Information Service in Bioastronautics*

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The documentalist or information specialist is very much the philosopher. It is his task to bring some order into accumulating knowledge—he calls this cataloging or classifying—then arrange it in some systematic fashion—information storage—so as to provide the service of making the relevant knowledge available to those who must work with it—information retrieval. The documentalist does not produce the knowledge with which he traffics, but must deal with it as it is given to him.

He has recently been handed such a proliferation of knowledges as "space biology," "bioengineering," "biodynamics," "aerospace medicine," "bioastronautics," "biotechnology," and so on. For the present, at least, such labels are treated as being in quote marks, because this is how the initial attempts at identification pop out of the literature of what is recognized as recently expanded or developing areas of sceintific endeavor. And I wish to call attention, not only to the recency of the labels, but also to the comparative novelty of the conditions and situations in which the aerospace scientist and engineer works.

It may be a little soon to exercise the temerity of defining some of the labels; but, so that we may communicate with each other, let Bioastronautics be defined as "information on the reactions of living organisms during space flight." And let the scientist or engineer working in this area be referred to as "astrobiologist" (if only it could be "bioastronaut," but because of some already preempted connotations, may I use the former term).

As with most definitions—even when incorrect—the making of them gives some sense of boundary, neat exclusiveness, or comfortable pinning-down. However, to look at the proffered definition, not as a semantic exercise, but as a possible referent to what this Bioastronautics could actually encompass—a referent to what the astrobiologist might want from his information service—the biological organism appears to be limited to certain tolerances. What then can environmental biology contribute to knowledge or control of his reactions in the apparently novel environment of space travel? Biotechnology offers techniques for biological experimentation; many of these techniques and others to be developed in this area of endeavor are needed to affect, measure, or control living processes during space flight. Bioengineering knowledge is needed to provide the life support systems for aerospace flight. Psychology, both its knowledge and its techniques, can contribute to the understanding and control of the sentient and thinking organism maneuvering in space. Interest in aerospace medicine implies some concern with the well being of the space traveler. A welter of possible subject terms comes to mind: weightlessness, radiation, vacuum, sanitation, hygiene, selection, training, vasomotor constriction, enzymes, and so on. And thus I call attention to the eclectic breadth of information involved in understanding and controlling the "reactions of living organisms during space flight."

Recency, *novelty*, and *eclectisism* are certainly not new problems to an information service. But calling attention to these characteristics can remind us of the effects they have on the information service that can or should be provided. It is a truism that one applies in a new area, when possible, the experience gained in older and more established areas; and one can admire the sophistication of documentary philosophies and procedures which might be imposed in a new information service. But for an area so recent and eclectic as Bioastronautics, it is my contention that the type of information service offered should in large measure be adapted to these characteristics and to the working habits and needs of the astrobiologist. And further, the type of information service required under these circumstances is primarily for purposes of *projection* and *extrapolation* of the available information to the research and development requirements of the working scientist and engineer.

The unknown is indeed writ large in a new area of scientific endeavor. The information that can be made available to the working astrobiologist is less often able to answer specific questions or provide points of fact, but it is more useful to him in suggesting, implying, or guiding the direction his research and development might profitably take. Too often he is required to project the seemingly related known to the possibilities within an as yet unknown realm; the information available to him must be extrapolated beyond the situation in which that information was gathered. Now the working requirements are not all as wide eyed or Buck-Rogerish as popular enthusiasm might sometimes suggest. Though it may one day be feasible and advantageous to modify living processes for the purposes of space travel, it is not now anticipated that we wish to create what an aerospace medicine specialist referred to as "some weird homo-spaceans." Rather, what is now known of the living organism in his earth environment is expected to be valid to some degree at least under the conditions of space travel. What is significant here is that this degree—the implied extrapolation—must be tested by the astrobiologist.

What are the peculiarities of the bioastronautical literature and of an information system that is to serve the astrobiologist? We have all had enough experience

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with the "expanding literature," the pragmatic inquiry, and new frontiers to know what these peculiarities are. Some of them, however, are particularly relevant in the case of Bioastronautics.

