tion of the late E. W. Brown's solution of the main problem of the lunar theory. The procedure adopted required the substitution of Brown's solution into the parts of the differential equations that represent the perturbative accelerations. A system of linear equations is then obtained, the unknowns of which are corrections to the coefficients of periodic terms and to the motions of the perigee and node. The novel difficulties of the problem arise from the large number of unknowns (over 6000) and the presence of small divisors which cause near-indeterminateness for some of the unknowns. It was found that grouping of unknowns into families overcame both obstacles. It permitted replacing the total system of equations by a number of subsystems. A process of iteration then converged to a definite solution. Eckert stressed that, although the work was begun before the era of high-speed calculators, it could not have been completed with the perfection achieved without powerful computing facilities.

Results reported in sessions on planetary theories and the three-body problem depended heavily on the availability of powerful high-speed calculating equipment. I. Izsak (Smithsonian Astrophysical Observatory) reported on his work on an analytical development of the planetary disturbing function on a digital computer. The principle is not essentially different from the development by Newcomb late in the 19th century, but these developments have not been extensively used because of the excessive amount of labor required. Yet they are almost indispensible if planetary theories are to be constructed which will be valid for an indefinite length of time.

D. Brouwer (Yale) reported on a recent result obtained by C. J. Cohen and E. C. Hubbard (Naval Weapons Laboratory) on the orbit of Pluto. By extending the numerical integration of the five outer planets with the Naval Ordnance Research Calculator (NORC) over 120,000 years, they found that a resonance relation between the elements of the orbits of Neptune and Pluto exists which prevents Pluto from coming closer than 18 astronomical units to Neptune at any time during the period covered by the numerical integration. The conclusion is probably valid for a much longer period, but this will require further exploration of the resonance relationship.

J. Schubart (Germany) presented an impressive compilation of numerical results, obtained while he was guest investigator at the Smithsonian Astrophysical Observatory, pertaining to orbits in resonance regions in the plane restricted problem.

The British Astronomer Royal, Sir Richard Woolley, gave an account of astrometric investigations of star clusters which have already yielded significant observational information on the structure of the Galaxy. Other contributions closely related to observational evidence were made by M. Schmidt (California Institute of Technology) on a revised potential of the Galaxy and by I. King (University of California, Berkeley) on the stability of star clusters.

The symposium was organized in cooperation with the Committee on Space Research of the International Council of Scientific Unions and received support from UNESCO, the government of Greece, the U.S. Air Force Office of Scientific Research, and the U.S. Office of Naval Research, as well as from the IAU.

DIRK BROUWER
Yale University Observatory,
New Haven, Connecticut

Virus Infections in Cold-Blooded Vertebrates

A conference on viral diseases of poikilothermic vertebrates was held in New York City 23–26 September 1964. R. Weissenberg, who in 1914 reported on lymphocystis disease in fish, the first viral infection of a cold-blooded vertebrate to be described, gave the keynote address, in which he reviewed 50 years of research on this disease.

The conference made possible new and expanded contacts between those interested primarily in viral infections of amphibia and those whose primary interest is diseases of fish. Such contacts in recent years have been mutually beneficial—for example, Granoff used the fathead minnow cell line, which was newly described by Gravell and Malsberger at this conference, to propagate the frog virus which he has recently isolated.

The first group of papers to be presented dealt with amphibia. The frog renal adenocarcinoma (Lucké tumor) was the topic of all but two of the 16 papers in this group, and collectively these papers represent a major advance in the study of this disease.

The etiology of frog renal adenocarcinoma has yet to be established, but the presence of virus in some tumor-bearing frogs was established by isolation and by electron microscopy. Rafferty (Johns Hopkins) isolated viral agents from tumors which bore Type A nuclear inclusions, but he was unable to isolate virus from frogs having no inclusion tumors. Granoff (University of Tennessee) also isolated viral agents from frog kidneys; these viruses proved lethal to frog embryos. Evidence for the presence of virus or virus-like particles was obtained by a number of electron microscopists—Barch (Michigan State University), Lunger (Rockefeller Institute), and Zambernard (Tulane). The new findings confirmed earlier ones made by means of electron microscopy and showed morphological similarities between viruses from Vermont and Wisconsin frogs.

Mizell (Tulane) suggested that a lysogenic-like state exists in frogs infected with renal adenocarcinoma, an hypothesis which integrates seemingly conflicting data from a number of sources. Although lysogenicity is best known in bacteria, latent herpes is another animal virus infection which resembles the lysogenic state.

The role of some fish viruses, unlike that of amphibian viruses, has been well established, and new findings were reported for several of the agents. In addition, the first "orphan virus" from fish cell cultivations was described by Clem (University of Miami). Electron microscopy and multiplication of infectious pancreatic necrosis (IPN) virus were described by Malsberger and Cerini (Lehigh University). They found that IPN virus measured 18 $m\mu$ and thus is the smallest known pathogen of fish.

Viral hemorrhagic septicemia of European rainbow trout, a serious infection with which the audience was, for the most part, unfamiliar, was the subject of a series of papers presented at the conference. The pathological behavior of the fish and the symptoms of the disease were clearly illustrated by means of color film and slides. Jensen (Denmark), who first isolated the causal agent, Egtved virus. described additional biological attributes of the virus. French workers (Besse and Bellet), while not disputing the viral etiology, firmly maintained that nutritional factors strongly influenced

the appearance and course of the disease.

