which is frequently commented on. At an open forum discussion of the activities of the society which was held on Saturday afternoon, many members said they enjoyed most the papers in fields other than their own, while those who present papers find it profitable and stimulating to attempt to make plain to scholars in other fields the results of their special studies. Some technical societies are at present lamenting the fact that their meetings have become so highly specialized that their programs are uninteresting or unintelligible to many of their own members and they are calling for papers of more general interest. Important discoveries can usually be presented in a manner that is intelligible to scholars in other fields, and if this can not be done they are not suitable for public presentation. Lord Kelvin is reported to have said on one occasion: "That physicist, who, having completed a research no matter how attenuated, on reaching the street can not explain his finding and its usefulness to the first man he meets, should return to his laboratory; his research is not complete."

It is probably true that general societies with non-technical programs do not notably increase knowledge in special subjects, but this is not their function. They do render an important service in stimulating wider interests and in promoting helpful associations among scholars in different fields. A society is first of all a social organization and not a library or laboratory. Information may be obtained in printed form, but nothing can be substituted for the social contacts which are promoted by such meetings.

The hospitality of Philadelphia to learned societies is proverbial, and this makes meetings in the Quaker City most enjoyable. Several years ago, when an international scientific congress was held in this country and was being entertained in various cities the general secretary of the congress telegraphed to the Washington committee asking what entertainment would be provided there. They replied that Washington would do whatever Philadelphia did. The general secretary telegraphed, "Philadelphia meets all hotel and other expenses." At once came back the answer, "Not on your life will we follow Philadelphia." The hospitality of the American Philosophical Society is probably unique among learned societies in this country; its luncheons, receptions and annual dinners are justly famous. But these are not merely gastronomic events but, much more, delightful occasions for social intercourse and scientific conferences. In addition to these general entertainments, the annual dinner given to the council of the society by one of its Philadelphia members is an event which no councillor would ever willingly miss. During the meetings all out-of-town members of the society and their wives as well as other persons who are invited to read papers are the guests of the society at a leading hotel. Undoubtedly this hospitality gives an air of friendliness to the meetings which is most delightful.

The annual business session was held on Friday morning, April 21. The president, Roland S. Morris, in his annual report stated that the invested funds of the society now amount to more than $7,000,000, with an annual income of approximately $200,000 available for general purposes. The budget allots about one half of this sum for grants-in-aid of research, $38,000 for the library, $25,000 for the publications of the society, $6,000 for the expenses of the meetings, about $10,000 for the executive office, $6,000 for the treasurer's office, $4,000 for the maintenance of the building, $6,000 for repairs and about $10,000 for miscellaneous expenses.

The committee on finance, consisting of eight of the leading financiers of Philadelphia who are devoted members of the society, meets regularly once a month and gives constant attention to the finances of the society. The committee on research, publications and library meet five times a year and devote much thought and care to these activities of the society. All committee members serve without personal compensation beyond actual expenses in attending meetings.

On Saturday afternoon, April 22, an open forum of the members for the discussion of the four principal activities of the society was held, and valuable suggestions were made for the improvement of the meetings, the library, the support of research and of publications.

The closing event of the meeting was the annual dinner, at which about 200 persons were present. The John F. Lewis Prize of $300 and diploma for an important contribution made at a stated meeting of the society, was awarded to Professor Henry Norris Russell for his lecture on February 17, 1939, on "Stellar Energy." The citation was made by Professor Harlow Shapley in an unusually happy and instructive speech and was responded to by Professor Russell. Other after-dinner speakers were Victor G. Heiser on his experiences on International Health Board, Jesse S. Reeves on "Neutrality," and Vannevar Bush on "Research and National Defense."

