dissolved atoms, can not be reconciled with the fact that no change in the lattice parameter can be detected by x-rays. It also contradicts the observation that the atomic influence decreases with increasing concentration of foreign atoms.

The latter conclusion seems to be more probable, since the formation of block-like complexes within a crystal produces large additional surfaces which absorb foreign atoms and thus form potential thresholds preventing the development of large free paths of electrons necessary for the crystal diamagnetism. It is obvious that the amount of foreign atoms necessary to form absorbed layers is many times smaller than the amount necessary for any volume-distortion. Furthermore, the change in internal surface conditions would scarcely be detectable by x-rays.

The size of these complexes calculated from the influence of foreign atoms comes out to be of the order of 1 micron (10^{-4} cm) and is in good agreement with the size observed microscopically by Goetz and is also in qualitative agreement with the theory of Zwicky of the secondary structure of crystals.

This picture of a crystal leads to certain predictions:

(1) The crystal diamagnetism should decrease as soon as the size of the crystal is less than the size of a crystal complex (secondary unit). (It was observed recently, first by Vaidyanathan, that colloidal particles of diamagnetic metals show smaller susceptibilities below a size of 1 micron.)

(2) The crystal diamagnetism should be influenced by any other change of the internal surface in the crystal. (The dependence of the diamagnetism of Cu on irreversible deformation was observed by Bitter, Lowance and Constant.)

(3) The electric conductivity—depending as well on the electric "transparency" of the crystal—should be affected the same way as the crystal diamagnetism. This was found true by Honda and his collaborators for the average susceptibilities on polycrystalline material.

It seems that the experiments described allow an insight into the constitution of a solid metal from a new angle; they also tie the crystal diamagnetism—a hithertofore isolated phenomenon—on to known electric qualities.

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THE NATIONAL ACADEMY OF SCIENCES. II

Certain factors determining the direction of growth of nerve fibers: H. S. BURR (introduced by R. G. Harrison). A problem which has baffled students of the nervous system for many years is the determination of the factors which direct the growth of nerve cell processes and fix their termination. We do not know why olfactory nerves always end in olfactory centers. We do not know that motor neurones from the brain always end at the proper level of the spinal cord for the innervation of specific groups of muscles. These have been generally assumed. If they are true we need to know what factors in the nervous system and its environment bring them about. Several years ago while studying a related problem an amazing result appeared in a number of experimental conditions. Transplantation in Amblystoma of an additional olfactory organ adjacent to that of the host resulted in the outgrowth of an olfactory nerve from the transplant, which, instead of joining the olfactory nerve of the host, grew into the wall of the brain a considerable distance behind its normal termination. Not all olfactory fibers followed this course: some did run with those of the host into the forebrain, some followed the branches of nearby nerves to the skin, still others wandered blindly in the environing mesenchyme. These latter conditions can be explained partially on the basis of known facts, but the problem in which a new connection is established with the brain is not so easily solved. It is of fundamental importance that an adequate answer be reached, for the inherent implications are far-reaching. In the experimental condition we have a specific nerve establishing a new, different, one might almost say wrong connection in the brain. If such a thing is possible under experimental conditions it implies that the factors which bring it about are fundamental to the organization of the nervous system. Further, it implies that in given conditions neurones, instead of having their connections established according to a fixed pattern determined by the genetic history of the individual and its interplay with environment, may make contacts that are different and new. If this be true, then environmental circumstances, if they are of the proper sort, may alter the pattern of organization of the nervous system and thus profoundly affect behavior. What, then, are the environmental changes that bring about this new pathway of growth in olfactory neurones? An analysis of 175 experiments shows that conditions are right for the new connection in 29 cases. Of these 17 occurred after operations at one particular stage of development (Harrison stage 32). Furthermore, though outgrowth of olfactory fibers does not begin until five days after the stage of operation, at that time the wall of the brain is full of mitotic figures confined, however, to the relatively restricted area to which the nerve fibers eventually reach. Rapid cell division has been shown to be an index of high metabolic activity and the latter to be the head of a physiological gradient. In all probability this gradient, acting through the medium of a bioelectric field, attracts the growing olfactory nerves. These reach the area and, as has been shown elsewhere, stimulate the contained cells to continued cell division. An augmentation of the

