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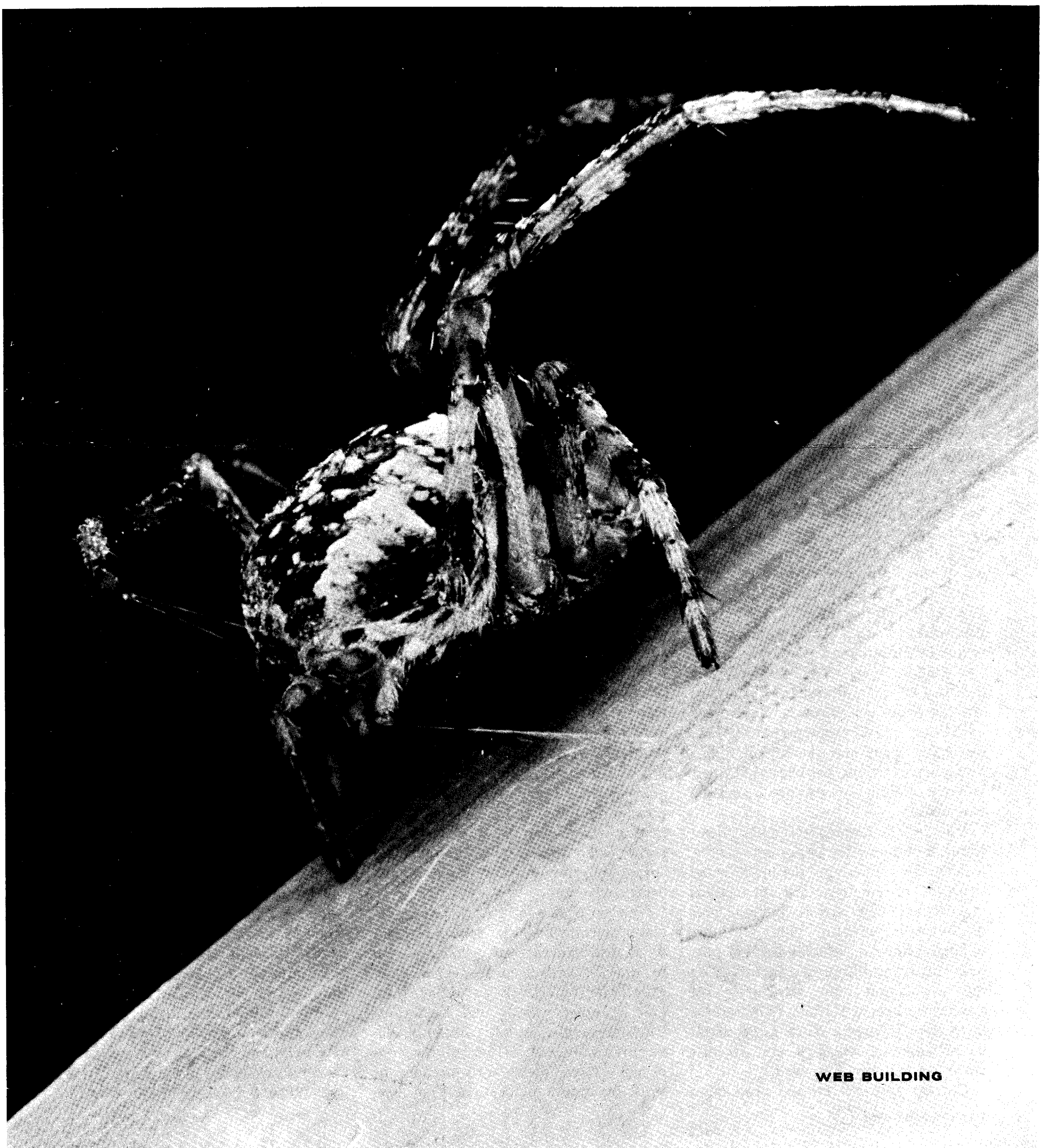


WEB BUILDING

Haskins Laboratories: Research on Human Communication, Marine Ecology, and the Biochemistry of Protozoa

Members of the staff will discuss and show the work at the Haskins Laboratories on 29 December 1967. See Science, *22 September 1967, for details about registration for the tour.*