EDWIN G. CONKLIN

THE NATIONAL ACADEMY OF SCIENCES

ABSTRACTS OF PAPERS READ AT THE ANNUAL MEETING

(*Continued*)

Auto-equivalent functions: GEORGE D. BIRKHOFF. An analytic function $f(z)$ of a single complex variable z is called auto-equivalent if there exists a one-to-one analytic deformation $\bar{z}=\varphi(z)$ of the neighborhood of $z=\infty$ which modifies $f(z)$ only by a factor $a(z)$ analytic or with a pole at $z=\infty$: $f(\varphi(z))=a(z)f(z)$. The class of auto-equivalent functions, together with its natural extension to matrices, includes an extraordinary variety of functions having fundamental importance in analysis.

Professor Birkhoff outlines his general theory of these functions, which will appear shortly in the *Annales de l'Institut Henri Poincaré.*

Minimal surfaces of general critical type: MARSTON MORSE and C. B. TOMPKINS. Many fundamental theorems in analysis depend upon the existence of a minimum of a function. The calculus of variations extends this theory to functionals. To obtain the point of minimum it is sufficient that the function be bounded below, be lower semi-continuous and the space in which the function is defined be compact. If one seeks all the critical points or configurations in a given problem, for example, the minimal surfaces bounded by a simple closed curve with continuously turning tangent, there are many critical configurations which fail to disclose themselves upon use of the minimum methods. The authors' recent fascicle (Paris) "Functional Topology and Abstract Variational Theory," lays down general principles which can serve to replace the classical minimum principles in general problems. The present paper shows that these general principles can be applied to the theory of minimal surfaces, with proofs of the existence of minimal surfaces without minimum area resulting. This is the first example of an application of the authors' general theory of critical points to multiple integrals and seems to open up a vast new field.

Infra-red absorption of hydrogen fluoride: W. H. RODEBUSH.

Electrophoretic studies on blood sera: DUNCAN A. MACINNES and LEWIS G. LONGSWORTH. The "electrophoretic diagrams" of blood sera have been obtained by a modification of the Tiselius method, in which the gradients of refractive index in the electrophoretic boundaries are automatically recorded. These electrophoretic diagrams indicate the number, the mobilities, the amounts and the relative homogeneities of the proteins present. The diagrams of the sera of normal animals have been found to be characteristic and entirely reproducible. The diagrams for pathological sera show, however, abnormalities, the interpretation of which is only begun. Particularly interesting diagrams are obtained from the proteins of nephrotic serum and urine. Although the distribution of proteins in the nephrotic serum is decidedly abnormal the electrophoretic diagram of nephrotic urine is, very closely, that of normal *serum.*

Responses to different levels of nutritional intake of riboflavin (formerly called vitamin G): H. C. SHERMAN and L. N. ELLIS. It is found in the case of riboflavin (as has also been found with calcium and with vitamin A) that there is a wide zone between the level of merely *adequate* (minimal-adequate) intake and the *optimal* level—that which gives best results in nutritional well-being and resultant health and vitality in long-continued experiments. In the first generation the plateau of externally demonstrable nutritional well-being is attained with intakes about three times higher than the minimal-adequate which supports normal growth and health with successful reproduction and rearing of vigorous offspring. In these offspring there are detectable successive gains in nutritional welfare with successively increased riboflavin value of the family dietary up to at least seven to ten times the minimum adequate riboflavin content of the food mixture. These further gains are, as yet, shown chiefly through increased capacity for growth both on their respective family dietaries and on a riboflavin-deficient diet. The findings are discussed in terms of body storage of riboflavin and of the influence of the level of intake of this substance upon the body's internal environment or general tissue condition.

Experimental results supporting the "fluid flow" theory of the biological action of ionizing radiations: G. FAILLA and K. SUGIURA (introduced by Harold C. Urey). In 1937 one of us[1] proposed a theory of the biological action of ionizing radiations, relating particularly to effects produced in living tissues when only a part of the animal's body is irradiated. According to this theory it should be possible to increase the radiosensitivity of a tissue by increasing its circulation and particularly by injecting (sterile) distilled water into it at different intervals subsequent to irradiation. An experiment to test this point has been carried out during the last six months, using animal tumors as the test tissue. The results are shown in Table 1. These results were obtained by injecting into

