

ORGANIZATION AND COMMUNICATION OF SCIENTIFIC COMMUNICATION*

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When I last spoke before this society as retiring Past-President I discussed, among other things, the population explosion. Today I want to examine a closely related problem that casts its shadow over all of science, namely, the information explosion. Both the increase in population and the increase in information will make great difficulties in the future. In the case of population there is a limit in terms of means of subsistence. For information, there is an equally definite limit in the possibility of assimilation. To control the situation we don't want censorship of scientific publication any more than we want enforced family limitation. The way to adjustment in each case is, I believe, through self-discipline which is the responsibility of the individual.

Each scientist must make his own decision as to the most efficient division of his effort between intake of information from the scientific literature and the development of new information in his laboratory. Furthermore, it is too obvious to need further comment that some organization of the raw information is essential. Some may be done by writers of reviews and textbooks, but proper organization must begin with the original publication.

At the present rate of increase of scientific discovery, due to the proliferation of new laboratories and the training of new investigators, the scientific world will some day be saturated with information. This will occur when it becomes cheaper and quicker to go into the laboratory and do an experiment than to search the literature to determine whether it has been done before and if so to read and evaluate the details. Improved techniques of retrieval of information, already discussed by Maurice Visscher, will postpone this evil day, but in any case both the saturation and the techniques of retrieval of information are concerned with the hard, detailed facts. I want to distinguish between the retrieval of such information and the development and exchange of ideas.

Ideas must be based on facts. They represent syntheses of facts in the forms of models and hypotheses which generalize and, more or less successfully, predict. Such organization of knowledge is the ultimate object of our research. When we have a good model we believe that we understand. Actually I believe that the most effective form of interchange of scientific information in the future will be in this form of organized information; namely the idea or the model and not the detailed facts on which the ideas are based. However, effective communication will always require a clear distinction between the original facts of observation and the hypothesis or model into which they are incorporated.

The task of gathering specific scientific facts can be delegated to many

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workers and the facts can be published for all to read and be grouped by computers according to index codes. However, the tasks of arranging facts, and particularly of drawing inferences and developing ideas, go on in single human brains. One of the hard, inescapable facts of biology is that the content or capacity of each human brain for facts is definitely finite; and some of our brains seem to be rather more finite than others!

Each scientific investigator must impose practical limits on his input. He must limit his problems to some extent and not try to know everything about everything. All of us have been selecting our input for many years. Several times I myself have happily but incidentally avoided detailed reading of bulky literature by moving into a new area. I would then make friends with the other kindred spirits who moved in with me, exchange information and ideas and techniques with them as rapidly as possible, and let the rest of the literature go by or read it only in second- and third-hand distillations and elaborations. Specifically my areas have been axonology, electroencephalography, the electrophysiology of the ear, and now human cortical evoked potentials. But in each case the relief has been only temporary.

Personal correspondence, laboratory "progress reports", informal man-to-man discussions, visits to laboratories and, more recently, our selected and highly organized symposia are all important means of communication. They supplement the traditional "corridor conversations" of our society meetings. Discussions are the best stimuli for the arranging of one's ideas, for selecting among them and for "trying them for fit" with the ideas of colleagues. I suggest that getting together, whether formally or informally, in small, congenial groups to discuss particular problems or techniques, should be included in the rationing of time and the planning of activity of every creative scientist. Of course, if one lives and works in a major scientific center such contacts are easy to develop and little time is spent in travel. The danger, on the other hand, in a large center is a surfeit of symposia, leading to either a retreat into isolation or complete mental lethargy or to frenetic and repetitive perpetual motion.

Nevertheless, however valuable the discussions in the "in-groups" may be, they bring with them another danger to effective communication, the danger of an overspecialized laboratory slang. Such jargon may greatly facilitate the exchange of information and the development of ideas within the group which knows it, but it utterly obscures ideas and their significance for the outsiders whom we must also reach. Each group must take the trouble to translate its laboratory language into a broadly accepted scientific vocabulary. Scientific communication is hampered enough by existing language barriers without creating new ones! More than this, each author must write his sentences efficiently for rapid assimilation by readers who skim. He must also provide an effective abstract and he must write a title that will lead to correct indexing for ultimate retrieval.

Here are some of my final words of advice to young investigators, to department heads and to laboratory directors alike.

1) Welcome opportunities to talk and visit and exchange ideas with scientific colleagues. "Lone wolfing" is out of style and inefficient.

2) Explain your experiments and ideas to elementary students or to friends who are not working in the same specialty. When you can get your ideas across to such students or friends with little specialized background, you will find you have stripped away most of your laboratory jargon and are ready to talk to or write for any audience, whether it be the American Physiological Society or the Scientific Community in general.

3) Write in moderation but write efficiently. Don't feel you must publish a paper every year or perhaps every six months in order to keep pace with annual reports and grant renewal requests. Build your papers around ideas. Get criticism of your manuscript from competent colleagues who know something but not too much about your work. Your friends may be more helpful and more sympathetic than the referee editors of the journals!

4) Participate in symposia, (within reason). They are particularly useful for the development and exchange of ideas as opposed to detailed facts.

5) Do your share of writing reviews. Make your reviews selective and synthetic, not merely catalogues of titles like a stack of IBM cards.

6) If you ever have an opportunity to contribute to the Handbook of Physiology, drop everything else and give it your utmost efforts. The Handbook series, advancing in a gigantic spiral through time and across one area of physiology after another, represents our best and most helpful single effort toward organized and systematic communication from one specialty to another and from one generation to another. To write a chapter in the Handbook is to ensure a bit of immortality. It is also a great responsibility because inclusion or omission in the Handbook may determine the survival of many an idea or even the body of information from which it was fashioned.

Now, to summarize my summary, I say, "It is the duty of each of you to organize your facts into ideas and to package your output well and put good handles on it."