(iii) development analogous to that of the superconducting magnetometers with superfluid helium for inertial sensors.

The next part of the meeting began with a comparison by D. Douglass (Jan Franck Institute, University of Chicago) of the phase transition in liquid helium and superconductors. He discussed the consequences of assuming first a real-order parameter to describe the ordered phase and then a complex-order parameter. By use of a somewhat arbitrary, so-called "self-consistent" cut-off procedure on the partition function suprisingly good agreement was obtained of the logarithmic contribution to the specific heat of helium at the λ-point. He showed then why the relatively large coherence length in a pure superconductor attenuates this logarithmic term to negligible proportions. Next, R. Kubo (University of Tokyo) reviewed the development of the theorem relating fluctuations and dissipation, and outlined a generalized statistical mechanical derivation of the proof. He compared the fluctuations of an order parameter to the Brownian motion of a macroscopic particle. Recent developments have shown how these time-dependent fluctuations can be related to a succession of time-independent averages which promise new understanding of the dynamic effects of critical fluctuations. In this regard, T. Tsuneto (Kyoto University) mentioned his recent work on the time-dependent and space-dependent fluctuations of the order parameter in superconductors where the recovery time for a fluctuation becomes increasingly long as the transition temperature is approached from both above and below. N. Tsuda (Institute for Solid State Physics, Tokyo University) presented some interesting new data on tunneling between various superconductors and phosphorus-doped silicon. Anomalies in the tunneling characteristic of the order of several millivolts were found in each case.

The final day of the meeting was devoted to discussion of the influence of magnetic impurities and spin fluctuations on the superconducting state. M. A. Jensen (University of Pennsylvania) reviewed recent work on the correlation between the magnetic susceptibility, the specific heat, and the conduction electron mass enhancement arising from interactions with the phonons and with paramagnetic impurity spins. He showed how these factors should influence the superconducting transition temperature and compared the prediction of the calculation with experimental values of the depression of T_c with paramagnetic impurities. The semantic question was raised: whether these spin effects could be called spin fluctuations or whether they should more correctly be considered part of the ground state of the system.

T. Sugawara (Institute for Solid State Physics) presented data on the influence of the Kondo effect on the depression of T_c for gadolinium and cerium impurities in lanthanum. An exchange coupling of opposite sign was obtained for Gd and Ce. From the work of Benneman, R. D. Parks indicated that the depression of T_c was extremely sensitive to the degree of spin orbit scattering and mentioned briefly his results on alloys of $InLa_{3-x}Gd_x$. Then T. Soda (Tokyo University of Education) outlined work on the s-d exchange interaction in a superconductor. Using perturbation theory he investigated under what conditions a bound state can exist in the vicinity of an impurity atom in a superconductor. For both the ferromagnetic and antiferromagnetic cases, he predicts a discrete impurity level in the energy gap if the exchange interaction is weak.

The seminar was attended by six participants and two observers from the United States and five participants and nine observers from Japan. Y. B. Kim and T. Sugawara were the respective coordinators of the two countries.

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Nervous Integration

Physiological and biochemical aspects of nervous integration in vertebrates and invertebrates were discussed at a symposium in Woods Hole, Massachusetts, 30 August–2 September 1967.

Eric R. Kandel and Howard Wachtel (New York University Medical School) summarized results obtained with their co-workers on the abdominal ganglion of *Aplysia*, which contains about 1500 neurons in its four quarters. The endogenously active cells of one quarter ganglion are neurosecretory; the other cells innervate the viscera. Impulses from neuron L10 produce: slow hyperpolarization in six cells of a second quarter of the ganglion; fast hyperpolarization in four cells of a third quarter; and, in the last quarter, depolarization of three cells and successive depolarization and hyperpolarization in another cell. All of these effects are mimicked by applied extracellular acetylcholine. Although there are no direct interconnections among these 14 follower cells, each of four cells that inhibits neuron L10 affects some of them, thus silencing neuron L10 and substituting a different pattern of activity among its followers.

The endogenous activity of one of the large secretory neurons of the same ganglion was reported on by F. Strumwasser (California Institute of Technology). This cell generates a burst of spikes about every 40 seconds, followed by a period of hyperpolarization whose termination causes the next burst. The cycle is initiated by a depolarization that accumulates during the burst. Tetrodotoxin blocks the spikes, but there persists a damped hyperpolarization-depolarization cycle of the same period, which depolarization restarts. Ouabain blocks this residual oscillation, indicating that it depends in part on a sodium pump. It is also blocked by reducing sodium or chloride outside the cell or by increasing chloride inside. The burst pattern has a superimposed circadian rhythm which can be entrained by light. The protein synthesis of the whole ganglion is affected by light, and actinomycin D can reset the circadian rhythm.

