since pyruvate was required. Although the nature of the reductant is not known, ferredoxin is ruled out, for it is not present in the organism. The nature of the reductant and the requirement for ATP are being investigated.

H. J. Evans (Oregon State University) reviewed investigations, conducted in collaboration with S. Ahmed, R. Lowe, M. Kliewer, G. Johnson, A. DeHertogh, and P. Mayeux, of the requirement and role of cobalt in nitrogen-fixing organisms. It was concluded that soybean plants forced to fix $N_2$ require cobalt, but no conclusive evidence was obtained that leguminous or nonleguminous plants supplied with adequate fixed nitrogen require cobalt. *Azolla folliculoides* grown in symbiotic association with *Anabaena azollae* exhibits a requirement for cobalt when cultured in nitrogen-free medium. The cobalt requirement for symbiotically grown *Azolla* can probably be accounted for by the requirement of the blue-green alga living in symbiotic association with the fern. The cobalt requirement exhibited by *Rhizobium* species grown in pure culture indicates that the requirement of symbiotically grown legumes reflects that of the nodule bacteria. Leguminous nodules and pure cultures of *Rhizobium* spp. contain 5,6-dimethylbenzimidazolylcobamide coenzyme, and the quantity synthesized is proportional to the cobalt supply. The only enzyme so far identified in the rhizobia that requires the $B_{12}$ coenzyme is the methylmalonyl mutase. Both bacteroids from leguminous nodules and cells from pure culture contain enzymes that activate propionate, carboxylate propionyl CoA, and convert methylmalonyl CoA to succinyl CoA. Cobalt-deficient rhizobia fail to oxidize propionate and exhibit little or no methylmalonyl CoA mutase in cell-free extracts. The addition of 5,6-dimethylbenzimidazolylcobamide coenzyme to extracts of deficient rhizobia restores methylmalonyl mutase activity.

In discussing the localization of fixation in soybean nodules, Burris reported Klucas's finding that the soluble portion of soybean nodules consistently contains the highest concentration of $^{15}N$ after short exposures to $^{15}N_2$, contrary to Bergerson's hypothesis that fixation occurs on the membrane. A round-table discussion resulted in little or no agreement on the role of nodule leghemoglobin.

C. C. Delwiche (University of California, Davis) made brief reference to work being done at the University of California on the relation of cobalt to nitrogen fixation. He went on to describe related studies of nitrification and denitrification which may have some bearing on problems of nitrogen fixation.

Recently it has been clearly established that *Nitrobacter* sp. requires molybdenum. Concentrations of $10^{-8}$ molar molybdenum as molybdate are adequate for normal cell growth and nitrification. No direct dependence of the nitrification reaction on molybdenum was demonstrable with cell-free preparations or with growing cells, nor could it be shown that molybdenum is required for nitrate or nitrite reduction.

The ammonium ion supported a much greater incorporation of nitrogen into cell material than did any other $^{15}N$-labeled nitrogen source employed.

Studies of the denitrification reaction were described in which the conversion of aberrantly labeled nitrous oxide to $N_2$ was observed by means of mass spectrometry. An isotopic equilibration was observed which indicated that in its conversion to $N_2$ nitrous oxide is equilibrated with a one-nitrogen compound.

A uniform method for reporting quantities of nitrogen fixed was the topic of a general discussion session. Participants agreed that the unit millimicromoles of $N_2$ fixed per minute per milligram of protein conforms to the system adapted by the International Commission on Enzyme Nomenclature and will be used in future publications.

A summary and suggestions of profitable areas of future effort were provided by J. R. Postgate (University of Sussex).

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## Calorimetry

The exchange of views on mutual problems and techniques, the development of cooperative schemes for the acquisition and dissemination of thermodynamic data, and visits to calorimetric laboratories were all accomplished at the 19th Calorimetry Conference, Washington, D.C., 13–16 October 1964. Joint sponsors for this conference were the National Bureau of Standards and the National Naval Medical Center of Bethesda, Maryland. This was the first time that a conference on calorimetry has been cosponsored by an institution primarily interested in the life sciences. Appropriately, thermodynamics provided a link between the physical and biological sciences.

The first day of the conference was devoted to tours of the many laboratories in the Washington area of interest to calorimetrists. Participants were able to see calorimeters of almost every known kind, from calorimeters for studies at very low temperature to those for studies at very high temperatures; from calorimeters for studies of inorganic reactions to those for studies of living processes.

