accelerated the rate of reaction without themselves reacting. The ions of the inerts were found to contribute just as much to the reaction as if the same quantity of ionization had been produced on the reactants in addition to the amount actually produced on them by direct action of the alpha rays. In other words, the reaction is proportional to the total ionization, not to the ionization of reactants alone. It was pointed out that this relation could be readily accounted for by exchange of charge if the positive ion of the inert could take an electron from the reactant molecule, thus leaving the latter positively charged. Such a theory appeared the more plausible, since the inert gases employed up to that time had ionization potentials higher than those of the reactants.

The alternative possibility was also mentioned, that *addition* of reactant and inert, not *exchange of charge* might prove to be the case, and that these points could be tested by using inerts like xenon and krypton with potentials lower than those of the reactants. For clustering by addition, a high *positive* catalysis would be found, but a high *negative* one might be expected for exchange under the influence of ionization potential, assuming the inert ion itself to have no clustering power.

Dr. R. B. Moore kindly put at our disposal several cubic centimeters of xenon and of krypton, portions of the original gases which he had fractionated for atomic weight determination[1] in Sir Wm. Ramsay's laboratory. Each of these after thorough drying was given a vigorous treatment with metallic calcium at 475° C. to remove any impurities that might have been accidentally introduced since they were prepared. They were then used to mix separately with reactants, acetylene, cyanogen and hydrogen cyanide. The velocity of polymerization was manometrically determined in the mixtures under the alpha radiation of known amounts of radon. The results unambiguously showed catalysis in proportion to the krypton and xenon ions, just as for the other inerts, He, Ne and A. The order of ionization potentials for all gases concerned is: He (24.5); Ne (21.5); C_2N_2 (16.3); A (15.2); HCN (14.8); CO_2 (14.3); Kr (12.7); C_2H_2 (12.3) and Xe (10.9).[2]

Since in all cases the reactions were positively catalyzed in proportion to the specific ionization regardless of the ionization potential, it is evident that the latter is not a factor, and that clustering about both kinds of ions as reaction centers is indicated. Of course, this catalytic evidence does not show that exchange of charge may not take place physically in the direction predicted by ionization potential, but it does prove conclusively that such exchange even if occurring is probably simultaneous with addition and does not influence the rate of reaction, which is proportional to the total ionization regardless of whether it be on an inert or on a reactant.

Indirect evidence of clustering about an inert may be seen in the fact that a small fraction of xenon in all three gases, C_2H_2, C_2N_2, and HCN, was found to have been removed from the gas phase along with the precipitated polymer. The xenon was easily recovered quantitatively by heating to about 300° to 350° C. By integrating the separate ionizations of xenon and of acetylene over the entire course of the reaction, the amount of inert removed by occlusion was calculated on the assumption of complete coprecipitation of the inert with each ion cluster of which it formed the nucleus. The quantity so calculated was five times greater than that found, showing that quantitative occlusion does not result from clustering. If all instead of part of the clustering had taken place around xenon, the discrepancy becomes yet greater. Apparently the inerts of higher molecular weight are more readily occluded in the polymer, as might be expected, than those of lower. The case of CO_2 removal with C_2H_2 precipitation, previously mentioned (*loc. cit.*), is more probably accounted for in this way than through true chemical action, but does not support exclusive clustering about the gas of lower ionization potential, since the ionization potential of CO_2 exceeds that of C_2H_2; and moreover the 12 per cent. disappearance of CO_2 exceeds the prediction even had 1 CO_2 been removed for each cluster of 20 C_2H_2 molecules.

Our inability to fasten any exceptional behavior upon CO_2 and N_2 as catalysts leaves all the more puzzling their failure to auto-catalyze reactions in which they are generated, as in the decomposition of NH_3 or of CO. Both of these decompositions have just been found to be normally catalyzed by neon, so that further work will be required to explain the behavior of CO_2 and N_2, which now appears quite anomalous in these particular cases.

S. C. LIND
D. C. BARDWELL
FIXED NITROGEN RESEARCH LABORATORY,
U. S. DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

[1] R. B. Moore, *J. Chem. Soc.*, Lond., 93, 2181 (1908).

[2] We are indebted to Professor K. T. Compton and Dr. Barton for some of the latest values in advance of their publication.

