middle of September, there is an almost continuous supply of adult beetles. The retarded individuals of one generation overlap the more advanced individuals of the subsequent generation.

AFTER searching the deserts and foothills of Russian Turkestan and most of Turkey for plants to control soil erosion, H. L. Westover and C. R. Enlow, plant explorers of the U. S. Department of Agriculture, have returned with about 1,800 lots of seeds after an expedition lasting seven months. Because of the unusually adverse conditions for plant life where much of this seed was collected, it is hoped that plants of real value for the Great Plains and the Southwest will be found in the collection. Most of the collections represent grasses or legumes which form a thick turf close to the ground. Others represent shrubs whose root systems looked promising as soil-binders. Seeds from a few trees also were brought back. Most of the seed lots came from plants that are edible by live stock, but this quality was not regarded as of principal importance in making selections. Officials of the Soviet governments gave the explorers every possible assistance. Botanical experts were able in almost every instance to give all the necessary information concerning the plants of the regions visited. This information made it possible to avoid plants that are poisonous or otherwise undesirable. The officials of the various republics supplied automobiles, horses and camels to transport the exploration party over Turkestan. Turkish government officials likewise cooperated in every way.

The department of physics of the University of Maine was host on October 27 to the staff members of the departments of physics of all the other colleges in Maine. This group meets twice each year for the purpose of discussing the teaching of physics in the Maine colleges. After an informal inspection of the laboratories, the program was opened with a paper on "Modern Concepts of Physical Units" by Professor N. C. Little, head of the department at Bowdoin College and a member of the committee on units of the American Association of Physics Teachers. The second paper was by Professor William R. Whitehorne, head of the department at Bates College, on a phase of photographic copying now being carried on there. Following a luncheon served in the physics library, the afternoon session was opened with a discussion of a new type of thermal conductivity apparatus by Professor A. L. Fitch, of the University of Maine. Following this came a discussion of grades in beginning physics led by Professor C. B. Crofutt. Two papers were given concerning researches at the university. R. A. Allen, a graduate student of physics, described an experimental study of the magnetic field intensity in the neighborhood of a long solenoid, and Professor C. E. Bennett described his researches on the optical constants of gases.

DISCUSSION

BALANCED DIETS, NET ENERGY VALUES AND SPECIFIC DYNAMIC EFFECTS

A FACT that is not infrequently lost sight of in contemporary nutritional research[1] is that the utilization of any food nutrient for any purpose in the animal body requires the simultaneous presence of all other nutrients required for that purpose. And for the most complete sustained utilization of any food nutrient, the proportions in the diet of it and all other required nutrients must attain or exceed certain minimum values. For example, an adult man may require 40 grams of protein daily, although, consuming only this, he will not be able to establish nitrogen equilibrium. If his energy requirements are simultaneously covered, he may be able to establish nitrogen equilibrium, but there is no reason to expect that he could prevent losses of nitrogen from his body indefinitely unless his daily diet contains also at least certain minimum proportions of each nutrient, inorganic as well as organic, that is required for all the animal functions essential to the maintenance of life. He is then receiving what may be called a "balanced diet" for adult maintenance. It is of course well known that diets may be unbalanced by including in them excessive proportions of some nutrients, such as protein or vitamin D, but this is a phase of the problem about which little definitely can be said.

For the growing animal we have a similar conception of a balanced diet, and in this case there is available much more information concerning nutrient requirements, for in the science of nutrition, as in the medical sciences, the adolescent animal has received much more attention than has the adult.