There is felt to be a lack of theory or systematics. Think, for example, of what biology itself was like before, say, Darwin tackled "the storehouse of facts." Theoretical analysis is concerned with relationships; it seeks to order and arrange; it provides frameworks and models for comprehending what has been learned or for gaining new insights. The lack is not necessarily an indictment of Bioastronautics, it is rather an expected characteristic when the facts are still being gathered. To the documentalist, however, this can mean that there are no ready-made classification systems or that the systematics now available are merely evolving. For example, rather than imposing a thesaurus or subject heading authority, the documentalist may have to pick and choose for yet awhile.

Another characteristic of a somewhat bouncy, if not noisy, nature is the amount of polemic material in the literature—what someone in the present instance has called "the cereal box literature." I am using the word "polemic" here, not so much in the sense of disputation or controversy, but as sort of chewing on the available data, sort of literary extrapolation. Polemic does indeed serve the purposes of stimulating ideas, pointing up new meanings, exhorting, or warning. But it also raises for the documentalist the problem of the viability of more of the material in his collection and adds to a literature search material which might better have been left to the musings of the individual scientist being served.

In a new and eclectic area, old terms or previous research are very apt to acquire or require new meanings, significance, or application. For example, if I understand correctly, the term "organic chemistry" originally referred to compounds produced only by living organisms. As you know, several of these compounds have now been synthesized (which to me is a staid and humble substitute for saying "created"); so what does the term "organic chemistry" mean now? Or, what is the current significance to space travel of the research during early balloon flights or mountain climbing expeditions? Or, in the psychobiology of visual acuity, what was originally an interest in subthresholds or limens—and so termed in any respectable authority list—popped up some decades later as the now jaded fad of "subliminal perception." Not a few information services have been castigated or computers kicked for not retrieving the new wine in the old bottles.

Astrobiologists have reported that it is not only desirable, but almost mandatory to exchange scientific information on an international basis. The sometimes earlier starts and the progress in Bioastronautics made in other countries are the reasons given for this need. But we should remind ourselves that exchange efforts should be directed to acquiring fresh information from properly designed research. The good services of the International Astronautical Federation in arranging for exchanges come to mind here.

• Astrobiologists sometimes speak of "experiments of opportunity": a biological experiment setup as a sort of "rider" in a vehicle flying for other reasons, as opposed to an actual orbiting biological laboratory. Such conditions may prevent the biological endeavor from being as rewarding as it might be. This, in turn, is apt to limit the definitiveness or cleanness of the information that can be provided by an information service. However, the National Aeronautics and Space Administration has recently initiated a Biosatellite Program, the first phases of which are to develop design criteria for a biosatellite.

According to any of the current academic delimitations of disciplines or science departments, an information service in Bioastronautics is decidedly mission-oriented, or project-oriented, or whatever term you prefer to distinguish servicing multidisciplinary research with given missions or objectives from the more traditional servicing of a field of science—for example, *Prevention of Deterioration Abstracts vs. Chemical Abstracts* or *Tobacco Abstracts vs. Biological Abstracts*. The mission-oriented information service is more apt to serve the individual scientist or engineer, rather than the multiple access unit. The needs of the user are more often pragmatically determined by the requirements of his project, rather than his professional field. The viability of the materials in the collection is apt to be of greater concern. The collections, procedures, and format are more affected by new projects, expanding areas, or change in direction of research. In a very real sense the mission-oriented information service is justified by the job it does. And this job is essentially to provide a specialized service geared to the project needs of the users. It does not necessarily follow, however, that there be fragmentation or proliferation of effort; the overlaps of coverage and the comparability of processing makes even more attractive cooperation with the discipline-oriented services.

If these, and others like them, be valid characteristics of an information service in so recent and eclectic an area as Bioastronautics, who is to make the projections and the extrapolations? For much the same reasons that the President's Science Advisory Committee in its recent report *Science, Government, and Information* recommends that technical information activities of an agency be part of research and development (not administration), it is the working astrobiologist who can best extract from the relevant information what he needs. And this in turn argues for making every effort to provide timely tools for current awareness, convenient and efficient means for the astrobiologist to identify for himself the literature relevant to his immediate purposes, and local access to the literature he has identified.

This is what NASA's Office of Scientific and Technical Information tries to do.