TABLE 1
EFFECT OF X-RAYS AND DISTILLED WATER ON THE GROWTH OF MOUSE SARCOMA 180 IN VIVO

X-ray dose in Roentgens	Per cent. tumor regressions	
	X-rays alone	X-rays + H_2O
500	2	30
750	13	60
1000	50	100
1800	100	100

the tumor 0.5 cc of sterile distilled water a few times a day during the first three or four days following local irradiation of the tumor with x-rays. Similar injections of distilled water into non-irradiated tumors do not cause regressions. Irrespective of any theoretical considerations it is evident that the radiosensitivity of Sarcoma 180 may be increased markedly by injections of distilled water following local treatment with x-rays.

Degrees of sterility in the female rat held on E-free rations: HERBERT M. EVANS and GLADYS A. EMERSON. It is well known that 500 mg of wheat germ oil or 3 mg of α-tocopherol will enable young mature rat females which have been reared and held on an E-free diet to give birth to normal-sized litters of living young. This curative dose of vitamin E is inadequate shortly after the eighth month of life, but a double or treble dose will act curatively. At the close of the first year of life the birth of living young can still be provoked by the administration of eight to ten times the original minimal effective dose. Older females conceive and implant, but the young can not be rescued by any practicable dose level of vitamin

[1] G. Failla, "Some Fundamental Aspects of the Cancer Problem." Supplement to SCIENCE, Vol. 85, 1937.

E. The cause of what appears to be increasing need for E on the part of the embryos is entirely obscure.

The relief of symptoms in major trigeminal neuralgia (tic douloureux) following the administration of massive doses of vitamin B_1 supplemented in some instances by concentrated liver extract: H. BORSOOK, M. Y. KREMERS and C. G. WIGGINS (introduced by T. H. Morgan and Max Mason). Major trigeminal neuralgia (tic douloureux), a disease of man, offers the following advantages for the study of the physiology of pain and of the chemical physiology of the nervous system. The disease in most cases (96 per cent.) is unilateral, and is restricted to the sensory distribution of the trigeminal nerve. The main symptom is intense facial pain. The effect of parenteral administration of large doses of vitamin B_1 in relieving the pain in this disease has been studied. The vitamin B_1 was given by intravenous injection in doses which varied from 10 mg to 100 mg. This was given every day six days a week. A well-balanced diet was supplemented by a daily intake by mouth of one ounce of an aqueous concentrate of the vitamin B complex containing 1,500 I. U. of vitamin B_1; and of a fish liver oil containing 9,000 vitamin A units (U. S. P. X1) and 1,700 vitamin D units (U. S. P. X1). No analgesics were used. Measurements have been made of the chronaxie and the sensory thresholds of the pain spots in the affected parts of the face and compared with the corresponding points on the opposite side of the face. No difference was observed between the two sides. Eleven cases have been under observation for eleven months; forty-five cases for six months. Of the cases observed for eleven months seven became practically symptom free in three months after treatment was begun and have remained so since without further injection of vitamin B_1. Two improved to a lesser degree. One showed no improvement. Essentially the same results were observed in the other forty-five cases under observation now for six months. In ten cases in which there was no improvement or incomplete recovery following the administration of vitamin B_1 in large doses for three to four months, there has been marked improvement when, in addition to the vitamin B_1, large doses of concentrated liver extracts were injected intra-muscularly every other day. A crude preparation containing one anti-pernicious anemia unit per cc but rich in other constituents of the liver was less effective than a more concentrated preparation which contained fifteen units per cc of the anti-pernicious anemia principle but less of other materials extractable from liver. No cases have yet been treated with liver extract alone. There are among the cases showing marked improvement a number over seventy years old who have had the disease in some instances for more than twenty years.