The opening paper of the conference was the Huffman Memorial Lecture entitled, "Heats of Biochemical Reactions," by J. M. Sturtevant (Yale University). The subject chosen by Sturtevant was particularly appropriate because Huffman himself was an outstanding pioneer in the measurement of heats of biochemical reactions. Sturtevant illustrated his talk with examples of heats of biochemical reactions from his own work on the heats of hydrolysis of peptide and amide bonds in several compounds of known structure. The effect of structure in reaction heat was also illustrated in the enthalpy changes for three transmethylation reactions leading to the formation of methionine. Sturtevant also pointed out that results from enthalpy studies in vitro often do not yield the real enthalpies in vivo because of the variation of enthalpies with the *p*H of the media in which they are studied. He illustrated this with studies of some enthalpies of ionization measured with various buffers in the solution. Following the lecture, T. H. Benzinger (National Naval Medical Center) discussed key biothermodynamic data and described a calorimeter capable of measuring energies as small as 4 millicalories.

During a special session on the driving forces behind the process of life, R. E. Davis (University of Pennsylvania) discussed the metabolism and use of proteins, fats, and carbohydrates in furnishing energy to life processes and the very important role played in metabolism in all forms of life by the compound adenosine triphosphate (ATP). The interactions of ATP liberate energy that is used for many chemical syntheses, for secretion, for osmotic work, for the production of light, for muscle contraction, and for many other energy functions in living cells. The synthesis and utilization of ATP are crucially involved in making energy

available so that cells can live. L. Kiesow (National Naval Medical Center) discussed the study of chemosynthetic bacteria, which leads to an understanding of many metabolic processes in life. With the energy from oxidation of nitrite and with added energy from the hydrolysis of ATP, these bacteria are capable of reducing diphosphopyridinenucleotide (DPN) to DPN·H. However, in simultaneously proceeding cell respiration the DPN·H is oxidized and generates more ATP than is required, resulting in a net increase in ATP. This breeder cycle has been studied and a thermodynamic analysis appears to be obtainable by a measurement of redox-potentials and calorimetric determinations of heats of reaction.

One session of the conference was devoted to radiometric calorimetry, a relatively new field to be represented. S. R. Gunn (Lawrence Radiation Laboratory) described a variety of calorimeters which can be used for measuring the radiation from radioactive sources. P. Mitacek (Argonne National Laboratory) discussed the measurement of absorbed doses of radiation by means of a calorimeter operating at liquid helium temperatures with a germanium thermometer. This combination has the major advantages of low heat capacity and high thermometer sensitivity; it gives a temperature rise one thousand times larger for the same energy input than could be obtained with a room-temperature calorimeter.

In a discussion on thermometry, G. T. Furukawa (National Bureau of Standards) described an automatic bridge which registers the resistance of a resistance thermometer up to 499.99999 ohms in steps of 0.00001 ohm. This complicated instrument provides a permanent record (typed sheet, punched cards, or tape) from an auxiliary buffer storage so that the bridge balancing action can continue without interruption. M. A. Frisch and H. Mackle (Queen's University, Belfast) described an a-c bridge for resistance thermometry which has the following advantages over conventional d-c bridge systems: (i) null detection by a sensitive galvanometer, subject to mechanical vibration and zero drift, is avoided; (ii) thermal electromotive forces are eliminated; (iii) faster response time is achieved; and (iv) the use of an a-c–operated bridge facilitates the incorporation of automatic recording devices.

In the subsequent general discussion on instrumentation a report was made on the use of the Hewlett-Packard voltage integrator to obtain energy by measuring the continuous voltage across a standard resistor. The instrument integrates the voltage automatically with respect to time. There was evidence to indicate the possible use of the Hewlett-Packard instrument to record automatically resistance as well as energy. The use and cost of electronic galvanometers, as opposed to the D'Arsonval type, as null instruments sensitive to 0.01–0.1 $\mu$v was discussed. The costs seem comparable. Although the D'Arsonval galvanometer discards a-c signals, the preference expressed by the participants was slightly in favor of electronic galvanometers.

In one of the sessions on low temperature calorimetry, W. V. Johnson (North American Aviation Science Center) discussed the construction and characteristics of silicon resistance thermometers for calorimetry in the temperature range of 2° to 20°K. In the following general discussion, several persons described their experiences with commercially available germanium-resistance thermometers at temperatures as low as 0.25°K.

Leading off a session devoted primarily to high temperature vapor pressure studies, P. W. Gilles (University of Kansas) in collaboration with J. M. Leitnaker (Baker University) reported on ways in which vaporization studies are useful for obtaining thermodynamic data. Gilles pointed out some of the pitfalls encountered, such as temperature establishment, vaporization coefficients, crucible interactions, and other materials problems. He referred to studies of some metal oxide, boride, and sulfide systems and emphasized a study made on zirconium diboride.

