into their hands and confirms them in their attitude."

If, as implied in the foregoing statements, emphasis on group and project researches is tending to discourage "rugged individualism" in research, it is desirable to re-emphasize the opinions of leaders in science that the greatest hope for extending its frontiers lies in continued encouragement and stimulation of the pioneering spirit in individuals:

"Many of the most important discoveries of scientific research have come from the intellectual adventures of individual scientists... Many scientific discoveries will continue to elude direction and organization as surely as would the creation of great music or poetry, or sculpture or art. Much of scientific research is exploration of the unknown, and I, for one, do not believe it is possible to direct the course of an explorer through unexplored territory." (Bronk)

"There is no substitute for human intelligence in science, so let us not act as if there were. If most of the riddles of life processes still lie obscure behind a closed door, let us not spend most of our efforts in ramming in that door by blind mass pressure, but rather let more people get busy with looking for the key or figuring out the combination of the lock." (P. Weiss)

"We seem to forget that in the past great discoveries have, with few exceptions, been made by individual workers, often working in great isolation; that some of the most important discoveries..."
have been made without any plan of research—largely by accident or in dreams... that there are researchers who do not work on a verbal plane, who cannot put into words what they are doing—whose thinking functions in terms of experiences, subconscious observations—who don’t know what they have been after until they actually arrive at their discoveries." (Richter)

That these generalizations also apply to circulation research is indicated in the Report of the Committee on Research Policies at the First Conference on Cardiovascular Diseases: “Untrammeled freedom of inquiry and conservation of individual initiative in the pursuit of knowledge are imperative. No agency should undertake to coordinate basic research, because any form of a restriction impoverishes fundamental studies and impedes the growth of knowledge.”

Writers who extol the advantages of individual or group research are, of course, aware that both are required for advancement in any province of science. The real question is not which is more important, but how well different objectives in research are kept in mind, how efficiently groups are organized, and how competently projects are attacked.

**The Field of Individual Research**

The aims and objectives of the lone investigator are determined by his ability and temperament. It is axiomatic that the investigator with superlative ability should be encouraged in every way to follow his inclinations in the pursuit of research. He should not be subjected to pressures which divert his interests, nor should he be given cause to worry periodically as to his future. Even if he belongs to A. V. Hill’s “freakiest category”—designated by Ostwald by the less derogatory term “romantic type”—a niche should be found for him where he would not offend society but would be protected from its adverse influence.

In the realm of circulation it should not be impossible to equal the basic contributions in methodology of Fick, Einthoven or O. Frank, or to match Hering’s discovery of the sinus buffer nerves. As a result of such basic work, advances in electrocardiography and hemodynamics are still being made. Unfortunately the number of gifted investigators who can aim at such high targets is relatively small; it would be foolish to bet too heavily on the chance that an adequate extension of knowledge can be realized through the efforts of these few. We must continue to depend largely on those who are able to shoot at lower targets. In general, foundations are laid by masters of science, but many a keystone has been added through recognition of the unexpected by gifted and enthusiastic amateurs, even though they lacked the professional skill to cement them firmly into the larger structure. Certainly, with training, many investigators with only average talent are capable of adding building stones to the wall of science. Independent investigators who occasionally become dissatisfied with their own achievements may well revitalize their faith by remembering that scientific progress has advanced quite as much by the addition of such building stones—or even the removal of those insecurely laid—as by the laying of an occasional keystone.

**The Field of Group Research**

It is the consensus among thinking investigators that group research has proven most valuable in the solution of problems that require application of existing knowledge to developmental projects or in acquisition of more data. The project system is adaptable to test or to elaborate existing theories and doctrines, but this is obviously a field for individual research as well. Coordinated effort has demonstrated its value in industrial research concerned with development and tests of new products; it has expedited the application of basic knowledge to many social and military problems. The harnessing of atomic energy is unquestionably the most outstanding example, and, indeed, has been largely responsible for the impetus for mass attacks on all sorts of problems.

Group research has proven equally productive in furthering diagnosis and treatment of disease. Thus we may be proud of our advances in surgical treatment of heart diseases, in selection of blood expanders, and in better diagnoses through cardiac catheterization. But
the researches concerned in this progress have consisted largely in collecting isolated facts, in screening therapeutic agents, or in developing surgical technics for achieving a practical end. They have contributed relatively little to our basic understanding of the circulation in health and disease.