gradient must then follow with profound effects upon all neurones in the field. The results of the experiments here presented are by no means conclusive, but they give definite clues as to the direction of continued research. At present all we can say is that our evidence suggests that areas of high metabolic activity are important elements in determining the organization of the nervous system. Factors, then, which stimulate or inhibit cell division could profoundly alter the pathways of neurones and hence the fundamental pattern of the nervous system with resulting changes in behavior. Such control is undoubtedly present normally in all vertebrates. Minor changes in the time relations of regulation may account for the development of amodal behavior in all forms but especially in man where the elaboration of the nervous system is greatest.

The developmental morphology of infant behavior pattern: ARNOLD GESELL (introduced by R. M. Yerkes). This paper reports methods and illustrative results of a systematic survey of behavior patterns throughout the first year of life. The survey has been in progress for five years and has been accomplished through coordinated studies by research members of the staff of the Yale Clinic of Child Development. The subjects were normal infants selected as to race, parentage and socio-economic factors. Twenty-five children have been examined at lunar month intervals from four weeks through fifty-six weeks of age. The infants were observed in a specially designed clinical crib under controlled conditions. The data cover the fields of posture, locomotion, prehension, manipulation, attentional regard, exploitive and adaptive behavior. The behavior of selected infants is being investigated in detail by photographic methods. By means of a photographic observatory equipped with a one-way-vision screen it has been possible to secure systematic cinema records of characteristic behavior at fourteen successive age levels. In experimentally controlled situations, like the prehension of a pellet or the exploitive manipulation of three cubes, the cinema proves an effective tool for the registration and analysis of behavior pattern. The cinema registers the sequence within a behavior episode; it chronicles the developmental changes in pattern at successive age levels; it preserves an authentic record which may be subjected to objective and comparative analysis. Each record incorporates its own time and space values which can be quantitatively expressed. Four feet of 16 mm film embody 160 frames, which depict 160 phases of a behavior episode, 10 seconds in duration. Repeating such a behavior situation at six advancing age levels yields a developmental record with over a thousand cinema frames or pattern phases. Cinema records aggregating 85,000 feet have been classified and catalogued by library methods. Specimens from the photographic records and from the analytic protocols will be shown to illustrate the use of cinematography in the charting of behavior forms. A special reel will show simultaneously in juxtaposition the behavior patterns of the selfsame infant in an identical situation at 24 and at 28 weeks of age, giving an immediate instantaneous view of a developmental increment. Structurally regarded, the behavior complex of the infant has a meaningful morphology, reflected in the developmental sequence and characteristic patterning of behavior forms. Ascertainable laws of growth are suggested by the underlying orderliness of these behavior forms and sequences. The cinema data in conjunction with the stenographic reports of the developmental examinations serve to define the increments and changing configurations of behavior growth. Systematically selected photographic records become the basis of an atlas delineating developmental trends. Using such records, we have begun the compilation of "A Photographic Atlas of Infant Behavior Patterns."

The vitamin B requirement: GEORGE R. COWGILL (introduced by L. B. Mendel).

A photometric survey of the nearer parts of the metagalactic system: HARLOW SHAPLEY and ADELAIDE AMES.

The natural history of the vibrato: CARL E. SEASHORE. This paper summarizes the present status of findings in an extended research program on the nature, the artistic legitimacy and significance, the variables, the evolution and development and the physiological basis of the vibrato in music and speech.

