within the reach of students who are unacquainted with mathematics beyond the calculus. But such students are not yet properly prepared to enter a subject like theoretical seismology. By presuming on a little more acquaintance with the powerful mathematical tools that are available the author could have greatly shortened and simplified the treatment of elastic waves. For example, the set of equations at the top of page 30 would be replaced by the shorter and easier statement that the matrix $A$ is a diagonal transform of $X$ by the orthogonal matrix $l$, and the reductions in Sections 68 and 69, which must appear very fortuitous to the student, would be presented as an application of a general theorem on the decomposition of a vector field into solenoidal and irrotational components. There would then be space for such topics as the work of Uller, Sezawa, and others on seismic waves, the method of Pekeris, a comparison of the travel-time curves of Jeffreys, Wadati, Gutenberg and Richter, and Macelwane, and a study of the earth's core, for which no satisfactory theory has yet been given. A discussion of these subjects written in as clear a style as the rest of the book would be most welcome to workers in seismology.

ARCHIE BLAKE
U. S. COAST AND GEODETIC SURVEY

# THE NATIONAL ACADEMY OF SCIENCES

## ABSTRACTS OF PAPERS[1]

*Measurement of solar radiation from high altitude sounding balloons:* BRIAN O'BRIEN, L. T. STEADMAN and H. S. STEWART, JR., introduced by Charles G. Abbot. Light received by a crushed quartz diffuser, with circular entrance aperture lying in horizontal plane when instrument is suspended at rest, reaches vacuum photocell mounted beneath diffuser with filter selecting desired spectral region. Identical area of photocell surface is illuminated irrespective of angle of incidence of solar beam. Photocurrent discharges condenser which on recharge causes radio transmitter to emit short dash. Frequency of dashes is proportional to light incident upon photocell. If instrument is suspended at rest with Sun at zenith angle z, the light intensity incident upon photocell is $I_h = k\ I_o \cos z$ where $I_o \equiv$ intensity of incident solar beam and $k \equiv$ instrument constant. An instrument suspended from a rising balloon swings as a conical pendulum of varying amplitude and ellipticity. For circular motion at half angle $\alpha$ the average intensity received by the photocell through one complete swing is $I = k\ I_o \cos z \cos \alpha$, the instantaneous values varying from $k\ I_o \cos (z - \alpha)$ to $k\ I_o \cos (z + \alpha)$. Since ten or more radio signals are transmitted during one complete swing and interval between any pair provides measure of intensity these yield directly the amplitude of swing and permit calculation of $I_o$ from observed values of I.

Test flights made above 20 km exhibit good radio performance to 80 km distance. Instrument swing observed by telescope agrees with amplitude determined from radio signals. Complete unit weighs 1 kilogram including batteries for three hours operation. Laboratory tests indicate response is reproducible to one part in 200. Circuit is self-compensating for fluctuation in battery potential. It is hoped that a precision in radiation measurement of the order of 1 per cent. may be maintained on an absolute scale, but further refinements are needed before this can be assured.

*Regulation of heat loss from the human body:* JAMES D. HARDY and EUGENE F. DU BOIS. Experiments have been performed on two normal men to study the regulation of body heat loss when exposed nude to environments ranging from 22° C. (72° F.) to 35° C. (96° F.). In the temperature range from 30° C. (87° F.), to 32° C. (91° F.) the body eliminated a minimum amount of heat, and this was equal to the basal heat production. Beyond the range of this neutral zone, either in hotter or colder environments, the heat elimination from the body increased. In atmospheres of 32° C. or higher the skin temperature changed but slightly and regulation of body temperature was brought about by increased vasodilatation and sweating. The mechanism in this range is so sensitive that a 2° C. (3.6° F.) change in environmental temperature will increase the sweating about 50 per cent. and the peripheral blood flow about 20 per cent. The effect of forced air currents from an electric fan were studied. In the temperature range from 28° C. to 30° C. the increased convection caused considerable loss of heat and fall of skin temperature. At 32° C. (91° F.) the turning on of the fan caused an immediate but temporary slight fall in the skin temperature. The cooling effect of an electric fan at these summer-like temperatures lasts only a few minutes. Automatic regulation of body heat loss is effective down to 29° C., which is the low temperature portion of the neutral zone. At this point the thermal gradient, the difference between the skin and surroundings, is 4.7° C., and this is the maximum gradient at which the body can maintain its temperature. Thus as the environmental temperature is dropped the skin should cool in such a manner as to keep this gradient constant, if body heat is to be preserved. Actually the skin drops at only half the rate of the environmental temperature, and the heat from the body is not preserved. The question arises as to whether this cooling of the skin is the result of some physiological reaction of the body (even though incomplete) or of the fall in environmental temperature. As has been presented by Hardy, the conductance of the peripheral tissues in this range is constant, so that there is no evidence of significant physiological reaction. The drop in surface temperature is due to the fall in environmental temperature just as in the case of any warm inanimate object. The body cools until some mechanism, as yet undetermined, causes the onset of a chill. The muscular activity thus brought about causes a large rise

[1] Continued from the issue of SCIENCE for November 5.

in heat production and a consequent rise in skin and internal temperature. With this rise the chilling ceases and the subject remains comfortable for an hour or so before another paroxysm. The metabolism of the subjects was basal almost to the onset of the chill, and no increase in oxygen consumption was observed except as accompanied by "tensing" of the muscles or the spasmodic muscular contraction of shivering. No evidence of Rubner's "chemical regulation" was observed.

