(F0Ib) shows absorption lines of Mg I, Mg II, Si I, Fe I, and Fe II below the earth's atmospheric cutoff, while in Sirius (A1V) the main feature is the Mg II resonance doublet. On 20 September 1966 Jenkins and Morton (*19*) flew an all-reflective *f*/2 spectrograph on an Aerobee rocket, and obtained spectra of eight stars in Orion with about 1-Å resolution. These photographs confirmed the earlier results of the wavelength shifts in the C IV and Si IV absorption lines and the unexpectedly weak interstellar Lyman-α lines. The wavelength range was extended to 1130 Å and revealed absorption lines of N V, Si III, and C III also shifted to shorter wavelengths in δ, ϵ, and ζ Orionis. During four Aerobee flights Stecher (*20*) has scanned the spectra of at least ten hot stars with 5- and 10-Å resolution longward of 1100 Å. He also has found the C IV and Si IV resonance lines to be in emission with absorption components to shorter wavelengths in some of the stars. On an Aerobee launched on 16 March 1967 Carruthers (*21*) used a windowless image intensifier to photograph spectra of some 12 stars from 1030 to 1400 Å with 2- to 3-Å resolution. He confirmed the shifts of some of these lines in ζ Orionis and found the same phenomenon in ζ Puppis, γ Velae, and ι and κ Orionis. Both the spectral data and photon counters lead him to suggest that the photon flux decreases shortward of 1150 Å even in the hottest stars.

Summary

According to theories of model stellar atmospheres only stars of spectral types from O to about B3 may be expected to be bright in the ultraviolet-wavelength region. Observations of the strong resonance lines between 911.6 and 1900 Å will yield new information permitting construction of better models for the outermost layers of OB stars. However, an adequate theory of line-formation, including non-l.t.e. effects, should be used if an accurate physical representation is to result. Already it has been demonstrated beyond doubt that O and B0 supergiants are surrounded by expanding atmospheres.

The spectrum between 1900 and 3000 Å is formed chiefly in the same layers of the star as is the part of the spectrum observed with ground-based equipment; consequently, ground-based observations can be used to establish an adequate model. With such a model, observations of the absorption lines due to the first and second ions of the metals should permit new and reliable determinations of the abundances of Fe, Cr, Mn, and Ti in B stars.

The photometric and the spectral observations so far available of O and B stars do not generally conflict seriously with the predictions of theory, provided that we use line-blanketed models for the comparison and that we correct for the effects of interstellar reddening when necessary.