Modes of infection in poliomyelitis: SIMON FLEXNER. The recent epidemic of poliomyelitis has raised again the question of the modes of infection in the disease. This question is being studied with respect to verminous and human agencies of carriage of the virus and the portals through which it penetrates into the body to reach the central nervous system. The results of this study will be presented.

Genetic and histological studies on mouse leukemia: E. C. MACDOWELL and MAURICE N. RICHTER (introduced by C. B. Davenport). Each of two strains of pedigreed mice has attained a high degree of genetic homogeneity by continuous inbreeding under the same external conditions over a period of nine years. One of these strains is characterized by the regular occurrence of spontaneous leukemia in a high proportion of all the mice that survive the first six months; in the other strain no certain case of leukemia has been found. As already indicated by Slye's findings, these two strains demonstrate that spontaneous leukemia is under specific genetic control. The appearance of leukemia in the first hybrid generation (F_1) of a cross between these two strains proves that the genetic differential involved in the development of leukemia in one strain, and in its absence in the other, may produce leukemia in the heterozygous condition; that is, this differential is not a single recessive gene. The heterozygosity of the F_1 hybrids is manifest in a distinct reduction in the proportion of spontaneous cases as compared with the pure-bred susceptible strain—a situation that can not be interpreted in advance of further genetic analysis. The leukemia of any of these spontaneous cases can be transmitted to young mice of the susceptible strain by inoculations with suspensions

of splenic lymphocytes. By successive inoculations thereafter the leukemia can be transmitted indefinitely from mouse to mouse with virtually 100 per cent. susceptibility. In one of eleven lines of such inoculations the disease has been passed through 149 mice since leaving the mouse from which it arose spontaneously. The four lines of inoculations that have been carried for considerable periods agree in, (1) finding their requirements for susceptibility satisfied by mice of the susceptible strain, and also (2) by hybrids between the two strains, but (3) in no case in mice of the resistant strain; they also agree (4) in showing a marked increase in virulence during the course of the early transfers. On the other hand, the leukemias carried by these lines differ (1) in their requirements for susceptibility, as indicated by different proportions of susceptible mice in the same segregating generation following a cross between these two strains; (2) they differ in the interval before the culmination of the disease; (3) in the duration of the stage during which the mouse is obviously sick; (4) in the distribution of lesions as shown in gross autopsy as well as in the histological pictures—for example, in the appearance of a normal or enlarged spleen, and in the presence or absence of leukemic cells in the blood.

The active agent involved in these inoculations has power to reproduce itself indefinitely. It may exist in many subtle variations involving special affinities for infiltration of one or another organ or tissue. These various states may be maintained constant for long periods of time through many passages or they may change with relative frequency. If the living cell itself is not this agent, the existence of the agent is very closely dependent on the life of the cell, in that innumerable attempts to separate the living cell from such an agent have failed. The parallels between the situation in leukemia, in which both the spontaneous occurrence and susceptibility to inoculation are under the control of genetic factors, and the situation in such neoplasms as have been studied by Little, Strong and Bittner, are remarkably close and stand as evidence towards a final analysis of the nature of leukemia.