The advantages of research by interdisciplinary teams are now well known, and there is general awareness of the significant role that the uncommitted investigator can play in opening up new research areas. These ideas were less familiar in the mid-1930's when Haskins Laboratories began as a small group interested in problems that did not fit into conventional categories. The experience at Haskins suggests that this is indeed a good way to do basic research—one that works best when groups remain small, are free to explore new problems, and have some flexible funds available on a long-term basis to overcome the insecurities of grants and contracts. For some of the programs in their uncertain beginnings, aid of this kind was provided by funds from the Carnegie Corporation of New York and the Rockefeller Foundation and, for the continuation of research by Haskins in all areas, by steadfast support from private sources. The diversity of current research programs is a consequence of operating on the basis that good problems are where one finds them and that small, interdisciplinary groups can best use their inherent mobility to explore promising new areas.

Human communication takes many forms, but the most important, surely, is language. Underlying the hierarchical structure of language are the sounds of speech. These are an integral part of linguistic structure and serve as uniquely efficient vehicles for the purpose of transmitting it. By studying the production and perception of speech, workers at Haskins Laboratories have been trying to learn more about its relation to language and to discover why it works so well.

Current research on the production of speech is aimed at finding relations between distinctive aspects of the articulation and the linguistic units of the speaker's message. In the stages between intended speech gesture and emergent sound there is much restructuring of the message so that the stream of speech sounds no longer correspond in any simple way to the original sequence of linguistic units. Nevertheless, a fairly close correspondence might be found nearer the message source, perhaps at the level of the neural signals and muscle contractions involved in articulation. The experimental procedure for testing this assumption is to record electromyographic signals from the muscles of lips, tongue, and palate while a person is speaking; then to look for patterns of muscle activity that correspond to the units of the message. Other measures are also used—cavity shapes from x-ray movies, air pressures within the mouth, gross adjustment of the larynx (by transillumination), vibration of the cords, and of course the sounds emitted from nose and mouth. The data, recorded on multichannel tape, are scrutinized for gross errors, then measured, compiled, and displayed by computer. It has been possible in this way to get basic information about normal speech, and to make comparisons with the aberrant speech due to cleft palate, aphasia, and deafness.

The perception of speech poses special problems. Since the acoustic stream is a restructured—or encoded—form of the speaker's message, one might expect its perception to differ from that of other sounds and even, perhaps, to require its own decoding device. This, indeed, is one of the conclusions from nearly two decades of work on speech perception. The characteristics of the speech decoder are being studied by presenting competing messages to the two ears. The right ear has the better path to the speech centers, normally located in the left cerebral hemisphere in right-handed people. Hence, when two syllables such as *cat* and *bat* are put into the right and left ears, respectively, the listener will most often hear *cat*. Not so with melodies or radar signals, which are reported to show a left-ear advantage, that is, tend to be processed by the right side of the brain. Because these laterality experiments relate so directly to the operations of the decoding mechanism, this aspect of speech is being studied quite intensively.

Another approach to perception is isolation of the acoustic cues that carry the information in speech. The experiments make use of sound spectrograms, and of synthetic speech generated from patterns based on them. By modifying and simplifying the patterns it has been possible to find out what aspects of the pattern—what acoustic cues—must remain for the patterns to be heard as speech. Initially, these patterns were painted by hand and converted to sound on a pattern playback. Now, computer methods are being used to generate the patterns from which speech is then synthesized, and also to modify the patterns (and, of course, the speech) for various experimental purposes.

The inverse of this method can also be used in studying speech perception. Knowledge of the cues can be used to formulate rules for constructing the patterns directly from a written message. Again, the computer is most useful in applying these "rules for synthesis" and thereby controlling a speech synthesizer. A long-term objective, in addition to that of learning about the nature of speech, is the use of synthesis-by-rule, and other methods of generating speech from written text to make ordinary books available to the blind in spoken form. This work, however, is still at the trial and development stage.

The special status of speech sounds —due, we think, to a dependence on encoding in speech production and a related decoding in perception—must pose unusual problems to the young child. All of his world is strange, and we might suppose that the speech process would be strangest of all. Yet normal children learn to use speech at an early age and without formal training. What they learn while they are learning to speak, and how and when, are questions under study collaboratively with colleagues at the Neurocommunications Laboratory of Johns Hopkins Medical School. Sometime between the ages of 1 and 2, children acquire a temporal coordination of gestures at larynx and lips (or tongue) that adults use to distinguish voiced from voiceless sounds, for example, *bat* from *pat*, not only in English but in most other languages as well. The child's performance can be assessed from spectrograms, which are used to find out just how and when he learns this motor skill. A related question is how and when he learns to hear the subtle differences between voiced and voiceless sounds.