References and Notes

1. A. B. Underhill, *Publ. Dominion Astrophys. Obs. Victoria, B.C.* **11** 433, 467 (1962).
2. The flux F_λ per unit wavelength, which is more relevant to observational procedures, is cFv/λ^2; F_λ in the ultraviolet probably exceeds that in the visible for types even later than B4.
3. D. M. Mihalas and D. C. Morton, *Astrophys. J.* **142**, 253 (1965); C. Guillaume, *Bull. Astron. Inst. Neth.* **18**, 175 (1966). In the first paper the detailed shape of the strong ultraviolet-absorption lines is taken into account; in the second, the line profiles are represented by rectangles.
4. D. C. Morton, *Astrophys. J.* **139**, 1383 (1964); **141**, 73 (1965).
5. C. Guillaume, W. van Rensbergen, A. B. Underhill, *Bull. Astron. Inst. Neth.* **18**, 106 (1965); C. Guillaume, *ibid.*, p. 175 (1966).
6. E. W. Elst, *ibid.* **19**, 90 (1966).
7. E. T. Byram, T. A. Chubb, H. Friedman, J. E. Kupperian, *Astron. J.* **62**, 9 (1957); J. E. Kupperian, A. E. Boggess, J. E. Milligan, *Astrophys. J.* **128**, 453 (1958); E. T. Byram, T. A. Chubb, H. Friedman, *ibid.* **139**, 1135 (1964).
8. T. A. Chubb and E. T. Byram, *Astrophys. J.* **138**, 617 (1963); E. T. Byram, T. A. Chubb, M. W. Werner, *Ann. Astrophys.* **28**, 594 (1965).
9. A. M. Smith, *Astrophys. J.* **147**, 158 (1967).
10. J. D. Alexander, P. J. Bowen, M. J. Gross, D. W. O. Heddle, *Proc. Roy. Soc. Ser. A* **279**, 510 (1964).
11. I. S. Gulledge and D. M. Packer, *Astron. J.* **68**, 537 (1963); personal communication.
12. A. E. Boggess, *Ann. Astrophys.* **27**, 805 (1964); A. E. Boggess and J. Borgman, *Astrophys. J.* **140**, 1636 (1964).
13. R. D. Bless, A. D. Code, T. E. Houck, J. F. McNall, D. J. Taylor, *Astron. J.* **70**, 667 (1965).
14. T. P. Stecher and J. E. Milligan, *Astrophys. J.* **136**, 1 (1962); T. P. Stecher, *Astron. J.* **70**, 643 (1965); *Astrophys. J.* **142**, 1683 (1965).
15. D. C. Morton and L. Spitzer, *Astrophys. J.* **144**, 1 (1966); D. C. Morton, *ibid.* **147**, 1017 (1967).
16. M. E. Stone and D. C. Morton, *ibid.* **149**, 29 (1967).
17. R. Wilson, *Publ. Roy. Obs. Edinburgh* **2**, 61 (1958).
18. K. G. Henize, L. R. Wackerling, F. G. O'Callaghan, *Science* **155**, 1407 (1967).
19. E. B. Jenkins and D. C. Morton, *Sky and Telescope* **33**, 162 (1967); *Nature* **215**, 1257 (1967).
20. T. P. Stecher, paper presented at Yerkes meeting of Amer. Astron. Soc., 1967.
21. G. R. Carruthers, *Astrophys. J.* **148**, L141 (1967); *ibid.*, in press.

Causality, Consciousness, and Cerebral Organization

Walter R. Hess

Psychology has been largely, if not exclusively, regarded as being in the domain of philosophy, and, until recently, reference to the brain as the substrate of psychological function was infrequent. It should be admitted that regional differences of approach exist; for example, in the United States psychological concepts are influenced more by the natural sciences than they are in tradition-bound Europe. The works of Herrick (*1*), Lashley (*2*), and Hebb (*3*), the publications of the experimentally oriented Canadian neurosurgeon Wilder Penfield (*4*), and more recent noteworthy works of Klüver (*5*), Ploog (*6*), Delgado (*7*), MacLean (*8*), and others are significant in this connection. On the other hand, it is surprising that the physiologists show some reluctance to teach psychological concepts. More than a minimum knowledge of the relationship between brain and psychological function is essential for students in biology and medicine, both because this function plays a role in the biology of men and the other higher mammals and because such knowledge is necessary for an understanding of mental illness. For all these reasons, an effort to survey psychological problems in biological perspective seems justified.

If a series of events relating to our past experience comes to our attention, we feel compelled to look for a causal

The author is professor emeritus of physiology, University of Zürich, Zürich, Switzerland.

link. In other words, it seems that an innate tendency to integrate simultaneous and successively induced perceptions leads us to an awareness of a causal relationship. The achievement of insight into cause and effect brings a feeling of satisfaction and relieves psychic tension. A simple example may illustrate this psychophysiological assertion. From my desk I see on the horizon a dark bank of clouds coming nearer and nearer. Suddenly lightning from the cloud strikes the earth. A little later I hear the thunder. Momentarily ignoring earlier experiences of this nature, I am confronted with a visual, followed by an auditory, experience. The two phenomena manifest themselves independently of one another. Continuing to watch, out of curiosity, I see after some time another flash of lightning and hear again, later, a clap of thunder. Repetitions of these essentially identical sensory experiences lead inescapably to the interpretation that the optical and the subsequent acoustical phenomena are somehow related.