It is reasonable to assume that the balanced or unbalanced character of a diet for growth will be reflected in the efficiency with which that diet promotes growth. The completely balanced diet will promote growth the most efficiently, in the sense that, when compared with any less completely balanced diet

[1] For example, vitamin units are commonly defined as amounts that will produce certain more or less well-defined physiological effects. In these definitions no reference is made to the simultaneous necessity of other nutritive factors, and in the methods used for vitamin assay no provision is made to assure adequate, or even constant, intakes of other nutrients.

in properly controlled feeding experiments, a greater rate of growth will be secured on the same amount of food. This is the principle underlying the Armsby "paired feeding" method, the most precise method that has yet been proposed for effecting ration comparisons. In this method, animals are paired on the basis of sex, parentage, weight and any other measurement (such as blood hemoglobin) that may be pertinent to the problem at hand, and the pair mates are then fed the same amount of the two rations to be compared, one to one animal and one to the other. Under these conditions the better balanced of the two rations will promote the more rapid growth, or in other ways induce a better nutritive condition, for example with reference to the blood or the bones; and conversely every improvement in a diet with respect to its power to promote growth and nutritive condition is *prima facie* evidence of a betterment in its balance. The reality of this conclusion seems obvious, and no precise definition of balance in diet on any other basis has been proposed in so far as the writer is aware. In fact, a search of current writings and text-books has failed to reveal that the conception of nutritive balance in diets or rations has received much intensive thought. On the evidential side, the conclusion is supported by the results of numerous paired-feeding experiments, which have demonstrated the possibility of distinguishing on this basis better from poorer balanced diets with respect to protein, vitamins, sugars and inorganic salts.

Of the balanced ration, it may be said that the more of it is consumed, the better nourished will be the animal with reference to which the ration is balanced, up to the point of repletion of its requirements. It is an attractive hypothesis concerning unbalanced rations that the more of them are consumed the poorer nourished will be the animal with reference to the functions with respect to which the rations are unbalanced. To the writer the hypothesis has much rational appeal and it receives factual support from some experiments performed in the nutrition laboratory at the University of Illinois. Thus, young growing rats subsisting on a diet of milk will develop anemia, because milk is unbalanced with respect to the requirements of the hematopoietic tissues; and furthermore the more milk the animals consume daily, the more rapidly will the anemic condition develop, although in all other respects the animals are well nourished. Again, young rats placed upon a diet high in calcium, low in phosphorus and deficient in vitamin D will develop rickets, and the rate of development of this bone disease is the greater, the greater the daily consumption of the rachitogenic diet. Of much the same significance is the fact that young pigs placed upon a protein-deficient diet will grow slowly, but with increasing intakes of food will become increasingly fat, representing a misdirected or uncoordinated growth. Probably further illustrations of the hypothesis that unbalanced rations, like toxic substances, exert harmful effects in proportion to the amounts consumed, will be forthcoming when it is subjected to systematic and quantitative study. The quite general failure of animals to consume unbalanced rations as avidly as balanced rations is understandable if the former may be considered physiologically harmful.

Some of the implications of the above conceptions of nutritive balance in diet are interesting and of importance to the science of nutrition. Attention will be restricted to the question of the utilization of the chemical energy contained in a diet, representing a nutritive summation of all the organic nutrients.

There is current in animal nutrition a method of assessing the energy value of rations that is far in advance of any method used in human nutrition. According to this method, introduced by Armsby some thirty years ago, the final value of a ration as a source of energy in metabolism is obtained by deducting from its gross energy (heat of combustion) all the losses of energy incident to its utilization. The metabolizable energy is the gross energy minus indigestible energy (gross energy of feces and intestinal gases) and unoxidized energy (gross energy of urine). The final, or net energy value, is equal to the metabolizable energy minus the increase in the heat production incident to the consumption and utilization of the ration. This latter increment consists largely (in farm animals) or entirely (in humans) of the "specific dynamic effect" of food. The net energy of a unit weight of a ration, expressed as a percentage of the contained metabolizable energy, measures the net availability of the latter.