Liver edema as a reflex response to cold: HENRY G. BARBOUR (introduced by Y. Henderson). The onset of fever resembles the reaction of the body to cold. The shivering or "chill" produces extra heat, and this heat is saved by withdrawal of most of the surface circulation. That water is also lost from the blood has been shown for cold baths and many types of fever. What takes this water from the blood, and is this process significant for heat saving? Researches in collaboration with Messrs. H. T. Marshall and B. F. Aydelotte, of the University of Louisville, afford answers to both of these questions. We have shown that fever poisons (cocaine, beta-tetrahydronaphthylamine, foreign serum in a sensitized animal) while concentrating the blood increase to about the same extent the water content of the liver. We have found the liver water similarly increased in "cold" fever, which is produced by direct application of cold to the thermostatic region of the rabbit's brain. Microscopic sections of such livers show the cells swollen with water at the expense of the canals which drain the liver. But after the sympathetic nerves to the liver are cut, the rabbit's blood no longer becomes concentrated when the brain is cooled. Further, a normal dog subjected to cold baths yielded an average serum specific gravity increase of .0035. The same animal after liver denervation showed an average specific gravity increase of only .0012. This would indicate that the liver takes up two thirds of the lost blood water. Small samples of two dogs' livers were also removed under local anesthesia, with the animal at complete rest. Before applying icepacks to the chest and thighs the respective livers contained 71.8 per cent. and 72.4 per cent. of water. After about one half hour of such chilling the same livers contained 73.7 per cent. and 73.1 per cent. It seems apparent that by a reflex response to cold, acting through the brain, the liver is induced to take up water. In the last experiment cited the liver glycogen fell from 2.8 per cent. to 2.1 per cent., a well-known phenomenon which tends to create a demand for water by increasing the osmotic pressure. How does removal of water from the blood to the liver save heat? Whenever extra heat is produced, if the body is to retain a normal temperature extra heat loss is demanded. A familiar instance is exercise. Here the demand for heat loss is met largely by the pouring out of water for evaporation on the body surface—sweat in man, saliva in the dog and extra water loss through the lungs and skin of mammals in general. In five rabbits we have carefully followed the water loss in the onset of cocaine fever. It is very striking that during the first half hour of temperature rise the water loss shows no significant increase. It actually decreased in two of our experiments. This lag occurs while the liver is taking up water and the blood is concentrating. Evidently the liver can thus retard surface evaporation and delay the onset of sweating. Later on, the fever temperature being established, the water loss may be doubled or trebled. The water loss from the body then seems to keep pace with that from the liver, for an average rabbit with cocaine fever loses by evaporation 3 or 4 cc extra water per hour. This is just the rate at which the liver releases its extra water, as shown by determinations from animals killed in the various stages of fever. Thus the liver plays a significant rôle in the mechanism by which the body saves heat in response to cold or in the onset of fever.

Organs capable of producing acetone substances. H. E. HIMWICH. Muscle of the normal mammal oxidizes both fat and carbohydrate, the latter in the form of sugar. Since insulin is needed for the oxidation of sugar, muscle of the diabetic animal burns fat only. On the other hand, the character of oxidations in the brain is unchanged by diabetes, since the brain, which utilizes carbohydrate exclusively, transforms sugar to lactic acid before oxidation and lactic acid is oxidized without the aid of insulin. Unless carbohydrate and fat are oxidized simultaneously, fat can not be completely burned and toxic end-products, the acetone substances, accumulate.

Thus only organs which oxidize both fat and carbohydrate, the latter in the form of sugar, are capable of producing acetone bodies during diabetes.

The relationship between chemical composition and taste: ARTHUR L. FOX (introduced by A. F. Blakeslee). In working with phenyl thio carbamide an accidental discovery disclosed the fact that this compound is tasteless to certain individuals, while to others it is extremely bitter. As slight alterations in chemical structure often cause great changes in physical or physiological properties it was considered of interest to determine whether this property existed in other related compounds. Therefore a large number of related mono aryl thio carbamides were investigated, and most of them were shown to possess the same property. Then symmetrical di aryl thio carbamides were studied and were also shown to possess similar physiological action. Various other thio carbamides were studied, but in almost every instance the same result was obtained. So far only two compounds have been found which deviate from the class to which they belong, but this deviation is believed to be due to insolubility.