With increasing frequency of repetition analogous successions are established as associative links, so that the conjecture of a causal relationship ultimately assumes the character of a certainty. Strictly speaking, no certainty exists but, at best, a high degree of probability. In everyday life one is, to be sure, surprisingly ready to assume a causal relationship. Obviously such a "short circuit" ordinarily suffices as a basis for adaptive behavior. In the case of a scientific investigation, one requires a higher number of identical successions before being ready to accept the intuitively conceived causal relationship as an established reality. Even then, in the area of biology at least, the causal relationship remains basically conjectural as long as the number of repetitions is not infinite. Nevertheless, we have to admit that, even in the pursuit of scientific interest, the number of repetitions required before the impression of pure coincidence is eliminated is relatively soon reached. After all, the willingness to think *post hoc, propter hoc* depends to a considerable degree on the personality of the observer. Irrespective of the number of repetitions, the persuasive power of the repetitions depends on conditional factors. There are men, for example, with a strong inclination to associate a comparatively short series of successive similar data with one another in the sense of a causal relationship. On the other hand, one knows laymen and researchers of outspoken skepticism who will not integrate successive similar data into an inferred causal chain even when the probability of an accidental succession is low. In the tendency to integrate or not to integrate, the individual's temperament, his previous experiences, his physical health, and his biological constitution play a not unimportant role. When the probable causal relationship offers a reward, he may be more likely to accept it. Further, mental age is a factor —as is seen, for example, when the child experiences a fairy tale as reality. The young, still inexperienced observer instinctively attempts to find a causal relationship, while the mature person is critical and does not exclude accidental succession so quickly. In the end, none of these arguments alters the fact that reality provides no objective criteria for arriving at a construct of causal relationships.

The Physiological Basis of Consciousness

The waking human being or higher animal has a large number of sense organs for making contact with the internal and external environment. The sensory cells function as receptors of organ-specific stimuli. Light flashes, for example, stimulate the rods and cones of the retina of the eye. Thereby the order of optic phenomena generated by the visual system is transformed into patterns of excitation of the visual pathways whose morphological organization is relatively well known (*9*)—for example, the projection of circumscribed retinal areas to corresponding elements of the visual areas in the occipital lobes of the brain. Far less advanced is exploration of the functional laws of the living brain. Actually, research in this sector of physiology is only now in process of development. The school of Jung (*10*) and the team of Hubel and Wiesel (*11*) have made significant contributions, particularly with respect to visual perception. Basic information is derived from observations concerning electrical stimulation of the visual cortex in man (*4*). Patients subjected to such stimulation in an effort to localize pathological foci in that area reported visual phenomena arising with the onset of stimulation. The sense of hearing was similarly involved when the stimulating electrode was applied to a certain region of the temporal lobe. Further, it has been experimentally established that the visual and auditory sensations experienced are associated with one another in the sense of a "causal" connection on the basis of temporal coincidence or spatial contiguity. In such cases consistent relationships between brain stimulation and subjective sensations (*4*) are as evident as those existing between natural stimuli and a determined flow of consciousness.

Findings such as the foregoing raise the question, How may the "causal" relationship between excitatory patterns of the nervous system and the development of conscious perceptions come about? Before we pose this problem, we must acknowledge that it is not now possible, and may not be possible in the future, to obtain such information. The subjective experience may be a direct expression of the condition of excitation of those centers which receive and integrate the sensory signals. In this case it would be only another aspect of the same process which one can objectify in the form of evoked potentials. An alternative explanation would be that of transmission of the integrated excitation pattern to a *specific system* whose principal activity is one of implementing release of the contents of consciousness. However, no criteria which would allow us to define such a process of transmission are, as yet, known. For the entire process which leads from the sensory stimulation pattern to the content of consciousness results exclusively in the mediating of relevant information. The process of transmission itself lies in an area into which we have no insight. Obviously reference to a reflex mechanism leads no further, so that physiology must give up the attempt to submit a comprehensive explanation. This is not to deny that there is a correlation between patterns of neural excitation and the release of corresponding contents of consciousness.

This situation is not unlike that existing with respect to verbal communication. The listener is unaware of the pressure changes acting upon his eardrum, and he does not perceive their transmission upon the sensory surface within the organ of Corti. Nor is he aware of the nervous impulses which are sent from the organ of Corti to the auditory centers of the brain.

