Meetings

Neural Basis of Vision

Over the past decade microelectrodes have been used to sample the responses of single cells in virtually all the visual centers of the vertebrate brain. The basic building blocks of visual perception have been revealed, neurons that extract highly specific information from the external world. Cells have been described which only respond to certain movements or colors or properly oriented contours, sometimes with an extraordinary degree of specificity. Today neurophysiologists are attempting to understand how each one of these feature-detecting units is engineered by the nervous system and how they are all unified into the global visual world we perceive. Many of the explanations appear to depend upon the connections nerve cells make with one another. What are the patterns of these connections, and the rules governing their formation? What proportion are fixed genetically, and what proportion are modifiable by the external environment? How do these factors change as one proceeds higher in the nervous system? These were the sorts of questions that brought anatomists, physiologists, and psychologists of Australia and the United States together in a symposium in Canberra, held in February at the John Curtin School of Medical Research under terms of the United States–Australia agreement for scientific and technical cooperation.

The neural circuitry of the retina is better understood than that of higher visual centers. The most precise circuit diagrams exist for the connections at the beginning of the visual system, where photoreceptors contact second-order neurons, bipolars, and horizontal cells. The synaptic untrastructure of these contacts are qualitatively similar in all vertebrates. Differences between various vertebrate retinas are not due to new types of synapses but to different proportions of the same types, and these differences become most apparent in the output of the retina, the ganglion cells. Ganglion cells of lower vertebrates are more specific in their stimulus requirements than are those of higher vertebrates. The more specialized a cell becomes the less potential information it carries, so that by delaying the process of specialization until the more central nervous system—where more nerve cells are available—higher vertebrates gain the advantage of extracting more features from the external world.

In higher vertebrates the retina sends its information along at least two separate visual pathways. One is the tectal system, which remains the major visual input of lower vertebrates; the other is the geniculo-striate system, which reaches its greatest development in higher primates. There was general agreement among the anatomists at the Canberra meeting that both of these systems reach the cerebral cortex but do so by entirely different pathways. How these separate visual systems function together in producing a single, unified visual world is open to conjecture. The geniculo-striate system undoubtedly functions to produce a fine-grained image of color and form; the function of the tectal system is much more difficult to epitomize principally because of the lack of physiological data. Some speculations were raised that it could act to orient the body in space or keep objects invariant in the face of eye and head movement.

The geniculo-striate system has received the greatest attention of physiologists and has led to the provocative hypothesis of Hubel and Wiesel, which attempts to explain cell function by a specific hierarchical arrangement of connections in the visual cortex. They have proposed that geniculate cells, all of which have concentrically organized receptive fields and receive their input from similarly organized retinal cells, project to simple cells in the striate cortex in a highly selective way, so that rows of geniculate fibers all synapse on the same simple cell and give it orientation-selective properties. Many simple cells of the same orientation are believed to synapse on a single complex cell that generalizes for a particular contour orientation in one area of visual space. Simple and complex cells of all orientations have been found. Some complex cells are considered to excite and others to inhibit hypercomplex cells; this makes the latter responsive only to oriented contours of a particular length. Hubel and Wiesel indicated that this serial processing continues to form higher-order hypercomplex cells sensitive to corners and even more complex geometric patterns.

This hypothetical scheme was challenged by the Canberra group, who proposed that there is more parallel processing between cells in the striate cortex of the cat. They envision some geniculate cells synapsing on simple cells but others synapsing directly on complex cells, and they think that some hypercomplex cells are formed without a complex cell intermediary. It will be difficult to test these alternative views without some more direct way of linking physiology with anatomy. From several laboratories came reports that attempts were being made to identify individual cells within the visual cortex by injecting dye into cells after their functional specificity had been determined.

Manipulation of the visual environment can produce permanent alteration of neural function all along the visual pathway in mammals. These effects are usually much more severe in the cerebral cortex than in lower visual centers. Kittens raised in an environment in which contours are all oriented in one direction fail to respond to orthogonal orientations, and cells in their striate cortex show similar deficits. Specificity to orientation is not totally learned, however, since hypercomplex cells that had been detected in the visual cortex of a newborn kitten were described at the symposium.

The physiology and anatomy of vision of color and form may provide clues to the circuitry of visual cortex, especially in higher primates where color vision is well developed. In the rhesus monkey the majority of neurons in the central retina and lateral geniculate nucleus are sensitive to both form and color. In the striate cortex many cells are only sensitive to form, and only a small fraction remain sensitive to both. Some cells in the latter category are amazingly specific, responding only to properly oriented contours of appropriate color and length. Some participants speculated on how far this hierarchy for both color and form continues, since psychophysics has suggested differences in the processing of color as compared with processing of other types of visual information, such as brightness and form. At Canberra this hierarchy was extended into the area of stereopsis with a report that depth perception occurred only with differences in brightness and was impossible with color differences alone. Some neurophysiological data suggested a tendency for color and form specificity to be inversely related in cortical cells, which imply separate hierarchical channels for these two features; these channels could develop after much spatial selectivity had already occurred.