Genetics of sensory thresholds:—taste for phenyl thio carbamide: ALBERT F. BLAKESLEE. Dr. A. L. Fox first showed that many people can not detect the bitter taste in crystals of phenyl thio carbamide. In an earlier publication, Salmon and I showed that taste deficiency for the crystals appears to be inherited as a Mendelian recessive. (The same conclusion has been reached independently by L. H. Snyder). In addition to "non-tasters" of the crystals, we were able to classify the "tasters" of the crystals roughly according to their taste acuity by means of dilutions at which the bitter taste was first detected. This work on taste thresholds has been extended. Thresholds for the "tasters" have been established from 1: 500,000 to 1: 5,000 dilutions. These extreme thresholds are rare. The commonest threshold is at about 1: 80,000. With a few possible exceptions, none could taste the pure crystals who could not taste bitterness in a dilution of 1: 5,000. Tests of thresholds in about 100 families indicate that acuteness of taste for the chemical is inherited, since there is an obvious correlation between the thresholds of parents and children. It has been the practice to test people with the dry crystals if they could not detect bitterness in a 1: 5,000 solution and to classify them as "non-tasters" if they did not report the crystals as bitter. It is now found that phenyl thio carbamide is also bitter to "non-tasters" for the crystals if the chemical can only be gotten to their sense organs in a sufficiently concentrated form. Most "non-tasters" can detect bitterness if a cold saturated solution is used. The few who are still negative to this test have been found to taste bitterness in a saturated solution in hot water or still better in hot weak alcohol. Many who could detect bitterness in relatively weak solutions were unable to taste the pure crystals, but, so far as retested with saturated solutions, they were found to react positively. Inability to taste the crystals may have something to do with differences in salivas as well as to differences in sense organs. A few could not detect bitterness in phenyl thio carbamide solutions but reported a different taste. Some said it was sour, some called it peppery and others described it as astringent like alum. There is evidence that a condition analogous to color blindness exists in regard to taste in that two substances which taste differently to most give to some the same sensory reaction. Thus two persons, who were given a special test, were unable to distinguish quinine from hydrochloric acid. Some tasted bitterness in weak concentrations but could perceive little difference between the various test solutions, each of which was four times as strong as the one previously tasted. Others showed reactions corresponding to the relative strengths of the solutions. There was no close relation between emotional response and threshold at which the taste was first perceived. Taste acuity for phenyl thio carbamide was found to have no close relation to taste acuity for other bitter compounds —picric acid and quinine sulphate—which also afford a wide range of thresholds. Likewise there was no close relation found with acuteness of taste for an acid and for a sweet. Differences in taste thresholds for a number of other substances have been found by us and other investigators. The same is true for odors. In the single case investigated we have found these differences in powers of sensory perceptions innate and hereditary. Evidence is thus given for the belief that humans are born with innate differences in respect to all their senses and that different people live in different worlds, therefore, so far as their sensory reactions are concerned.

Glucoside formation in methylated glucoses: P. A. LEVENE and A. L. RAYMOND. The ring structures of the γ- and normal glucosides of the fully methylated sugars have been established beyond dispute, whereas those of the non-substituted sugars have continued to be a matter of discussion. The structure of the normal glucosides of the non-substituted sugars has recently been demonstrated to be that of a pyranose so that there remained for consideration only the γ-glucosides of the non-substituted sugars. For these the butylene and propylene oxidic structures are under consideration. To choose between these two possibilities, a study has been made of a 3-monomethyl and a 4-monomethyl sugar as regards their glucoside formation. It was found that while the 3-methyl sugar gave two glucosides, a normal and a typically γ-, the 4-methyl gave only a normal glucoside. This would seem definitely to exclude the propylene oxide structure and favor the assignment of the butylene oxide structure to the γ-glucosides. In support of this view is the fact that the rate of glucoside formation in the case of the 4-methyl sugar is similar to that of tetramethylglucopyranose, which has only position 5 unsubstituted.