Study of the speech process is interesting in its own right. It is, moreover, a route to practical applications, not only in the engineering of devices for speech recognition, bandwidth compression, and prosthetic aids to the blind or deaf, but also to the more common problems that arise in connection with the use of language by normal and handicapped people.

The research on speech has necessarily been interdisciplinary, requiring close working cooperation among linguists, experimental psychologists, and engineers. The team is headed by F. S. Cooper and A. M. Liberman (University of Connecticut). Many of the senior staff have primary attachments to the teaching staffs of nearby universities, but do their research at Haskins Laboratories. The group includes also postdoctoral fellows, doctoral candidates, and skilled technical assistants.

Marine ecology, especially the nutrition of small marine organisms, is the central interest of Luigi Provasoli and co-workers. The approach used to clarify relationships between the organism and its environment, and between associated organisms, is to define their nutritional requirements by using axenic cultures and synthetic media. Studies in vitro are necessary to control the variables; aseptic conditions and artificial media are essential in determining the need for growth factors produced by other organisms and present in the environment in quantities too small to be detected chemically.

An early phase of this research dealt with the design of artificial media, methods of purification, and studies of the growth requirements of the unicellular marine algae, which are the primary producers and the food of most

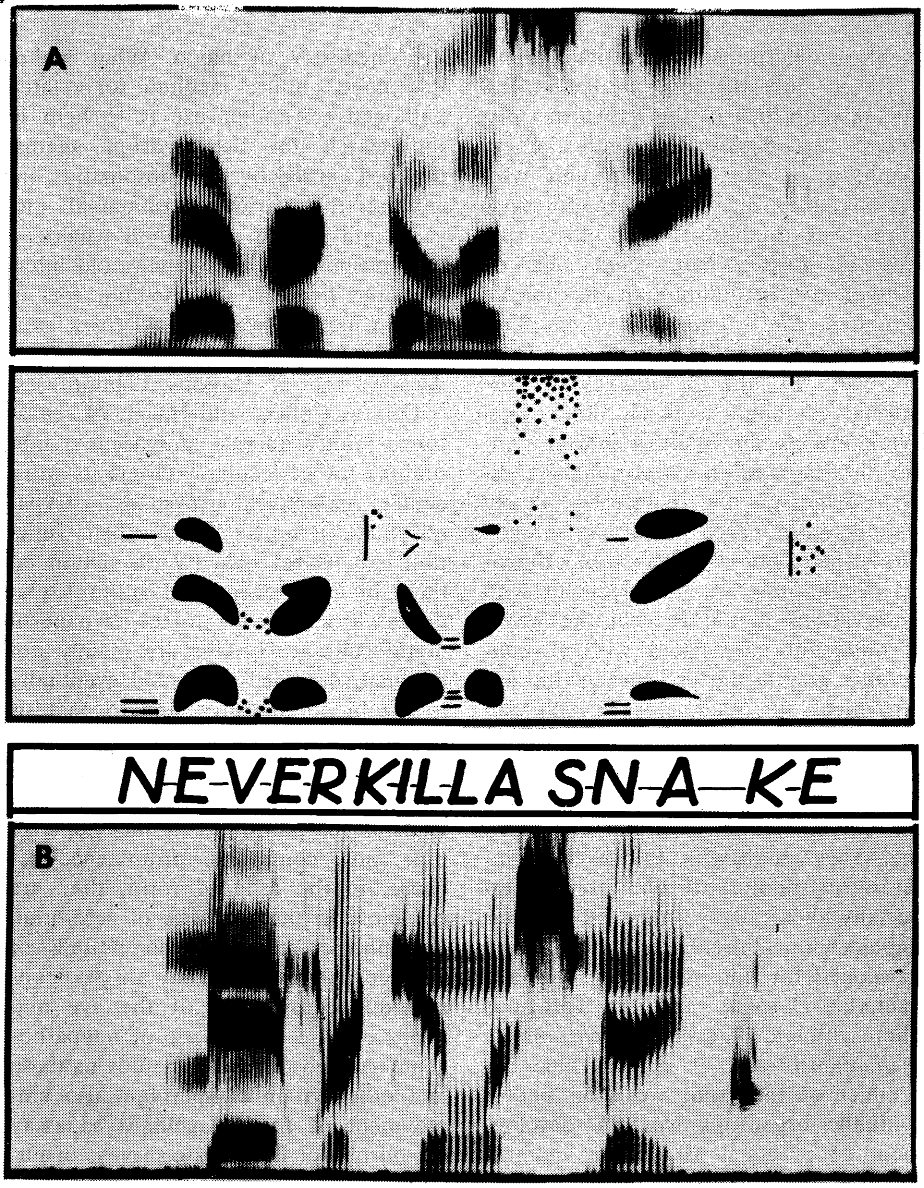
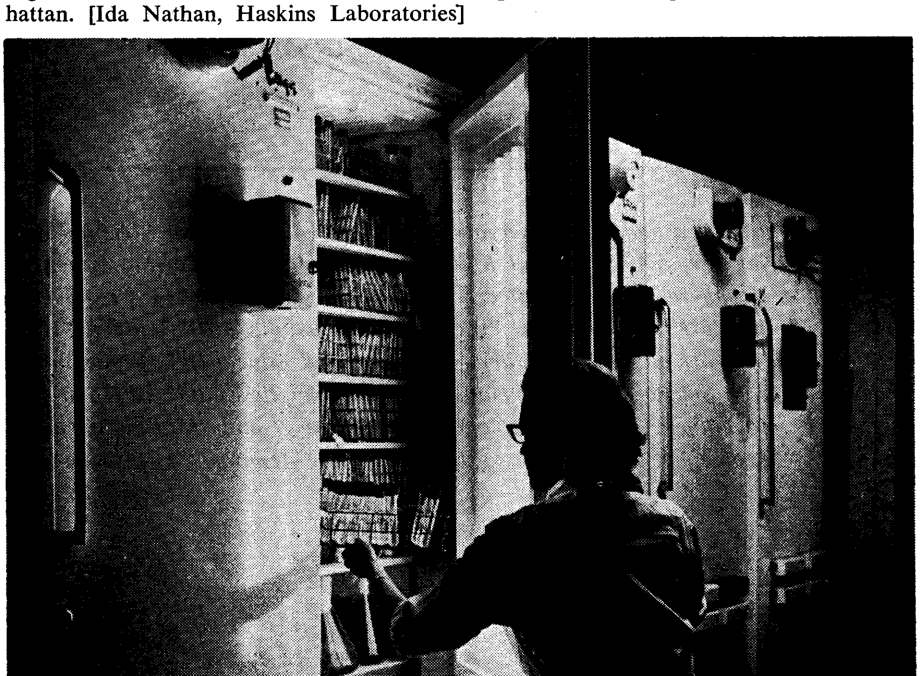