A. O. D. Willows (University of Oregon) described his recent work on the nudibranch *Tritonia*. Like other gastropods, *Tritonia* has huge pigmented neurons. They are more favorably situated than those of *Aplysia* for behavorial studies; the whole central nervous system is permanently attached and grouped in three ganglia near the dorsal surface. Thus the animal could be suspended by hooks around a dorsal incision and the cells stimulated and monitored by intracellular pipettes while the animal moved. Stimulation of certain cells always caused the whole animal to stiffen; other stimulations produced turning. Some cells responded to a sufficiently strong stimulus of the branchial tufts; the tuft was withdrawn just as the cell fired. Weaker stimuli did not fire the cell, and excited only local peripheral withdrawal. Natural or intracellular stimulation of any member of another group of neurons in the central ganglia sometimes caused

the whole group to discharge an elaborate 30-second patterned response. This was always associated with the release of a complex series of escape movements.

Melvin J. Cohen and Jon W. Jacklet (University of Oregon) and Edward M. Eisenstein (State University of New York at Stony Brook) described their experiments on the cockroach, from which they isolated the prothoracic ganglion with its two legs. Following G. A. Horridge (St. Andrews University, Scotland), they placed saline baths so the legs dipped in and out of saline in their independent motions. Both legs were shocked whenever one of them, the "P" leg, was immersed. After 4 minutes the P leg has "learned" to avoid shock by maintained flexion; while the other leg, which had received the same number of shocks but uncorrelated with its position, continued to move in and out of the saline. A foreign metathoracic ganglion placed in a leg will innervate a previously denervated muscle and cause clonic twitching.

Each of the 23 segmental ganglia along the ventral cord of the leech contains about 350 unipolar neurons surrounding a central neuropil. D. A. Baylor and J. G. Nicholls (Yale University School of Medicine) described experiments on individual segmental ganglia isolated with their associated segments of skin. On each side of a ganglion are seven cutaneous sensory cells, each with its characteristic morphology, electrical character, adequate stimulus (touch, pressure, or tissue damage), receptive field, and neural connection. During regeneration in the adult leech, each of these neurons reestablishes its old cellular connections and reinnervates its old cutaneous territory, sometimes even if this part of the skin has been displaced by an operation.

Lacking proprioceptors, the crab eye is stabilized by visual pattern alone. The eye follows moving points of light, including moving intermittent lights with off periods as long as 20 minutes. Withdrawal of the eyestalk for as long as 1 minute is followed by return to the original position relative to the visual field. The strength of the extension is proportional to the strength of the previous withdrawal. These are three of several forms of memory in the crab's eye described by G. A. Horridge. If a steady light, moved in the dark, blinks in its new position, the eyestalk will swing to restore the retinal locus of the light. After several swings, however, the eye will no longer identify these lights, and will cease to move between them; it will also adapt its swing to prevent hitting objects placed in the way.

Donald Kennedy (Stanford University) summarized work on neurons in the abdominal ganglion chains of the crayfish, where sensory, motor, and interneurons control the posture of the tail segments. Axons of interneurons go through several ganglia, in each both receiving sensory input and branching to innervate higher interneurons and motoneurons. Kennedy and his co-workers sometimes found fibers of interneurons whose spikes were necessary and sufficient to cause particular coordinated tail movements, or inhibition of movement, and which could be driven by touching certain hairs. Usually, there were interneurons between the primary sensory receiving neuron and such a "command" interneuron. Single spikes in these interneurons were converted to temporal and spatial patterns by the final motoneurons and associated cells.

In lobsters both gamma amino butyric acid (GABA) and the natural neuromuscular and presynaptic inhibitory transmitter cause increased permeability to chloride. They also have the same pharmacology. E. A. Kravitz (Harvard Medical School) and co-workers have studied GABA metabolism in single lobster axons. They find that concentrations of GABA in excitatory axons is .001M and is .1M in inhibitory axons. Stimulation causes release only from the inhibitory axons. They found that GABA metabolism resembles that in mammals: α-ketoglutarate transaminates with GABA to degrade it to succinic semialdehyde, and to generate glutamic acid, the suspected excitatory transmitter. In inhibitory axons there is sufficient glutamic decarboxylate activity to convert most of this glutamic acid into GABA. GABA then probably controls its own concentration by inhibiting this enzyme. GABA and glutamate are not degraded when released at junctions, but are actively transported back into cells.