*The physical laws of heat loss from the human body:* JAMES D. HARDY (introduced by Eugene F. Du Bois). Using a large respiration calorimeter, a comparison was made between the heat loss from two nude men and that lost from a blackened cylinder (artificial man) filled with water whose temperature could be controlled. Of the two men studied the larger lost more heat than the smaller, but on the basis of the total surface areas the heat losses were the same. These men lost almost exactly the same amount of heat by radiation and convection as the artificial man per degree difference in the temperature of the surfaces of the air. The proportion of losses between radiation and convection were almost identical. In the case of the men it was of course necessary to subtract from the total the heat lost in vaporization of moisture, about 24 per cent. It was also necessary to allow for the fact that the surfaces between legs and under the arms, etc., do not lose heat by radiation and convection. The effective surfaces of their bodies concerned in the loss of heat calculated from a comparison with the artificial man came to 79 per cent. of the total surface areas. Calculated by photography and actual measurements the values were 78 per cent. to 80 per cent. As soon as the men moved the heat lost in convection was increased and the surface temperature dropped, causing a decrease in radiation. More heat was eliminated through the cooler skin than had been eliminated through the warmer skin. This apparent contradiction of Newton's cooling law had been observed by Barr and Du Bois in the shivering periods of malarial chills. The explanation of the paradox lies in the increase in convection, which is not necessarily dependent on the differences in temperatures. It is possible from such observations to measure the thermal conductance (or what is the same thing, the blood flow) of the peripheral tissue. Body tissue, itself, is highly insulating, and the heat from the internal organs may be considered as being carried to the skin by the blood stream. If the internal (or rectal) temperature, the heat eliminated and the average skin temperature be measured, it is possible to calculate the relative flow of blood to the peripheral tissues. In warm atmospheres 34° C. (94° F.) the blood flow is about three times as large as the rate at 28° C. As the environment is cooled the blood flow decreases to a minimal rate at 28° C. (83° F.) and remains at about this level, even though the environmental temperature drops to 22° C. (72° F.), at which point the subject will shiver in a relatively short time. This means that vasomotor adjustment in man is limited largely to the high temperature range and that vasoconstriction at lower temperatures plays a minor rôle in insulating the body against cold.

*Rates of adjustment of body water content:* E. F. ADOLPH (introduced by L. J. Henderson). Water balance may be described by correlating rates of water intake and output with the water contents of the organism. Such relationships are illustrated by data for dog and man. In normal dog and man, water exchanges were measured in initial periods after the water content had been either increased by introducing water into the stomach or decreased by periods of water privation. In a dog provided surgically with esophageal fistula, so that drinking could be measured without the water drunk gaining access to the body, rates of intake were ascertained also during steady states of desiccation. At diverse water contents, output varied markedly by only one path, namely, urine formation; and gain varied by one path, namely, ingestion. The rates of intake and of output were equal at only one water content, namely, the usual one. Whenever the content of water was experimentally modified, it returned rapidly to this usual content; in deficit by faster net gain, in plethora by faster net loss. The two species showed quantitative differences in urine outputs as related to body weights. In half an hour, dogs fully made up any water deficits, but men ingested only one third to two thirds of the water required. Similar correlations of rates of adjustment with states of deficit and plethora have been made for other species and parts of organisms, and for other substances, energies and forces. Each describes quantitatively a kinetic equilibrium by which a constancy is reattained after displacement.

*Studies of water metabolism in pregnant women:* W. T. POMMERENKE (introduced by Carl G. Hartman). Visible edema, inordinate gain in weight and suppression of urinary output provide crude evidence of water storage in certain toxemias of pregnancy, notably in the convulsive state of eclampsia. It has been suggested that the convulsions of eclampsia and certain other symptoms of toxemia of pregnancy are due in part to this excessive water storage. To what extent the alleged deposition of water also relates to normal pregnancy is not so clear and forms the basis of this study. Water made available to the organism comes from that ingested as such, or with food, and that liberated as a result of metabolism. The water output represents in addition to the obvious water in the urine and stools that lost through the skin and lungs which can be estimated by indirect methods, depending on the metabolism of the individual. The algebraic sum of water made available to and that lost from the body represents the water balance. Controlled experiments on 3 pregnant women over periods from 5 to 12 days demonstrated storage of water. This observation was confirmed by studies of electrolyte balances and concentration of bases in the blood, the assumption being that such bases are lost by the body in about the same proportions as they appear in the plasma.