Artificial hormone substances: TREAT B. JOHNSON. The synthetic organic chemist is very much interested in the study and preparation of artificial substances which may prove to be of practical value in the prevention and cure of diseases. He is very desirous of

utilizing the resources of his science in every way possible for the benefit of mankind. Both the animal and plant are productive in their growth of active principles which exert a pronounced physiological action when liberated in the living organism, and their separation and utilization by man has contributed greatly to the advancement of almost every field of medicine. We have adopted the materials that nature provides for us, and we have also gone further and modified these materials, purified them, and have been extremely successful in making many new combinations of great medical value. We are now advancing to the third stage of this program in the development of drugs for the use of man, and it is the organic chemist who now seeks to duplicate further the natural products to produce new organic derivatives from them and to prepare in his laboratory entirely new compounds related structurally to the natural substances and finally to create artificial materials which may serve as practical substitutes for nature's products. Among the many substances formed in the animal metabolism are the glandular secretions which our physiologists have designated by the general term, "hormones." These interesting products are secreted in animal economy in extremely small quantities, but they are very powerful in their physiological action, and it is known that an animal can not live and grow without their aid. These active substances serve in animal metabolism as chemical messengers, so to speak, and they exercise a very fundamental part in regulating all the normal life processes. In other words, without the proper functioning of these glandular organisms which produce these secretions, man can not live. Thyroxine and adrenaline are two important representative organic substances which are found in the secretions of special glands, and they represent two of the most important substances which we classify under the term "hormones." It is an interesting fact that the structures of both of these substances have been established, and the chemist has been able to prepare both of them artificially. We are, therefore, now able to produce two of these important hormone principles in our laboratories, and are therefore not dependent for their supply on natural materials. It is an interesting fact that, as a result of advanced research by the organic chemist, absolutely new organic constructions can be synthesized which show almost the same physiological activity of many of these hormone principles which nature provides for her service. When substances of this type are obtained by the organic chemist, their structure established and their physiological activity shown to duplicate the materials found in nature, they are spoken of as artificial hormones. The substances discussed in this paper belong to this class of compounds. They represent new compounds which have never been prepared before and have been found to show a physiological activity which duplicates that of natural hormones of certain types, and therefore are of extreme interest to the chemist and call for an exhaustive study. There is a great probability that some of these organic combinations will be found to be perfect substitutes for natural hormone compounds and lead to products which are far superior in their physiological activity to those already produced by nature. The field of investigation is a most inviting one to the chemist, and the thiazol compounds which have been chosen as a group of compounds deserving of chemical attention offer possibilities of synthesis which are not common to many classes which the chemist can select for his work. It is possible to prepare, in the series under investigation, compounds, for example, that are far less toxic than the natural hormone—adrenaline—and still retain a physiological activity that promises a possibility of very practical application in medicine. This work has been in operation in the Sterling Laboratory for the past four years, and a program of work has been mapped out which will keep certain members of the staff occupied in this field for a long time.

The influence of complex salt formation on the electronic structure of iron oxides: OSKAR BAUDISCH (introduced by T. B. Johnson).

Further studies of rate of growth of albino rats: ARTHUR H. SMITH and W. E. ANDERSON (introduced by L. B. Mendel).

The Arizona expedition for the study of meteors: HARLOW SHAPLEY, E. J. OPIK and S. L. BOOTHROYD.

The adequacy of ocular compensation to bodily rotation: G. R. WENDT (introduced by Raymond Dodge). Graphs will be shown (by lantern slides) which show the relationship between the velocity of the slow phase of vestibular nystagmus and the velocity of bodily rotation. Using normal college students as subjects, and photographically recording eye-movements through closed eyes by the Dodge mirror recorders it has been found that in the simple conditions of rotation used in this experiment ((1) translation through 65 degrees in two seconds, (2) harmonic oscillation through 15 degrees) the velocity of compensatory eye-movements bears a constant relation to the angular velocity of rotation. The velocity of the eyes at any moment is found to vary directly with the velocity of the head. Related to earlier work by Dodge, his collaborators and others, it will be pointed out that these results make definitively untenable the notion that vestibular stimulation operates on the reflexes by acceleration alone. In these experiments the response of the eyes is not related to acceleration but to velocity.

(*To be concluded*)

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