A law of denervation: WALTER B. CANNON. When nerves which deliver impulses to smooth muscle, skeletal muscle and glands are severed and allowed to degenerate the denervated structures become specially sensitized to excitant or depressant drugs. Nerve cells which receive impulses from other nerve cells may be regarded as being innervated by them. Section of fibers which convey impulses to the nerve cells of a ganglion, for example, renders these cells more sensitive to chemical stimulation. Partial denervation has a similar effect. Likewise, when nerve cells in the spinal cord are partially deprived of the connecting fibers which normally influence them, the "denervated" cells become more readily excitable by chemical agents or by a chemical change in the blood.

The chemical composition of the gaseous nebulae: I. S. BOWEN and A. B. WYSE. The lines hitherto observed in the spectra of the "gaseous" nebulae are for the most part attributable to gaseous elements, such as hydrogen, helium, nitrogen, oxygen, etc. Many of the lines are known as "forbidden lines," since they are not ordinarily observed in the laboratory; in the conditions of extremely low density obtaining in the gaseous nebulae, however, the "forbidden lines" are frequently stronger than the so-called "permitted" or ordinary laboratory lines. We have recently made long-exposure photographs of the spectra of three of the brightest planetary nebulae. In one or more of these objects, more than fifty new lines have been observed, of which nearly one half have been identified. In addition to the gases and a few other elements already known to be present, we find evidence for the existence in the nebulae of silicon and of the metallic elements, magnesium, potassium, calcium and iron. The relative abundance of the various elements in a planetary nebula can be roughly calculated from the intensities of the spectral lines, if the physical conditions of the nebula are taken into account. Such a calculation has been made for one of the nebulae observed, NGC 7027, which happens to be especially suitable for the purpose. (As far as present observations go, there is no reason to doubt that NGC 7027 in its chemical composition is typical of the "gaseous" nebulae in general.) Russell has already determined, in a somewhat analogous manner, the relative abundance of the chemical elements in the sun's atmosphere. In spite of the extreme difference in appearance between the spectrum of NGC 7027 and that of the sun's atmosphere, we find no evidence for any difference in chemical composition between the two objects. When an element is observed in the one object and not in the other, the apparent difference is attributable to differences in physical conditions, such as temperature and density, rather than to differences in chemical composition.

Determination of a stellar darkening coefficient from observations of an eclipsing variable: GERALD E. KRON (introduced by W. H. Wright). It is known, from observation of the sun and the implication of simple theory, that stellar disks are dimmer near their edges than at their centers. The amount of this "darkening at the limb" is an important physical constant; observation of its dependence upon temperature and color would aid theory, and make possible more accurate determination of fundamental physical constants of stars. The eclipsing variables, double stars partially or wholly covering each other during orbital revolution, offer the only known means of observing limb darkening. The way in which the light varies as an eclipse progresses will depend upon the degree of uniformity of illumination of the stellar disks. The shape of the "light curve" is affected also

by other physical constants of the system. These additional constants as well must be determined from the light curve. Altogether the problem is so complex as to make strong demands upon the data of observation. and the precision of photometric measurement has heretofore been insufficient to permit disentangling the effects of darkening from other somewhat similar ones due to other causes. A photoelectric photometer was recently constructed for use with the 36-inch refractor of the Lick Observatory. It employs a Kunz potassium hydride photocell sensitive to deep blue light, operating in the circuit of a direct current amplifier. Good observing conditions, the comparatively large size of the telescope and the use of a special optical device that permits the almost instantaneous comparison of two stars have made it possible to obtain unusually accurate photometric observations. The eclipsing variable YZ (21) Cassiopeiae was observed with this instrument. A complete light curve with two minima defined by 54 normal points having probable errors of ± 0.0011 magnitude was obtained. Approximate values were assumed for six physical constants of the stellar system, namely, the darkening coefficients and radii of each star and the orbital inclination and eccentricity. Corrections to these elements have been derived by a method of "least squares" adjustment newly developed by A. B. Wyse. The derived value of the darkening coefficient is $0.502 \pm .037$. The relatively small ratio of the probable error to the total possible range of the quantity itself (4 per cent.) is an indication of the close accordance of observation and theory, and is regarded as justifying the analytical procedure employed.