Fig. 1. (A) "Visible speech" patterns made by a sound spectrograph from a spoken utterance and the simplified patterns, hand painted from the spectrogram, that can generate the same speech synthetically. (B) Representation of computer input and output. The written text guides computation and synthesis of the spoken message, represented by its spectrogram. [Haskins Laboratories]

Fig. 2. Homemade marine environment, complete with sunlight, in midtown Manhattan. [Ida Nathan, Haskins Laboratories]



herbivorous invertebrates. It was found that many algae, though photoautotrophic, require vitamins (notably B_{12}), thiamine, and biotin. Patterns of vitamin requirements which seem to characterize each major algal group are now discernible. These specializations, along with other unknown algal idiosyncrasies, may indeed determine the algal succession and blooms which are a striking feature of natural habitats.

Related work is in progress with the seaweeds. Photoperiodism governs the life cycle of *Porphyra tenera*, a common Japanese staple. Thus, by artificially varying the length of the day it is possible to shorten a yearly cycle to 4 months. Sea lettuce *Ulva* and its relative, *Monostroma*, also used as food in Japan, lose their normal morphology when cultured aseptically in artificial media. They revert to filamentous or unicellular growth. Normal morphology of *Monostroma* is restored by substances which are produced by certain marine bacteria and by the several red and brown seaweeds that normally grow in the same environment—a striking example of interrelations. The active substance is a fraction that reacts as a "tannin," but higher plant tannins are inactive. Several derivatives of benzoic and cinnamic acids temporarily restore the normal morphology of sea lettuce; but algal tannins are without effect on *Ulva*, or phenolics on *Monostroma*. Clarification has to wait on advances in the chemistry and biosynthesis of the algal tannins.