Yet he can understand the meaning of a spoken message. This achievement is based upon associations which were developed between sensory stimulation and central patterns of nerve excitation at an early stage in the learning process. Whenever similar patterns of verbal stimuli are presented, the old memories and the corresponding contents of consciousness become reactivated and comprehended. Thus, there is no trace of a causal evolution of understanding of verbal stimuli by way of an uninterrupted chain of conscious correlates of the sensory mechanisms. Instead, central patterns of excitation are elicited as though by resonance when specific sensory messages arrive. However logical this may sound it does not explain the process of transformation itself, which seems to be a separate biological faculty. No road to its understanding seems open at present.

Subjective Experience and Neural Events

It has been known for a long time that light surface elements in the neighborhood of a dark field appear lighter than elements that lie away from the light-dark border. This difference in brightness is felt explicitly although objective checking shows that all the light fields are identical in tone. Therefore, until a short while ago the so-called simultaneous contrast had been interpreted as a subjective phenomenon. Recently this contrast effect was shown to be already manifest in the neural plane of the visual system (*12*). This was something of a surprise. The evidence discloses that contrast phenomena are basically produced by collateral inhibition involving neighboring elements at retinal as well as central levels. The physiological effect of this mechanism is the sharpening of the border between light and dark areas in the visual field. Thus the correspondence between subjective impressions and patterns of neural activity in the visual system is documented.

A second example of the close interrelationship between function of brain systems and mental processes is the well-known fact that consciousness is lost when critical areas of the brainstem are damaged (*13*). In contrast, consciousness remains unaffected when only parts of the cerebral cortex are damaged. At most, a limited defect may result, such as a scotoma of perceptive integration. In spite of this defect, the patient remains conscious of the situation and is capable of answering questions intelligently. His self-awareness and his orientation in space and time are undisturbed. With this, proof exists that specific psychic functions are bound to specific nervous structures. Still, the intervening process between stimulation of nervous elements and the formation of a conscious perception remains beyond our grasp.

A third example concerns the release of definite sensations through artificially induced stimulation of the brain. One recalls the activation of a characteristic behavior pattern in experimental animals (goats) after intradiencephalic injection of hypertonic saline. Their response was a massive intake of water (*14*). This behavioral reaction is identical to that induced by long-term deprivation of water. The electrolyte concentration in the tissue is increased, and the thirsty animal is impelled, as the human is under similar conditions, to quench its thirst by drinking. The observation implies that the stimulated area of the brain contains receptors which control osmotic pressure by regulating the water balance. The immediate impulse is normally given by the specific sensation of thirst in association with the positively conditioned satisfaction of removing the thirst sensation.

Another example of drive behavior elicited by stimulation of the diencephalon concerns food intake (*15*). Here, extreme voracity may develop under the influence of central excitation, resembling that seen after prolonged fasting or as a consequence of insulin-induced fall of the blood sugar level. Such increased intake of food (bulimia) is also seen in some psychically disturbed human subjects. Thus, physiological hunger, experimentally induced hyperphagia, and pathological bulimia appear interrelated inasmuch as they may be subserved by identical cerebral systems.

Another set of observations refers to manifestation of rage and fear elicited by stimulation of the hypothalamus in cats (*15*). With the onset of artificial stimulation the cat begins to snarl, hiss, and spit. It arches its back or crouches, it bristles, and it lashes its tail. Thus, the typical defense reaction develops, as in an animal threatened by an enemy—for example, a cat threatened by an attacking dog. The question is raised, Are these effects due to the direct stimulation of efferent pathways? This is obviously not the explanation. For, if the experimenter reaches toward the cat at the climax of excitment, it strikes at him angrily in a well-directed attack. At the onset of stimulation the animal may inspect the environment and, in its search for a refuge, may suddenly jump off the laboratory table and flee to a hiding place. These observations indicate strongly that the stimulation, induced attack, and flight reactions are not purely motor effects; rather, they represent interactions between highly integrated central patterns of motivational behavior and conscious visual perceptions of the environment.