B. W. Moore and V. J. Perez (Washington University School of Medicine) have been characterizing brain-specific proteins. They make antibodies against those brain proteins with values of DEAE-cellulose and starch gel mobilities not shared by proteins from other tissue. These proteins are then assayed immunologically in a wide variety of animal brains and brain areas. Protein S-100, the protein with the highest known electrophoretic mobility, is immunologically specific to brain. Its molecular weight is 20,000 to 25,000, and its concentration in wet rat brain tissue is 0.3 mg/g. It is mostly concentrated in the white matter, probably in axoplasm, and is not found in rat brains until 12 days after birth. Protein 14-3-2 is also an acidic protein; is probably also highly brain specific; is found mainly in grey matter; weighs 50,000; and accounts for 1 mg/g of brain. Both proteins are immunologically uniform throughout many vertebrates, suggesting stringent structural requirements for proper function.

Bruce S. McEwen (Rockefeller University) described beginnings of three methods of identifying proteins generated in the brain after training. By separating proteins by disc electrophoresis precipitation with labeled antiserums, he found that protein S-100 turns over in the brain in a few hours, much faster than total protein does. Second, 3 weeks after he injected rats with labeled leucine and trained them to reach with their unaccustomed forepaw, there was a slight but suggestive increase in the amount of labeled protein in the brain area that controls reaching, compared with the rest of the cortex. Finally, Bernice Grafstein (Rockefeller University) and McEwen have found that labeled protein from the goldfish's eye reaches the optic tectum at two main times after injecting labeled leucine into the eye—16 hours and 11 days. The faster protein is bound to a cellular particulate.

B. W. Agranoff and R. E. Davis (University of Michigan) described the effect of injecting onto the surface of the brain sufficient puromycin to block its protein synthesis. Like electroconvulsive shock, this blocked the formation of permanent memory. They trained goldfish to cross a barrier when a light appeared, to avoid a forthcoming shock. Puromycin, injected just as training is complete and the fish is returned to the home tank, is followed in 6 hours by the beginning of a shock avoidance deficit which becomes complete and permanent in 60 hours. If the fish are not returned to their home tanks after training, insensitivity to puromycin ("memory consolidation") is delayed until they are. It is as though fish do not consolidate adaptive behavior until it proves able to get them out of the dangerous environment.

M. V. L. Bennett (Albert Einstein College of Medicine) gave a detailed comparison of electrical and chemical synapses. The function of most known electrical synapses seems to be either to give fast responses, as in escape systems such as the Mauthner-giant axon synapse of fish, or to give accurate synchronization, as in axonic terminations onto some electroplaques or between cells in the central nervous system. Chemical synapses are superior in providing longer temporal summation (since transmitter is not removed when the postsynaptic cell fires) and in providing inhibition much more efficiently. They are probably also essential for low-level amplification at receptors. Both types of synapse can be arranged to provide linear, nonlinear, and one-way or two-way transmission between cells. It seems possible that electrical synapses could provide amplification (by utilizing regenerative membrane), defacilitation, and facilitation. Hence in many instances it seems unsafe to infer modes of transmission from functional requirements.

M. Jacobson (Johns Hopkins University) described results obtained by rotating the eyes of *Xenopus laevis* at various larval stages and mapping the retino-tectal projections of the resulting adults. He discovered that the tectal projections of the ganglion cells are determined at larval stage 30, first along the anterioposterior axis, and then along the dorsoventral axis, in a period of 7 to 10 hours. By autoradiography he demonstrated that DNA synthesis in the ganglion cells ceases at larval stage 29, just before specification of the central connections of the ganglion cells begins. The characteristic retinal morphology does not begin to appear until about stage 33.

R. L. Sidman (Harvard Medical School) pointed out that genetic mutants may be used to obtain information about neural function, embryology, or physiological genetics, and that there are 90 known neurological mutations in the mouse. Sidman and co-workers have studied four mutations of the mouse's cerebellum. In *swaying* mice some midline tissue is missing; the rest is scrambled, but the local cerebellar architecture is normal. In *weaver* the cerebellar granule cells die before migrating from the surface to their normal position below the Purkinje cell layer. In *staggerer,* they die after migrating there, perhaps because the Purkinje cells are delayed in maturation. In *reeler* the granule cells do not migrate past the Purkinje cells. This type of disruption also occurs in reeler's cortex and hippocampus, the only other areas where neuroblasts migrate past neurons.