THE NEW STATUS OF NET ENERGY DETERMINATION

ATTENTION was called, in the April 18, 1924, number,[1] to the net energy conception of Armsby, as the

[1] Forbes, E. B., "The Net Energy Conception," SCIENCE, April 18, 1924, Vol. LIX, No. 1529, pages 350–351.

simplest and most inclusive of all general measures of nutritive value; and resolutions of the American Society of Animal Production endorsing Armsby's conception of net-energy values were quoted.

At a later date notice was given, in the June 6, 1924, number,[2] of a forthcoming paper[3] correcting all the net-energy values of feeds for cattle which had been published from this institute, on account of certain advances in understanding and method of determination; and now, as a result of further progress in our studies of the respiration calorimetry of cattle, and in view of the general interest in net energy as a scientific measure of nutritive values, we take this occasion to enumerate all the recent changes, and to indicate their effects in relation to general procedure and to accuracy in net-energy determination.

The Fasting Katabolism as a Measure of the Maintenance Requirement of Energy

It has been the practice at this institute to determine the maintenance quota of energy by Armsby's heat-increment method, that is, by comparing the heat production at two levels of feed intake, relating the difference in heat outgo to the difference in feed, and computing to the heat production on a fasting basis.

Armsby followed this procedure because he believed that it was impracticable to determine the fasting katabolism directly. We find, however, that it is entirely feasible directly to determine the fasting katabolism, and the data now at hand indicate that this value is a much higher and more nearly constant figure than is the computed fasting katabolism.

We have considered several possible explanations of this higher directly determined value, and further data may add to our understanding, but at its face value the present evidence seems clearly to indicate that the difference between the directly determined fasting katabolism and that derived by computation from super-maintenance feeding periods signifies a more efficient or economical utilization of energy below than above maintenance.

In this light, employing the directly determined fasting katabolism as the measure of the maintenance requirement of net energy, this raising of our figures for maintenance requirement has the effect to reduce the apparent difference between the heat production of fasting and at a maintenance level of feeding, while it leaves unchanged, of course, the difference between the heat production at maintenance and at full feed.

[2] Forbes, E. B., "Correction of Net Energy Values," SCIENCE, June 6, 1924, Vol. LIX, No. 1536, page 511.

[3] Forbes, E. B., and Kriss, Max, "Revised Net-Energy Values of Feeding Stuffs for Cattle," *Journ. Agr. Research*, Vol. XXXI, 1925, No. 11, pages 1083 to 1099.

In other words, this change of standard as to maintenance requirement of energy implies decreased heat increments, and increased net-energy values, from fasting up to maintenance, the corresponding values above maintenance remaining unchanged. It seems to be necessary, therefore, to establish new net-energy values for maintenance distinct from and higher than those for growth (including fattening), and for milk production.

It is our expectation that net-energy values for maintenance and for the various types of production may be determined in each case directly, or, after direct determination for one purpose the values for the other purposes may be derived by the use of established factors.

Incidentally, this important change promises to relieve us from a situation of great embarrassment on account of the variability of repeats in the published net-energy determinations, due to the mixed effects of different proportionate amounts of submaintenance and supermaintenance heat increment.

Correcting the Observed Heat Production to a Standard Day, as to Standing and Lying

Since the energy cost of standing is materially higher than that of reclining, it is necessary in order to render experimental data comparable, to compute the daily heat production to a standard day, as to standing and lying; and the standard arbitrarily adopted was twelve hours' standing and twelve hours' lying.

The older method for making this correction was based on the observed differences in heat emission by radiation and conduction, while the subject was in the standing and the lying positions. These observed differences in heat emission, however, are in reality determined not only by the relative intensity of metabolism, but include also heat stored in the platform upon which the animal lies, and radiated when the animal stands. In addition, the heat absorbed by feed and water introduced, and the heat given off by the cooling of the excreta, contribute further errors; and, still further, it is entirely impracticable to separate the latent heat of water vapor emitted, on this basis. The combined effect of all these factors rendered the separation of the heat production according to intervals of standing and lying, by the earlier method, quite definitely erroneous.

We now accomplish the purpose of this separation by a much simpler and more nearly correct procedure. Thus the observed heat production is corrected to the standard day by the use of a factor representing increase in heat emission due to standing, this factor having been experimentally determined with a fasting animal. According to this new method the

only data necessary to the computation of the heat production of the standard day are the total heat production, the weight of the animal, the time spent standing and the factor representing increase in heat emission due to standing.