With these definitions in mind, the first implication of the above-defined conception of nutritive balance in a ration or diet is that, except for differences in digestibility, the net energy value of all perfectly balanced rations is the same under the same conditions of feeding, or, somewhat more precisely, the net availability of the metabolizable energy of all perfectly balanced rations is maximal for any imposed conditions of feeding. When the net energy conception was developed by Armsby, it was his idea that each food material had its own fixed characteristic net energy value and that the net energy value of a ration was the weighted mean of the net energy values of the constituent foods. All his investigations at Pennsylvania State College were based upon this simple hypothesis, which was not inconsistent with any of the theories of energy utilization prevalent at that time. Forbes and his associates have been impelled to depart from this hypothesis of Armsby, first, because of experimental evidence to the effect that the net energy value of a ration or feed is not constant, but depends upon the conditions of feeding, and second, because other evidence indicated that the net energy value of a ration bore no simple relation to the net energy value of the constituent foods. However, Forbes' recently announced "law of maximum normal nutritive value,"[2] although it advocates the use of completely balanced rations in determinations of net energy values, does not state nor imply that the net availability of the metabolizable energy of such rations will be maximal and identical. In fact, the statement that "an individual foodstuff expresses its normal and most characteristic nutritive value . . . only as it is a part of a ration which is qualitatively complete and quantitatively sufficient . . . " seems opposed to this deduction, which, if true, would lead one to suppose that the most characteristic nutritive value of a food would be observed only when it is fed alone. When properly balanced with other foods, its distinctive nutritive properties would be entirely submerged in a resultant optimal combination that would be no better nor worse than that of many other possible mixtures of foods. The recent developments in the net energy conception, initiated and defended by the Pennsylvania group, have tended to complicate the problem of net energy determinations and perhaps even to discourage those who have hoped to put the conception to practical use in the rationing of farm animals. But if all perfectly balanced rations exhibit the same net energy value (except for differences in digestibility) under the same conditions of feeding, then the problem is greatly simplified and the plan of its solution is clear; furthermore, the probability that the solution will be sufficiently simple to possess great practical value is enhanced.

A second important implication from the conception of a balanced diet developed above is that the specific dynamic effects of the various nutrients are not characteristic values except when they are fed to animals singly. When the nutrients are fed in combinations, the specific dynamic effects of the mixtures will be less than the weighted mean of the individual effects, and this decrease will continue as the combinations approach a perfectly balanced combination for the animal under experiment, of which the heating effect will be minimal. In this discussion, the term "specific dynamic effect" will be applied to the total excess heat developed by a given food or nutrient, and not to the so-called "peak" effect, which possesses an extremely limited significance.

[2] SCIENCE, 77: 306, 1933.

This is a decidedly heretical deduction. It is, however, a direct corollary of the preceding implication, since if the net availabilities of the metabolizable energy of all perfectly balanced rations are maximal and identical, then their specific dynamic effects must be minimal and identical.

Current theories attach definite heating effects to proteins, sugars, starches, fats, and even the various naturally occurring amino-acids, and teach that combination of these nutrients does not modify appreciably their characteristic effects as metabolic stimulants, but these theories fail to account for many facts in the science of nutrition. Eight years ago Carman and the author[3] showed that the mere inclusion of 1 per cent. of sodium chloride in a ration predominantly made up of corn increased its growth-promoting value by from 40 to 50 per cent. in paired-feeding experiments with rats and chicks, without appreciably affecting its digestibility. Assuming reasonably that this effect could not have been the result of a depression of the basal metabolism or of the muscular activity of the experimental animals, it must have been an expression of a great increase in the net energy value of the ration and as great a depression in its specific dynamic effect. As we said at the time: "The growth data of this experiment afford a striking illustration of the fact that the utilization of food energy by growing animals may be greatly impaired by an improper balance among indispensable dietary factors." None of the current theories of the cause of the specific dynamic effect of food would seemingly account for this phenomenon.

Protein ingested alone by animals causes a marked specific dynamic effect, much greater than any other nutrient, but when incorporated into a protein-free diet, otherwise complete, it must decrease the specific dynamic effect of such a diet rather than increase it, because the combination will be more efficient in maintaining the energy balance of an adult animal or in increasing the energy balance of a growing animal. Weiss and Rapport[4] were greatly mystified when they found that calorigenic amino-acids, administered to dogs along with proteins, failed to increase the calorigenic action of the latter. But equally mystifying from the standpoint of the current theories of the specific dynamic effects of food is the action of amino-acids in improving greatly the efficiency for growth of rations containing protein complexes deficient in those amino-acids.[5] In all probability this increase in efficiency means a decrease in the specific dynamic effect, assuming again that the basal metabolic rate

[3] *Jour. Biol. Chem.*, 68: 165, 1926.