From the discussions which followed the various papers it was evident that there is a need to confine viruses which cause serious diseases to their respective continents of origin; Egtved virus should be prevented from being introduced into American trout and, conversely, IPN virus should not be introduced into European trout. Because of the present lack of regulation of import and export of fish and fish eggs, it is likely that such viruses will be introduced, and researchers must shoulder some responsibility for effecting changes to prevent this.

Several papers on fish cell and tissue culture reflect the need for, and growing employment of, these techniques in fish virology. At the same time it was evident from both the sessions on amphibians and those on fish that the embryonate egg could be used to good advantage in poikilothermic vertebrate virology, as the avian egg is in homoiothermic animal virology. Similarly, there is a need for experimental animals free at least of specific infectious diseases, if not of all infectious diseases.

Cultivations of cells from poikilothermic animals have been used to propagate a variety of viruses from warm-blooded animals. Tubiash (U.S. Bureau of Commercial Fisheries) renewed a plea that such cells be considered for use in the production of vaccines for human use, since they would not be likely to introduce into the vaccine agents which are oncogenic or pathogenic to man.

The final session concerned immune reactions in cold-blooded vertebrates. Rather surprisingly, Sigel (University of Miami) found evidence that anamnesis in these animals may be defective, or at least different from that in higher vertebrates.

The conference was sponsored jointly by the New York Academy of Sciences and the Eastern Fish Disease Laboratory of the U.S. Fish and Wildlife Service. The principal chairman and organizer was S. F. Snieszko, director of the Eastern Fish Disease Laboratory.

It is of historical interest that this was the first such conference of international scope; participants included representatives of Canada, Denmark, France, Germany, Israel, Italy, Yugoslavia, Switzerland, and the United States. In addition, the titles of papers contributed from East European countries were read, their authors' attendance being prevented because of complex international relations which obstruct scientific communication and progress.

The collected papers from this conference will be a prime reference for many years in vertebrate microbiology, pathology, and immunology.

KEN WOLF
Eastern Fish Disease Laboratory, Kearneysville, West Virginia

Thin Films: Nucleation, Growth, and Structure

The first symposium of the newly formed Thin Film Division of the American Vacuum Society was held in Chicago on 29 September 1964. The theme chosen for the symposium was "Nucleation, Growth, and Structure of Thin Films." The emphasis was on new results in this field.

In his opening remarks, the division chairman K. H. Behrndt (Bell Telephone Laboratories) emphasized the importance of a better understanding of film structure for those who fabricate and use thin film devices. Such devices make use of the unique properties of thin films, as well as of their thinness; these properties more often than not are dictated or at least greatly influenced by the structure of the films, which includes crystalline orientation, grain size, strain, defect structure, surface roughness, and concentration of impurities. The structure in turn is determined by the phenomena which control the nucleation and growth of the film. This is true regardless of the method of film preparation.

The application of the electron microscope to the study of thin film growth, making possible direct observation of the film as it is deposited, has had a large impact on our understanding of the initial stages of film growth. H. R. Poppa (General Dynamics/Astronautics) reported on some new results he has obtained with this technique. So far most of this work has been of qualitative nature. At this meeting, he described quantitative investigations of the nucleation and growth process as it occurs for silver on carbon substrates at incident beam fluxes of the order of 10^{13} atoms per square centimeter per second. It was possible to infer the surface diffusion energy of silver on carbon substrates as about 20 kcal/mole.

Electrodeposited films have traditionally been neglected in previous meetings of this type. The paper by K. R. Lawless (University of Virginia) was therefore received with special interest. Using electron diffraction and electron microscopic techniques, Lawless studied the growth and structure of nickel, gold, and copper films electrodeposited on single crystal metal substrates. He concluded that continuous films of these metals develop at thicknesses of less than 50 Å, except for gold films, which may be discontinuous longer on specific substrate crystal faces. Deposits of copper and nickel showed a very nearly perfect orientation relationship to the substrate for all thicknesses up to 1000 Å, but gold films had a tendency to develop polycrystalline areas above 500 Å. The structure of the electrodeposited films in this study was found to be a very critical function of substrate surface conditions and the plating current, but these films seemed to be generally more nearly perfect than vacuum-deposited films.

Nucleation and the coalescence of nuclei were discussed by R. F. Adamsky (P. R. Mallory and Co.) in a paper on the growth of epitaxial films of gold and silver films. Nuclei as small as 5 Å have been found. Coalescence to form larger islands depends on the mobility of atoms and clusters on the substrate. This mobility was found to be highest on deposited single crystal substrates. The density of the nuclei was counted as a function of evaporation time and was found to vary sharply with deposition time and substrate temperature. Nucleation rates were measured as a function of substrate temperature.

The influence of gases on the growth and structure of thin films was the subject of a paper by E. Bauer and G. Turner (Michelson Laboratory, China Lake, California). This paper was concerned with the theory of the accommodation and condensation coefficient of gases on crystals, and their effect on the crystal growth proper, that is, after the nucleation step. Comparisons with experimental data were made, but this paper brought out clearly that there is much still to be learned about the influence of gases on thin films.

Recent work on the structure and annealing behavior of thin copper and gold films deposited at temperatures near 80°K on glass and then annealed to temperatures up to 300°C was reported by R. W. Vook and F. Witt