The experiment with goats mentioned above is even more convincing (*16*). In the standard experimental procedure the animals are first acquainted with a well-defined source of water. After being deprived of water for a period they begin to seek water at this source. To reach it, they must surmount an obstruction and climb a ladder. After many trials the second part of the experiment begins—namely, electrical stimulation of specific structures of the diencephalon when the animal is hydrated. The trained animal uses the ladder promptly, goes directly to the familiar water vessel, and drains it. The short time between the beginning of stimulation and the action described leads to one conclusion: the effect of electrical stimulation of specific diencephalic structures manifests itself in the subjective sphere as a drive, thirst. This drive gives inducement and direction to the behavior, through which the tension of drive is relieved. Thus, it seems appropriate to conclude that, under the influence of brain stimulation, experiences stored in the memory are actively integrated with instant perceptions and released as behavioral responses.

Effects of Psychotropic Drugs

Electrical brain stimulation is not the only means whereby subjective experiences may be elicited or modified; they may be influenced considerably by the action of chemical agents. One of the best-known examples is the effect of ethyl alcohol. With moderate doses, the individual's mood is usually improved; he experiences an increased desire for adventure, including an urge for verbal communication. His euphoria is accompanied by a suppres-

sion of inhibition. For this reason the ventures of the inebriate lead all too often to catastrophe. Another group of substances, the amphetamine compounds, also increase initiative and give the individual the courage for risky undertakings. Certain drugs which influence mental disturbances are particularly interesting from the medical point of view. The effect of stronger doses of ethyl alcohol is revealing; such doses lead to a dimming of consciousness, even to total loss of consciousness. This observation indicates an important sensitivity of consciousness to chemical influences (*17*), which is further revealed in the action of anesthetics upon basic properties of cerebral elements. Such modifications show that chemically defined receptors, as constituents of nerve cells, are in play at the molecular level. Little is known about this field today; however, the means for further investigation are at hand—for example, through study of the effect of drugs on explants of clinical biopsy material.

In addition to drugs which suppress consciousness there are drugs whose action manifests itself in the psychic sphere in other ways. One of these, lysergic acid diethylamide (LSD), is an appropriate "research instrument." Even minimum doses produce very striking psychic effects—for example, primitive visual perceptions such as colored clouds and changes in brightness of visual patterns, like scintillations or flickerings. One psychiatrist (*18*) has described more complex visual impressions, such as spirals, ornaments, fern branchings, and wood carvings, which he experienced in a self-trial. Such imagery arises from latent memory traces. Even more impressive is the case where fragments of acquired knowledge appear in the visual field—for instance, images of benzene rings or chromosomes. Experiences of this nature are noteworthy because similar visual phenomena, such as stars, wheels, colored balls, and disks, are reported by the patient when the brain surgeon applies electrical current to the occipital cortex for purposes of diagnosis (*4*). Artificially elicited perception of the contents of consciousness, on the one hand through electrical stimulation and on the other hand through the administration of a chemically defined substance, is all the more arresting because this activity is based on excitation of elements that lie in the visual-projection areas of the brain. Thus the actions of LSD may be considered a modification of discharge of nervous elements of the visual system. As mentioned above, fragments of stored experience are often part of the activated pattern of excitation. An example is one subject's identification of a wall with a railway embankment. A hallucination was joined to this illusion; the subject believed that he saw an overhead electric line, which in reality was not there but which belonged to the full picture of the electrified Swiss train system. From this, it appears that the mechanism of hallucination may eventually become understood through a biologically oriented approach.

Causality and Motivation of Behavior

The behavior of a cat in an open field on the lookout for an enemy seems to be motivated by the imminent threat. The cat's watchfulness and active search for a refuge confirm this interpretation. While emotions may be the impelling force, the *waking consciousness* determines the organization of a flight reaction. For successful avoidance, coordinated muscular action is called upon. Such action occurs through excitation of precisely defined central mechanisms. To me it is clear that such an explanation can be deduced only from one's own experience. From the objective point of view one might take exception to this interpretation. On the other hand, scientific observers can be expected to be guided in their view by their specialized knowledge concerning the organization of brain and behavior—knowledge which has led to the recognition of principles applicable in both man and other higher animals. Such is the problem of motive and execution of acts controlled by the conscious will. Therefore, the question is, Where do the activating impulses originate?