IMPROVEMENTS OF TECHNIC

In addition to the above-mentioned considerations numerous minor improvements of technic have had the effect greatly to increase the accuracy of the experiments upon which the net-energy determinations are based, thus:

(1) The digestion period has been increased from ten to eighteen days, the calorimeter period from two to three days, and the preliminary period in the calorimeter from four and one half to thirteen and one half hours;

(2) The fact that refusal of feed can not be compensated for is now recognized, and the occasion for such corrections is avoided;

(3) The fact that the previously customary shearing of the steers at the beginning and at the end of an experimental program (to account for growth of hair) has the effect to raise the critical temperature of fasting to a point above the maximum temperature attainable with our calorimeter, as now equipped, and consequently that the animal must not be shorn, has been experimentally demonstrated;

(4) An improved insulation of the movable shield, in the calorimeter, which regulates the exposure of the cooling coils to the air of the chamber, has practically eliminated the need for changes in rate of cooling-water flow in the course of a seventy-two-hour calorimeter period, thus increasing, on several accounts, the accuracy of the heat measurement;

(5) A provision for the moistening of the air before it goes into the Bohr meters, thus preventing the lowering of the water-level in the meters, by evaporation, increases the accuracy of the air measurements;

(6) There have been improvements of carbon, nitrogen and moisture control as follows: by the use of refrigeration is prevented (a) the loss of carbon and nitrogen from the daily aliquots of feces during the course of an eighteen-day experiment; and (b) the loss of carbon from feces samples retained for the furnace determination of carbon, in the fresh material; and (c) the preservation of feeds by refrigeration makes possible the analysis of the same from the fresh condition, working to a dry instead of to an air-dry basis;

(7) The use of the new Wiley mill makes possible an improved moisture control in feeds by reason of rapid grinding, with greatly reduced attrition; and,

(8) An improved control of carbon loss from excreta during drying in an air oven, preliminary to bomb estimations of energy and carbon, has been attained by improved conditions of drying, checked by furnace determinations of carbon on the fresh materials.

In view of these very material improvements of understanding and method the idea of determining significant and useful net-energy values of feeding stuffs seems to be in a greatly improved status, and work on this project is going forward rapidly.

The writer is pleased to acknowledge that the credit for these several improvements is largely due to the cooperating members of the staff of the institute, namely, J. August Fries, W. W. Braman, D. C. Cochrane, Max Kriss, C. D. Jeffries, R. B. French, R. W. Swift and J. V. Maucher.

E. B. FORBES

THE INSTITUTE OF ANIMAL NUTRITION,
PENNSYLVANIA STATE COLLEGE

SOME ECOLOGICAL RELATIONS OF THE HYPOGAEOUS FUNGI

THE following notes were made by the junior author at the suggestion of the senior author in connection with a study of the various types of peridial structure shown by California species of *Hysterangium*. The statements are largely in the form submitted by the junior author. The senior author has edited and added to these statements.

The occurrence of hypogaeous fungi of various sorts (Tuberales, Hymenogastrales, Endogonaceae, Elaphomycetaceae, etc.) in surprising number and variety in the coastal region of western North America from central California northward naturally leads to the query as to why this region is seemingly so particularly adapted to the growth of these organisms. A similar condition has been noted by Thaxter for the coast of South America along the straits of Magellan (*cf.* Thaxter, *Bot. Gaz.*, 50: 432, Dec., 1910).

At the suggestion of the senior author, his co-author made some observations tending to throw light on the climatic-edaphic-biotic complex existing in her collecting district, which is one yielding abundance of material. The following statements prepared by her refer most particularly to her experience with members of the genus *Hysterangium*:

Practically all the collecting reported on was done on King's Mountain in the Sierra Morrena section of the Santa Cruz Mountains, directly west of Redwood City, California.

The vegetation in this region is typical of a mixed forest association, being made up mostly of Redwood (*Sequoia sempervirens*), Fir (*Pseudotsuga taxifolia*), Tan Oak (*Lithocarpus densiflora*), Madrone (*Arbutus Menziesii*), Manzanita (*Arctostaphylos Manzanita*),