M. H. Goldstein (Johns Hopkins Medical School) reported on the properties of units in the cat's auditory cortex. Using unanesthetized muscle-relaxed cats, he and coworkers confirmed that a small dose of barbiturate quiets most units in the auditory cortex. Unlike auditory nerve fibers, whose other properties can be predicted from their preferred frequencies, cortical units have many parameters. In 100 units classified as sensitive or not sensitive to tones, noise bursts, and clicks, there were units in all eight possible categories. A few were sensitive only to swept tones. Units also varied in firing pattern and preferred frequency range. Units with narrowly tuned overlapping optimum frequency ranges occurred in columns separated by regions of broadly tuned cells.

D. H. Hubel (Harvard Medical School) summarized recent studies with T. N. Weisel on the striate cortex of the monkey. The neurons of layer IV B, where the thalamic visual projection ends, are all monocular, and cells related to the two eyes are segregated, forming a mosaic. Cells above and below a left-eye area, for example, are dominated by the left eye, but affected by the right eye to varying degrees. The boundaries of these columns are cut by the boundaries of smaller columns containing cells with common receptive field axes. In layer IV B the receptive fields are simple, while those of the layers above and below it are usually complex and hypercomplex. Sometimes the axis-orientation columns are shaped like pillars about ¼ degree in cross section. Other times they form thin parallel slabs, like slices of bread. As an obliquely penetrating electrode passes through these slabs, the receptive field axes rotate progressively in discrete steps of 10 to 15 degrees, sometimes continuing for several rotations.

The conference was held under the auspices of the Society of General Physiologists. It was arranged and edited by F. D. Carlson, president of the Society. The proceedings will be published by Prentice-Hall and is scheduled for publication in March 1968.

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Calendar of Events

Courses

Tropical Botany, University of Miami, 17 June–26 July. Stipends, travel allowances, waiver of tuition, and graduate credit are available. Twelve students will be selected on the basis of nationwide competition. *Deadline for applications: 1 May.* (Dr. Taylor R. Alexander, Coordinator, Advanced Seminar in Tropical Botany, Biology Department, P.O. Box 9118, University of Miami, Coral Gables, Fla. 33124).

Application of the Electron Microscope to Problems in Molecular Biology, Oak Ridge, Tenn., 30 September–19 October. This advanced seminar will stress specimen preparation, examination techniques, and interpretation of results. It will be designed for participants, at the postdoctoral or advanced Ph.D. student level, with a good background in some branch of molecular biology. (Dr. Lucien Caro, Biology Division, Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tenn. 37830)

Organism-Sediment Interrelationships, Bermuda Biological Station, St. Georges, Bermuda, 1 July–1 September (supported by NSF). Emphasis is on the interrelationships of organisms and sea-floor sediments with special attention to coral reefs. Each student is expected to spend half of the seminar on an independent research project. The seminar is open to students from any discipline related to marine science who have completed 1 year of graduate work and are not actively working on a Ph.D. thesis. Stipends for travel and living expenses are available. *Applications must be returned by 15 April.* (Dr. Robert N. Ginsburg, Department of Geology, Johns Hopkins University, Baltimore, Md. 21218)

Sensory Evaluation of Foods, University of California, 17–21 June. The course is designed for research personnel of industrial, government, private, and academic laboratories, and will cover techniques for laboratory evaluation of sensory properties of foods and beverages, with application to specific commodities. Fee: $20. (Mrs. Helen Raikes, University of California Extension, Davis 95616)

Integrated Circuits Engineering, University of Arizona. Will be offered at three different times: 3–14 June, 17–28 June, and 8–19 July. Is designed to educate the participant in all aspects of modern integrated circuit design and fabrication. It will be an intensive 80-hour program with emphasis on practical laboratory experiences using the facilities of the solid-state engineering laboratory to fabricate components and circuits. Fee: $450. (Dr. R. H. Mattson, Electrical Engineering Department, University of Arizona, Tucson 85721)

Biological Electron Microscopy, University of Southern California, 3–14 June. This course is designed for professional and laboratory personnel desiring knowledge and experience in tissue preparation for examination with the electron microscope. No prior skill in electron microscopy is required. The class is limited to 12 participants. Fee: $250. (Dr. Robert F. Bils, Hancock Foundation, University of Southern California, Los Angeles 90007)