One may say that this category of phenomena cannot be compared with the category discussed above. On the other hand, no one can deny that the display of behavior presupposes the action of forces, for, without them, nothing would be set in motion and there would be no resistance to be overcome. Voluntary acts are no exception. What is difficult is to determine the type of activating force. As the matter stands, one can only argue by exclusion. Certainly, conditions required for the release of nuclear forces are not present; gravitational forces also are excluded, for today it has been shown that psychic processes take place normally under conditions of weightlessness. The activating forces could be molecular or electromagnetic. Possibly, as yet undiscovered forces may be active which belong to none of the known categories, forces inherent in the living neuronal system of man and other higher animals. Such a concept may mean, to be sure, a revival of the long-departed vitalistic theory. This suggestion is not so absurd, since the experiments which seem to have ruled out vitalistic processes have concerned only somatic or organic functions. However, psychic functions are a reality for the living individual even though they cannot be objectified by outsiders.

Causality and Communication

The substitution of verbal symbols for perceptions of reality plays an important role in causal thinking. An example of such substitution is the reporting of a conference, with mention of the names of the participants. To this conference report only a few details need be added to convey meaningful information concerning the course of the transactions and the conclusions reached.

Acoustical and optical symbols are also used, moreover, and not only for communication between man and man. A dog reacts to the call of its name as a consequence of its education. It looks about, comes to its master, and responds when asked, through word and sign, to perform tricks it has learned.

In the human, basically complex information can be reduced to symbols of fixed, brief design which denote, nevertheless, wide-reaching conclusions. The highest development is found in the symbols of mathematics. Here, data can be expressed through ciphers and other signs which denote qualitative as well as quantitative aspects, and new insights can be developed.

Sense stimulations which are integrated into a pattern of neural excitation are transferred automatically to the environment by the receiving and perceiving subject. This transfer corresponds to the long-known rule of excentric projection. The consequence of this is that no clue concerning localization and organization of the nerv-

ous system comes to us from the cerebral process, which is induced through sense organs. On the other hand we receive through the resolving power of receptive systems information about the environmental source of stimulation. In visual perceptions derived from both eyes, for example, paralactic shift is utilized in composing an integrated stereo image. The impression that the sensory stimulation originates in the environment is confirmed through the directed motor reaction—for example, through the grasping of a visually localized object. The successful attempt to grasp the object confirms the correlation between perception and reality. Involved are consistent temporal and spatial relationships which produce the impression of causality (*19*).

Simple mechanisms for the preservation of life are genetically controlled and subject to phylogenetic selection. Important individual behavioral patterns are determined prenatally. Complex reactions, on the other hand, are learned postnatally, and their release is under the control of conscious will. Through frequent repetition, psychic functions become partially or totally automated. As a result, the desired success is achieved with more speed and more precision, and mechanisms of great complexity are mastered.

Summary

This article is based upon data which are suitable for the correlation of behavioral research and experimental neurophysiology. Causal thinking manifests a sort of integrative activity which brings simultaneous and successive patterns of nervous excitation into a subjectively meaningful frame of reference. While neuronal patterns determine the content of consciousness, they fail to provide clues concerning the transformation of such patterns into subjective experience.