*Oxidation of the phospholipids:* W. R. BLOOR (introduced by G. H. Whipple). It had previously been found that oxidized phospholipid could transfer oxygen to reduced methylene blue at body pH (7.4). Attempts were

made to use it to oxidize dextrose under the same conditions. The attempts were without success even when air or oxygen was passed through the solution. It was observed, however, that the pH of the solution was lowered, which indicated that some oxidation had taken place, presumably in the phospholipid. The amount of oxidation was not great. Oxidation of phospholipid was then attempted with hydrogen peroxide at 37° C. and pH 7.4. Purified brain lecithin and cephalin were suspended in neutralized 30 per cent. hydrogen peroxide and kept at 37° C. for 24 to 48 hours. The solutions were then extracted with ether and the extracts analyzed. It was found that under these conditions about 75 per cent. of the lecithin had disappeared but only about 25 per cent. of the cephalin. The residue from the cephalin consisted largely of insoluble material, while that from the lecithin resembled the original lecithin, although the iodine numbers of the fatty acids had been greatly reduced. The products of the oxidation consisted largely of carbon dioxide and volatile acids the nature of which has not yet been determined.

*A chemical study of the balance sheet of fat absorption in the rat:* MATHIAS F. F. KOHL (introduced by D. D. Van Slyke). Balance sheet studies on the absorption of elaidic acid, the stereo-isomer of oleic acid, have been carried out on male rats weighing approximately 100 grams. The studies were made over hourly and daily absorption periods using two dietary régimes, the feeding of elaidin as the sole food source and as 40 per cent. of the caloric intake. The rates of absorption and disappearance of the absorbed elaidic acid are different under the two régimes but are found to be relatively continuous and constant. When elaidin alone is fed, most of the absorbed fat is apparently consumed in the vital processes of the organism with the deposition of only a small part of the absorbed fat. When ample protein and carbohydrate are supplied along with the elaidin, the amount of the absorbed fat disappearing is markedly reduced with a consequent greater storage of ingested fat. Elaidin when once deposited in the adipose tissue disappears at a slow rate; over thirty days are required to clear the depots of the elaidic acid that is deposited when elaidin is fed over a three-day period as 40 per cent. of the caloric intake. The conclusion is drawn that the elaidin that is continually being absorbed from the intestine is used to supply the energy requirements of the tissues for fat. This demand is reduced by an ample supply of protein and sugar which the cells catabolize preferentially to fat. The absorbed fat in excess of this cellular demand for fat is removed from the circulation into the fat depots, where it remains as a relatively inert deposit until periods of under-nutrition, when it is called forth again to supply the metabolic needs. Definite regulatory mechanisms of fat metabolism are in evidence, but nothing is known of their nature.

*Experimental diabetes insipidus:* ROWLAND T. BELLOWS and WILLIAM P. VAN WAGENEN (introduced by Harvey Cushing). Diabetes insipidus is generally considered to be an abnormally increased secretion of urine. There are other phenomena observed in the disease, however, which have been largely ignored. These suggest that it is a fundamental disorder in the water metabolism, in which the abnormally increased thirst, or polydipsia, is of prime consideration. In the experimentally produced disease in dogs the water intake appears to govern the amount of urinary output, and when the water intake is restricted the animals appear to remain in water balance. Dogs with diabetes insipidus gain weight and become obese when their thirst is satisfied, but fail to do so when the water intake is restricted to the normal amount. When diabetes insipidus is produced in dogs with fistulae of the esophagus, it is found that the animals continue to be thirsty, even though they are maintained in water balance by the administration of water per esophagus. These considerations suggest that the excessive thirst plays the leading rôle in diabetes insipidus rather than the polyuria and that the satisfaction of the polydipsia leads to the chronic retention of water. Two forms of diabetes insipidus are generally recognized—temporary and permanent. Our studies reveal a peculiar relationship between them. They appear to possess different characteristics than mere duration and to depend upon a different type of injury in the pituitary region for their production.

*Biographical Memoir of Edward Salisbury Dana:* ADOLPH KNOPF. (Read by title.)

*Biographical Memoir of Edwin Brant Frost:* OTTO STRUVE. (Read by title.)

*Biographical Memoir of Robert Simpson Woodward:* F. E. WRIGHT. (Read by title.)

# SPECIAL ARTICLES

## ANTIRABIC IMMUNIZATION WITH CULTURE VIRUS RENDERED AVIRULENT BY ULTRA-VIOLET LIGHT

PREVIOUS investigators have shown that rabies and poliomyelitis viruses, among others, may be rendered avirulent by ultra-violet light.[1] But reports in the literature indicate that a virus thus made avirulent is unable to immunize animals against a test inoculation; according to these experiments, immunizing potency is retained only when virulence has not been completely destroyed.

Evidence is presented in this communication showing that rabies virus may be exposed to ultra-violet

[1] G. Sankaran and W. A. Beer, *Indian Jour. Med. Res.*, 22: 581, 1935; John E. Gordon and Thomas P. Hughes, *Jour. Immunol.*, 30: 221, 1936; J. A. Toomey, *Amer. Jour. Dis. Child.*, 53: 1490, 1937.