Solar variation and weather: C. G. ABBOT. Author presents a diagram showing the average march of departures from normal temperature at Washington for 16 days following 320 occasions of rise or fall of the sun's radiation as measured at Montezuma, Chile. Data were separated into 12 groups, one for each month of the year, for the average march of departures differed from month to month. Well-marked opposition of the curves is shown following, respectively, rise and fall of the sun's radiation. Large solar changes are followed by large temperature departures. Results of the first 6 years agree closely with results of the last 6 years covered. To clinch the demonstration, author computes the march of temperature departures similarly for 16 days preceding the dates of solar change. He correlates the results preceding and following those dates. Prior to solar changes the correlation coefficient between rising and falling cases is $+11 \pm 6$ per cent., which is meaningless. Following solar change the correlation is -54 ± 5 per cent., eleven times its probable error and therefore significant. The separation of temperature departures following rise and fall of solar radiation frequently exceeds 10° and sometimes even 20° F., though the average solar change is but 0.7 per cent. Solar variation, therefore, appears to be a major influence in weather, and if solar constant values accurate to $\frac{1}{8}$ per cent. could be obtained daily they would seem to afford means of predicting details of weather for two weeks in advance.

Geologic growth of Asia: BAILEY WILLIS. Among the generally accepted traditions of geology is the assumption that continents are ancient features of the earth's crust, with essentially their actual form, and that they originated in some primeval stage of cooling or crustal formation. It has long been known that they consist chiefly of granite, which has been uptruded from within the globe, and it is now established that the molten granitic bodies spread out in the form of thin discs in the outer crust. While perhaps several hundred kilometers in diameter, any such disc is usually not over 30 kilometers thick, and the underlying rock is commonly basalt. It is recognized that each one of the great continents is made up of a number of such discs of granite, between which the granitic layer may be relatively thin or be represented by smaller intrusions, or be lacking altogether. Thus the concept that a continent is a vast expanse of primeval granite is replaced by the fact that each continent is a mosaic of comparatively small nuclei, which may be more or less closely contiguous or widely separated. Furthermore, it is established by the relations of the intruded granite to fossiliferous strata or by radio-active analyses of the granites themselves that the intrusions differ greatly in age. Some are as much as one or two billion years old; others reached the outer crust as recently as sixty to thirty million years ago. The younger eruptions have tended to rise around the older bodies or between them and they thus fill in the interspaces. The process constitutes continental growth. It has been in progress since the earliest ages of geologic history and presumably is still active. In this paper the known granitic nuclei of Asia are enumerated, according to the data contributed by British, Russian, Chinese, Japanese and American geologists, and it is shown that continental Asia has grown from a few widely separated nuclei of Archean age to the actual expanse by successive uptrusions of granite, very important additions having been made during the Mesozoic era and some even as lately as in Tertiary time. The conclusions have critical bearing upon theories of continental permanence, continental drift and paleogeography.

A hypothesis of submarine canyon origin: DOUGLAS JOHNSON. The origin of submarine canyons of great depth cut far back into the margins of the continental shelves has been debated for more than fifty years. No wholly satisfactory solution of the problem has as yet been found. The following working hypothesis is offered for consideration: Water expelled from consolidating sediments and water under artesian pressure moving through the sediments may find exit in the form of submarine springs on the deeply submerged seaward face of the continental shelf. Spring sapping on land is known to have produced canyons in a relatively brief interval of time. Spring sapping along the shelf margin continuing throughout long periods of geologic time could conceivably produce the results observed. Past geological conditions are believed to have favored this method of origin. Acceptance of the hypothesis would dispose of most of the difficulties confronting other explanations of submarine

canyon development. The explanation at present most popular, that the canyons are normal river valleys deeply submerged, calls for very great vertical oscillations of land level or sea level. Evidence corroborative of such great changes is lacking. Erosion by submarine currents is widely questioned on the ground that the potency of such currents seems small in comparison with the results achieved. Various other interpretations meet difficulties equally formidable. It is believed that the hypothesis of spring sapping under conditions similar to, but not identical with, those now existing on land has advantages which make it worthy of serious consideration.