References and Notes

1. C. J. Herrick, *The Evolution of Human Nature* (Univ. of Texas Press, Austin, 1956).
2. *The Neuropsychology of Lashley* (selected papers of K. S. Lashley), F. A. Beach, D. O. Hebb, C. T. Morgan, H. W. Nissen, Eds. (McGraw-Hill, New York, 1960).
3. D. O. Hebb, *The Organization of Behavior* (Wiley, New York, 1949).
4. W. Penfield and T. Rasmussen, *The Cerebral Cortex of Man* (Macmillan, New York, 1950).
5. H. Klüver, *J. Lancet* **72**, 567 (1952); ———, in *Ciba Foundation Symposium on the Neurological Basis of Behavior*, G. E. W. Wolstenholme and C. M. O'Connor, Eds. (Little, Brown, Boston, 1958), p. 175.
6. D. W. Ploog, *Jahrb. Max-Planck-Ges.* (1963), p. 130; P. D. MacLean, *Animal Behaviour* **11**, 32 (1963).
7. J. M. R. Delgado, *Intern. Rev. Neurobiol.* **6**, 349 (1964).
8. P. D. MacLean, *Psychosomat. Med.* **11**, 338 (1949); *A.M.A. Arch. Neurol. Psychiat.* **78**, 113 (1957).
9. S. L. Polyak, *The Vertebrate Visual System* (Univ. of Chicago Press, Chicago, 1957).
10. R. Jung, in *The Visual System*, R. Jung and H. Kornhuber, Eds. (Springer, Berlin, 1961), p. 410.
11. D. H. Hubel and T. N. Wiesel, *J. Neurophysiol.* **28**, 229 (1965).
12. G. Baumgartner, in *The Visual System*, R. Jung and H. Kornhuber, Eds. (Springer, Berlin, 1961), p. 296.
13. B. J. Alpers, *Res. Pub. Ass. Nervous Mental Diseases* **20**, 725 (1940).
14. B. Andersson, *Acta Physiol. Scand.* **28**, 188 (1953); ———, P. A. Jewell, S. Larsson, *Ciba Foundation Symposium on the Neurological Basis of Behavior* (Little, Brown, Boston, 1958), p. 76; B. K. Anand and J. R. Brobeck, *Yale J. Biol.* **24**, 123 (1951).
15. W. R. Hess, *Diencephalon, Autonomic and Extrapyramidal Functions*, O. Krayer, Trans. (Grune & Stratton, New York, 1954); ——— and M. Brügger, *Helv. Physiol. Pharmacol. Acta* **1**, 33 (1943); R. W. Hunsperger, *ibid.* **14**, 70 (1956).
16. B. Andersson and W. Wyrwicka, *Acta Physiol. Scand.* **41**, 194 (1957).
17. W. R. Hess, *The Biology of Mind* (Univ. of Chicago Press, Chicago, 1964).
18. W. A. Stoll, *Schweiz. Arch. Neurol. Neurochir. Psychiat.* **60**, 1 (1947).
19. W. R. Hess, *Psychologie in Biologischer Sicht* (Thieme, Stuttgart, ed. 2, 1967).
20. The work discussed was supported by a grant from the Swiss National Foundation of Scientific Research.

Arbovirus Infections of Laboratory Workers

Extent of problem emphasizes the need for more effective measures to reduce hazards.

R. P. Hanson, S. E. Sulkin, E. L. Buescher, W. McD. Hammon, R. W. McKinney, and T. H. Work

Prior to 1950, only an occasional report was concerned with the need for protection of laboratory personnel who came in daily contact with disease-producing agents. Sulkin and Pike (*1*) had collected data on viral infections contracted in laboratories in the hope that this information would be helpful in determining where the greatest caution must be exercised in working with viruses. The magnitude of the overall problem of laboratory-acquired infections, however, became evident in an extensive survey (*2*) which revealed over 1500 instances of laboratory-acquired infections resulting in 39 deaths. A standing Committee on Laboratory Infections and Accidents of the American Public Health Association (APHA/CLIA) (*3*) has maintained a file of cases of laboratory-acquired infections whether reported to the public or by private communication; so far, there have been over 2700 cases with 107 fatalities.

Molecular biologists interested in the relation of viruses to the metabolic systems of cells and in the structure of their nucleic acids may now be added to the many virologists who have long worked with a heterogeneous group of viruses known as arboviruses. The health hazard inherent in the manipulation of these viruses may not be well known to many of the newer investigators who lack clinically oriented training.

The arboviruses, a contraction of

The authors are members of the American Committee on Arthropod-borne Viruses/Subcommittee on Laboratory Infections (ACAV/SLI). Dr. Hanson is in the department of veterinary science, University of Wisconsin, Madison; Dr. Sulkin is in the department of microbiology, University of Texas Southwestern Medical School, Dallas; Dr. Buescher is in the department of virus diseases, Walter Reed Army Institute of Research, Washington, D.C.; Dr. Hammon is in the department of epidemiology and microbiology, University of Pittsburgh, Pittsburgh, Pennsylvania; Dr. McKinney is at Ft. Detrick, Frederick, Maryland; Dr. Work is in the department of infectious and tropical diseases, University of California School of Public Health, Los Angeles.