It would, however, be an unfair assessment of scientific progress to say that no new pathways have been opened by team work, in the broadest sense of the term. As recently re-emphasized by Green,7 "Some of the greatest experimentalists of all times...thoroughly enjoyed working intimately with a band of colleagues and, in many cases, owed much of their success as experimentalists to the qualities that some of their colleagues possessed."

THE CONSTITUTION OF RESEARCH GROUPS

In expounding the virtues and faults of group research, the organization and competence of teams have received scant attention.

One type of organization considered ideal by advocates of group research is built around a full-time director who has both investigative and administrative experience. He virtually selects the team of experts in the disciplines required for the project which he has designed or which is assigned to the group. This plan is more common in industrial fields; it is still rare in cardiovascular research, but is bound to become more extensive as large bequests for such ventures become more numerous. A well-constituted group of this kind can promptly adapt new technical developments in cognate sciences to their problems. The data thus acquired through tricky apparatus are more apt to be reliable than if used in untrained hands. The benefit derived from critical suggestions of participants with different viewpoints during, rather than after, experiments is obvious.

Nevertheless, such an organization has defects in studies of the circulation. The director must be certain that formulations expressed in mathematical, statistical, physical, and chemical terms are applicable to corporal conditions. The best talent from various disciplines is not likely to be attracted. Individuals are expected to work together harmoniously in the interest of the project rather than for their own personal advantages. Emolument rather than innate research drive is apt to determine entry and continuance in such groups.

A second and more common type of research group is organized among individuals in a laboratory or hospital who, on account of other primary duties, can devote only a part of their time to investigation. The motive is admirable, but the type of organization realized varies tremendously. In the best, the principal investigator has had adequate training in the methodologies required for the project; he participates actively in the work and continually checks as well as encourages his assistants and technicians. Further, other department duties are so organized that every member of a team can give undivided attention to research for considerable spans of time. Unfortunately, however, this “best type” of organization cannot always be realized: The principal investigator may not have had experimental training and may hope to gain it during the course of actual participation. He may direct the group from his office. Investigations may be interspersed on an occasional morning or day between necessary routine duties. The team may contain so many adjunct experimenters who desire a taste of research that they cannot be properly supervised; they become a liability rather than an asset.

A third method for constituting research groups differs from the foregoing ones in that the team is not recruited by a research director or principal investigator, but the individuals select the chief under whom they wish to work. An investigator with previous experience is usually welcomed as the partner of a more mature investigator. His ideas as to strategy of experimentation are apt to be pertinent, and his discussions in the group are generally rewarding. An inexperienced person is assigned to a qualified investigator, essentially as an apprentice. Under proper
guidance he gains technical proficiency, but he
does not contribute essentially to the investiga-
tion. The fact that he is learning is accepted
as adequate reward; he expects no recognition
as co-author on any publication that may
result. If he displays aptitude and diligence he
shares more and more in the research partner-
ship. In this way workers in a team grow up
together and learn to coordinate their efforts.

The competence of individuals in such groups
continues to increase. Defects in their back-
ground become apparent, and steps are taken
to remedy them. Having reached the status of
established investigators they are generally
given the choice of selecting their own prob-
lems and of heading their own teams or of
joining other established investigators in a joint
problem. Additional associations are often
established with colleagues in cognate sciences
who are more competent and mature than any
experts that could be added to the team. It is
to such superlative teamwork of coequal in-
vestigators that Green’s comments seem to
pertain. Through such types of group research
difficult problems are solved; but, in addition,
individual competence is established and a new
crop of independent investigators is trained.
Should they assume independent posts, they
carry forward the traditions and precepts of
their former chief without necessarily concur-
ring in all of his doctrines and concepts.

Such a program can be advanced materially
by support of individuals at all levels in a re-
search career. Fortunately, various agencies
interested in cardiovascular research now make
it possible for any earnest person in an estab-
lished group to derive adequate support
throughout his career. For example, the Ameri-
ap Heart Association awards pre- and post-
doctorate fellowships ranging from $3500 to
$5000 for one- or two-year periods which enable
younger scientists to train for research careers
under experienced supervisors. If competent
and active, a young scientist can realize an
Established Investigatorship ranging from
$6000 to $9000 in six years.

The creation by affiliated local heart associ-
ations of corresponding fellowships and in-
vestigatorships which provide training and
continuance in research for worthy candidates
in their own areas, deserves earnest con-
sideration.

CARL J. WIGGERS

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