Biographical memoir of Wallace Hume Carothers: ROGER ADAMS. (Read by title).

Biographical memoir of Edwin Herbert Hall: P. W. BRIDGMAN. (Read by title).

SPECIAL ARTICLES

AN INTERMEDIATE HOST FOR THE SWINE INFLUENZA VIRUS

SWINE influenza is a disease in which two infectious agents, one a virus and the other a bacterium, are etiologically essential. The disease, either as it occurs naturally in the field or as it is transmitted experimentally in the laboratory, is highly contagious, and no intermediate host is required to explain its epidemiology, once an epizootic has started. However, no satisfactory explanation of how or where the disease persists during the 8 or 9 months elapsing between the yearly epizootics has yet been advanced. During such interepizootic periods the swine population in the middle western hog-raising states is, so far as can be told, free of swine influenza. The bacterial component of the etiological complex, *H. influenzae suis,* can persist apparently indefinitely in the upper respiratory tracts of some recovered swine, but similar persistence of the virus can not be demonstrated. The origin or source of swine influenza virus responsible for the fresh epizootics each autumn thus has remained obscure. It is with the epidemiology of these "first cases" of swine influenza that the experiments to be briefly outlined in the present paper are concerned.

Because the swine lungworm, a nematode parasitic in the bronchioles of the bases of the lungs of swine, enters prominently into the experiments to be described, a short account of its life cycle, as determined by the Hobmaiers[1] and by Schwartz and Alicata,[2] will be given. The cycle in brief is as follows. The embryonated lungworm ovum passed in the swine feces is swallowed by an earthworm, in which it hatches as a first-stage larva. After undergoing development within the earthworm the larva eventually reaches its third stage in which it is capable of infesting swine. It remains in this stage until its earthworm intermediate host is ingested by a swine, when it is liberated, penetrates the swine intestinal mucosa and migrates to the respiratory tract by way of the lymphatics and blood stream. The whole of this cycle can occupy a span of several years for its completion or, under the most favorable conditions, can be completed in slightly less than one month. Lungworms constitute a very common parasite in swine reared under the usual farm conditions.

In the present experiments feces and bronchial exudate, containing embryonated lungworm ova, and adult lungworms were obtained from swine that had been ill of swine influenza for from three to five days. This material, after mincing the adult lungworms with scissors to free their ova, was mixed with loamy topsoil and fed to earthworms. Beginning one month later, earthworms were removed from time to time, from the barrels of earth in which they were kept, for use in experiments. They were fed to swine intact but usually mixed with a small amount of dry grain feed. Two swine fed in this way in the first experiment remained apparently normal, and it seemed that the experiment must be interpreted as negative. These two particular swine had, prior to their earthworm feeding, been used in another experiment during the course of which they had received three intramuscular injections of a suspension of live *H. influenzae suis* at eight-day intervals. They had developed no illness. After the apparently negative result of the earthworm feeding there was occasion to inject them again intramuscularly with a suspension of live *H. influenzae suis.* On the third day following this injection they developed clinically typical swine influenza. With this fortuitous suggestion that a provocative stimulus was required to elicit infection, other similar experiments were conducted. Swine were fed the lungworm-infested earthworms and developed neither illness nor virus-neutralizing antibodies. After a period of observation of from 11 to 30 days they were injected intramuscularly with a suspension of living *H. influenzae suis.* No illness resulted from the first injection. However, when the injection was repeated eight days later, characteristic swine influenza resulted after three days.

In other experiments the procedure was varied to coincide with that of the initial experiment, and in these the swine received two preliminary intramuscular injections of suspensions of live *H. influenzae suis* at

[1] A. Hobmaier and M. Hobmaier, *Münch. Tier. Woch.,* 80: 365 and 433, 1929.

[2] B. Schwartz and J. E. Alicata, *Jour. Parasit.,* 16: 105, 1929–30; 18: 21, 1931; and *U. S. Dept. Agric. Tech. Bull.* No. 456, 1934.