The nutritional relations between unicellular algae and some of the filter-feeding crustacea (brine shrimps and *Daphnia*) are being investigated under aseptic conditions. Particularly interesting are the results concerning the differences in nutritional value of various algae and the nutritional requirements as determined with artificial diets.

Recent investigations on the symbiotic relationships of the flatworm *Convoluta roscoffensis* deal with the resynthesis of the symbiotic unit with various green algae. A successful symbiosis was established with three species of *Prasinocladus* and one of *Platymonas*, in addition to the normal symbiont, *Platymonas convolutae*. This apparent lack of specificity is offset, however, by the prepotency of the normal symbiont over all other algal symbionts as shown by a shorter reinfection time and an extraordinary ability to dispossess and replace completely a competitor, even if it has already established symbiosis. These experimental peculiarities are in agreement with observations in nature that the worm is uniformily associated with *P. convolutae* despite the presence in the environment of other algae which can establish a successful symbiosis.

Biochemistry of microorganisms is the primary research area in which S. H. Hutner and his group are working. They share with Provasoli an interest in photosynthetic protists, especially those likely to be of continuing biochemical use. Defined media were developed for nonsulfur photosynthetic bacteria, *Euglena*, and the voracious photosynthetic flagellates *Ochromonas malhamensis* and *O. danica*. One byproduct of this joint work on photosynthetic organisms was the development of practical assays for vitamins (notably B_{12} in material ranging from natural waters to industrial fermentation broths and to blood.

At present, Hutner and his group are trying to improve methods for using trypanosomatid flagellates and the ciliate *Tetrahymena* as biochemical and chemotherapeutic research tools. Such media offer a unique way to explore the chemistry of blood. What makes it a good culture medium for related pathogens? Another use is to help in the search for better drugs against diseases caused by trypanosomatids, including the various leishmanial diseases and African and South American trypanosomiasis. This renews old interests: the first defined medium for an animal parasite was devised for a nonpathogenic trypanosomatid some two decades ago at Haskins Laboratories.

Queens College and Haskins Laboratories jointly operate at Queens a laboratory for molecular biology; its work centers on subcellular systems in trypanosomatids, especially as their function can be revealed by the action on them of carcinogens and antiprotozoal drugs. Studies with intact trypanosomatid cells at Haskins are mainly nutritional, designed to extend eventually to the blood parasites, and to analysis of drug resistance and its enzymatic basis. Some of the nonpathogenic trypanosomatids are unique assay organisms for pteridines of the biopterin type, now come into prominence because, in the reduced form, they are cofactors in the synthesis of serotonin, epinephrine, and other compounds of neurological interest. They are also conspicuous constituents of the eye pigments of insects. The use of nonpathogenic trypanosomatids for studying these and other vitamins—perhaps also employment of these flagellates as assay organisms for large-scale surveys of nutritional status among school children —is being explored in cooperation with H. Baker and O. Frank of the New Jersey College of Medicine and Dentistry.

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See Science, *22 September 1967, for details about registration and hotel reservations for the AAAS Annual Meeting. Additional reports on events or symposia taking place during the AAAS Annual Meeting appear in the following issues of* Science: *22 September, "Evolution of the Earth's Atmosphere"; 29 September, "Terrestrial Adaptation in Crustacea"; 6 October, "Behavioral Research—New York Zoological Park"; 13 October, "Weather Modification"; 20 October, "Hazards of Iodine-131 Fallout in Utah"; 27 October, "New York Botanical Garden—Research and Education"; 3 November, "New York Aquarium and Osborn Laboratories of Marine Sciences"; 10 November, "Psychoanalytic Studies in Child Development" and "Adhesion in Biological Systems"; 17 November, "Lamont Geological Observatory" and "Marine Science"; and 24 November, "Crime, Science and Technology," "Molecular Approaches to Learning and Memory," and "Man and Transportation.*