All of the scientific and technical reports prepared by the several laboratories and research centers in the NASA complex are, of course, accessioned into the information system. By agreements, exchange arrangements, and automatic distribution lists, reports of other agencies are acquired, including those from government agencies, universities, industry, and independent research organizations both in the United States and abroad. By cooperative arrangement with the American Institute of Aeronautics and Astronautics, the periodical and book literature is covered by AIAA's technical information service.

The report literature (unpublished in a "classical" sense) is announced, abstracted, and indexed in NASA's *Scientific and Technical Aerospace Reports*—appropriately known as *STAR*. The periodical published literature is covered in AIAA's *International Aerospace Abstracts*. Both *STAR* and *IAA* are issued semimonthly on alternate weeks. Each issue is arranged in two major sections: the first presents informative abstracts; the second includes the subject, corporate source, author, and report number indexes. In addition to the indexes in each semimonthly issue, cumulative indexes are distributed which integrate and cumulate the indexes quarterly, semiannually, and annually. Both *STAR* and *IAA* follow the same format, the same abstracting and indexing techniques, and the same indexing terms to provide the individual user with compatible bench tools.

In addition to these two compatible services, NASA also assists in the support of the Aerospace Medicine Bibliography Project at the Library of Congress, the publication of abstracts in the *Journal of Aerospace Medicine*, and the relevant abstracts in *Meteorological and Geoastrophysical Abstracts*. The interest here is in complementing or supplementing the aerospace coverage with abstracting and indexing in depth by experts in the subject matter field itself—the "identifiable area" approach.

Prior to each issuance of *STAR*, the NASA system provides for automatic distribution of the reports covered in the journal to local centers where they can be available to the individual user as he identifies them in the announcement journal. The distribution is either in macroform (that is, full-sized printed copies) for reports published by NASA, and in microform for NASA and non-NASA reports covered, except those subject to reproduction limitations.

The next step is the forthcoming implementation and evaluation within the NASA complex of a system for selectively disseminating report literature. This involves the matching of profiles of user needs and interests with profiles of report content. Such a system does not presume to "prepackage" what information it will provide, it does not attempt to impose a classification or indexing system beyond what is needed by the information service to retrieve the documents in its collections, and it is primarily determined by the characteristics of the user.

Certainly much of what has been described in this paper is not unique. What is regarded as significant, however, is that the whole system is deliberately geared to current awareness and local access by the individual scientist and engineer. The emphasis is on helping the individual user to identify what is relevant to him so that he may project and extrapolate as befits the subject matter expert.

And this is appropriate to servicing such an area as Bioastronautics. An information service must gear itself to the characteristics of the area to be served lest it find itself in the same relation to its users as science fiction has to the products of sober research.

Searching X-Ray Diffraction Powder Data with an Inverted Coordinate Index*

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The X-ray diffraction powder method of identification of solid substances has been described as a fingerprint method in that each substance in the solid state gives a unique pattern. As with the fingerprint method of identification, it depends on matching the pattern of the unknown with established data. This use of the powder diffraction pattern was clearly envisaged by Hull, who in the *Journal of the American Chemical Society* for the year 1919[10] described this use of the pattern with examples of how it could be employed. However, the method was not applied for lack of data which was in part due to the lack of hardware to record the patterns conveniently. It took almost 20 years to overcome these hurdles. The method took on practical importance with the publication by Hanawalt and Rinn[9] of the Dow Chemical Company in 1936. These authors realized that application of the method was dependent on setting up a convenient method for searching data. They described a ledger type of index in which data was entered as it accumulated. Their publication[8] in 1938 of diffraction data on 1000 substances initiated the use of the method on a practical basis.

These data have grown under the sponsorship of a Joint Committee of The American Society for Testing Materials, the American Crystallographic Society, and the British Institute of Physics so that now over 10,000 substances have been recorded, and the file is growing at the rate of about a thousand patterns a year. Cooperative schemes, which are sponsored by the Joint Committee, for collecting and producing data are in operation in several countries. The method found most ready acceptance by mineralogists and metallurgists to whom crystallography was a basic subject, and it has been extended to wide coverage of inorganic chemicals and the more common organic substances, which now number about 5000.

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