A breakthrough in vision research has been the development of techniques for studying single neurons in awake, trained monkeys. This approach is undoubtedly going to facilitate the exploration of higher brain centers, which must be very depressed in the anesthetized state. The initial successes with this method are taking place in visual motor systems, where eye movements can be directly related to neuronal activity.

The meeting made it clear that vision research will proceed to develop better techniques to link structure with function in all visual centers in order to uncover the general rules nature uses to construct visual brains—and ultimately man's visual world—by interconnecting nerve cells.

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A Matter of High Priority: IV Jornada de Flora y Fauna Amazonica

The Fourth Meeting on Amazon Flora and Fauna was opened by the Bolivian Secretary of Agriculture on 15 October 1971 in Santa Cruz, Bolivia. The Secretary of Industry and Commerce, a competent economist, explained the importance of ecological surveys in a variety of areas, including political decision-making; integral studies of the renewable natural resources to assure the sustained yield management of commercially valuable species; well-defined and protected national parks and wildlife refuges to stimulate the tourist industry and market; lists of endangered species; and examples of ecological catastrophes caused by well-meaning, but incompetent, agricultural and forestry practices. The ministerial speeches and the subsequent lectures and discussions were taped and broadcast, so that the actual audience of the meeting was far larger than the almost 200 persons who physically attended. Some of us wondered skeptically what the media "rating" of such programs would be, but the organizing commission assured us that the use of transistor radios is widespread, and that people are interested in topics that concern their own region. Dr. Valdivieso (a Bolivian member of the American Academy of Orthomolecular Psychiatry and of the World Center of Group Psychotherapy) discussed the future of Bolivian Amazonia from data based on anthropological, clinical, and sociocultural studies. He stated that, "in terms of mental health, the failure of the natural defenses in the human organism leads to suicide. In ecological terms, the failure to comprehend rationally the importance of the conservation of flora and fauna means collective suicide." The people living in the Amazon Basin do not want to commit suicide. Some 30 papers were presented that covered topics ranging from problems caused by the introduction of the African bee to problems of regional planning of future settlements to avoid overcrowded cities. J. D. Candia, dean of the University for Tropical Agriculture, spoke about the ecological conditions of the chapare. Several other papers dealt with legislative programs, and the report of the delegate from Ecuador, who presented his country's new wildlife legislation and ordinance of implementation, was highly praised. It was especially pleasing to the group to know that many of the recommendations of the Third Meeting on Amazon Flora and Fauna held in Tena, Ecuador, in 1970 have already been implemented.

Traditionally part of the meetings consist of field trips. The participants at the Fourth Meeting were given an opportunity to fly over one of Bolivia's projected national parks and also to visit a wildlife refuge near Trinidad (Department Beni). Perhaps the most impressive testimony to the fact that, in spite of all difficulties, something can be done to promote conservation in the Amazon Basin is the Botanical Garden of Santa Cruz. In 1965, Prof. Kempff transformed a piece of wilderness into the *Hortus Amazonicus Tropicalis Boliviensis*. He left the existing vegetation, labeled it, added some more species from the Amazon Basin (but no plants from outside the region).

It is interesting to reflect on the history of these gatherings. The first meeting was held in Belem, Brazil, and was cosponsored by the Association for Tropical Biology (ATB). The second meeting (in Florencia and Leticia, Colombia) still had the moral support of the ATB, but all expenses were paid for by the host country. The third and fourth meetings were organized entirely without the financial or moral support of any international biological, ecological, or conservation agency. This, however, did not diminish the appeal of the conference, where representatives of governments could meet expert scientists and enthusiastic students to discuss the most urgent problems and the best ways to confront these problems. The meeting in Santa Cruz made 18 recommendations. Copies of these can be obtained from Noel Kempff Mercado, Presidente, Comisión Organizadora Casilla 123, Santa Cruz, Bolivia.

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Forthcoming Events

August

5–6. **Perform Tests and/or Examinations on People Who Have Shown Sensitivity to Fluorides from Fluoridation**, Fact Finding Committee, Milwaukee, Wis. (R. J. H. Mick, 915 Stone Rd., Laurel Springs, N.J. 08021)

14–16. Association for **Computing Machinery**, Boston, Mass. (C. Giltner, Lincoln Lab., Massachusetts Inst. of Technology, P.O. Box 73, Lexington 02173)

14–17. **Biometric** Soc., Western North American Region, Montreal, P.Q., Canada. (J. W. Kuzma, Dept. of Biostatistics, Loma Linda Univ., Loma Linda, Calif. 92354)

14–17. American **Statistical** Assoc.,