[4] *Jour. Biol. Chem.*, 60: 513, 1924.

[5] H. H. Mitchell and D. B. Smuts, *Jour. Biol. Chem.*, 95: 263, 1932.

and the activity of the experimental animals was not depressed by the amino-acid supplements.

Apparently the specific dynamic effects of isolated nutrients fed as such have very little if anything to do with the specific dynamic effects of mixtures of nutrients, particularly balanced mixtures. Without being able to specify the exact causes of the metabolic stimulation induced by the consumption of food, we may nevertheless conclude reasonably that its intensity is dependent primarily upon the degree of accumulation of the end-products of digestion within the tissues, which is in turn dependent for any given intake of food upon the rate of utilization of these products by the tissues. Their rate of utilization will be determined by the proportions existing among them, such that the better the balance with reference to the requirements of the animal the more rapid the rate of utilization and withdrawal from the cellular fluids. The metabolic stimulation thus occurs only when there is an excess of nutritive material in the tissues, and is to a considerable extent proportional to this excess. It is possibly a mechanism operating merely for the removal of excess food material from the body cells in the interests of physiological efficiency.

These speculations are now being investigated experimentally in the Division of Animal Nutrition of the University of Illinois.

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A COLOR TEST FOR VITAMIN C

WHEN ascorbic acid is boiled with HCl, CO_2 is given off, apparently the molecule loses water and furfural is formed. That furfural is formed in this reaction may be demonstrated by the use of the aniline, phloroglucinol and orcinol tests. The reaction with aniline, in which a pink color is produced when the acid solution, after boiling with HCl, is brought to a pH of 5 to 6 by adding aniline, is quantitative and may be used for the estimation of ascorbic acid. Pentoses, pentosans, hexoses and hexosans are interfering substances, but various procedures may be used to obviate the interference by these materials. Efforts are being made to develop a quantitative method, based upon this reaction, for the determination of ascorbic acid in plant and animal tissues.

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ITALIAN WORK ON LIVER THERAPY

IN none of the publications concerning the award of the Nobel Prize for their work on liver therapy in anemia by Dr. George W. Whipple, Drs. Minot and Murphy, is mention made of the carefully controlled experiments on dogs and rabbits (1910–1912) carried out by Professor Alfonso Pirera,[1] of Naples, under the direction of the late Professor Pietro Francesco Castellino (1864–1933), of the University of Naples. They proved, clinically and experimentally, the value of liver, liver juice and liver extract in the treatment of anemia. They also demonstrated that liver injections increased the leucocytes, particularly the granulocytes. Liver injections are now being given in the treatment of granulopenic conditions, malignant neutropenia, or agranulocytosis.

While a student and associated with Professor Gaetano Salvioli (1853–1888) at Genoa, and working with Professor Edoardo Maragliano, Professor Castellino already recognized, at that time (1886–1892), the value of liver in the anemia of tuberculosis and spoke of liver stimulating bone marrow activity and the regeneration of blood.[2]

To Whipple, Minot and Murphy goes the credit for establishing, on a scientific basis, the general use of liver in the treatment of anemia. *Priority* for the early observation and *the discovery* (experimentally and clinically) of the value of liver and *liver injections* in the treatment of anemia should, in all fairness, go to the late Professor Castellino and his associate, Professor Alfonso Pirera.

In this connection, I may add the following references of interest:

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[1] Il Tommasi (*Napoli*), 7: 26, 601–617, September 20, 1912, and 7: 27, 625–636, September 30, 1912.

[2] Pietro Castellino, *Nuova Vita* (Torino, Roma, Societa Editrice Nazionale Di Propagande I gienica), 3: 15, December 12, 1912.