In a session on experimental thermochemistry at high temperatures, an important but difficult field, O. Kubaschewski (National Physical Laboratory, England) discussed the shortcomings and prospects for metallurgical thermochemistry. In the following general discussion on the problems of high temperature thermochemical measurements, it was generally conceded that, although the problems are great, realistic accuracy goals toward which to strive are: fractions of a percent ($<$ 0.5 percent) up to 500°C; 1 or 2 percent up to 1000°C; and possibly 5 percent at 1500°C. Kubaschewski pointed out that measurements should be continued up to 2000°C to be of maximum value in metallurgical thermochemistry.

Of special interest was the session on the thermodynamics of electrolytic solutions. In the keynote talk, K. P. Mishchenko (Leningrad Technological Institute) dealt with the results of 15 years of experimentation on the calorimetric characteristics of aqueous and nonaqueous solutions over a wide range of concentrations and temperatures (−6° to +75°C). In all the nonaqueous systems studied the energetic picture (the sign of the variation of enthalpy of solution with temperature, the sign of the partial molal entropy, and the heat capacity of the solution as related to the components) is directly opposite to that found in water. The specific behavior of water as a solvent is connected with its regular structure and with the exceptionally important role of short-range intermolecular forces. Mishchenko was the chairman of the Soviet All-Union Conference on Calorimetry held in 1963, and his attendance—the first from his country—at our conference may mark the start of an exchange of calorimetrists between the two conferences.

In addition to the sessions mentioned previously there were the usual sessions on combustion calorimetry, which included papers involving the relatively new fluorine-bomb calorimetric technique, and sessions on miscellaneous reaction calorimetry, which included three determinations of the heat of reaction of tris-hydroxymethyl-aminomethane (THAM) with 0.1*M* HCl. Some of the keynote papers were: "The determination and significance of entropies of transition in inorganic compounds" by L. A. K. Staveley (Oxford University); "The heats of combustion of some cyclic ethers measured in the gaseous state: some remarks on future developments in flame calorimetry" by G. Pilcher (University of Manchester, England); and "Some recent developments at the thermochemistry laboratory in Lund" by S. Sunner (University of Lund, Sweden).

At several of the discussion sessions Guy Waddington (Office of Critical Tables) served as moderator on the exploration of the need for an international journal on thermodynamics and thermochemistry. One view, strongly stated, was that proliferation of new journals should be resisted because it has been extremely difficult to establish and maintain international journals of high quality. An opposing opinion was that the increasing number of papers in this field from many countries makes inevitable the eventual

segregation of such papers in a separate journal or section of a journal in which quality must be provided by appropriate editorial policy. No action was taken but the consensus was that the problem merits further study.

An appeal to authors was made by Rachel Dudley (National Bureau of Standards) to report all vital information in their publications and to cooperate with the data-compilation group by submitting to it unpublished data.

In addition to the laboratory tours and technical sessions, a business meeting was held. The following officers were elected: R. Hultgren (University of California), chairman-elect; D. C. Ginnings (National Bureau of Standards), S. Sunner (University of Lund, Sweden), and C. E. Vanderzee (University of Nebraska), new members of the board of directors. Also at the business meeting two resolutions were made by the conference concerning standard samples: First, because of the rapid depletion of a Calorimetry Conference sample of aluminum oxide, which is used as a standard in heat capacity measurements, the National Bureau of Standards will be asked to add a suitable sample of aluminum oxide to their standard sample program. Second, because of the need for standards to be used in reaction calorimetry and the apparent suitability of the reaction of THAM with aqueous HCl as a standard reaction, the National Bureau of Standards will be asked to add a suitably purified sample of THAM to their standard sample program.

The 1965 Calorimetry Conference will be held at Iowa State University, Ames. Program chairman for the meeting will be Ralph Hultgren (University of California, Berkeley), to whom inquiries should be addressed.

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## Bioastronautics and Space

Unusually free exchange of experiences and ideas between American and Russian space scientists was a highlight of the third international symposium on Bioastronautics and the Exploration of Space, sponsored by the U.S. Air Force Aerospace Medical Division and arranged by Southwest Research Institute. The symposium attracted over 600 scientists, physicians, and engineers from all over the world to San Antonio, Texas, 16–18 November 1964. At their request, the three Russian representatives held two private sessions with their American counterparts; there was free discussion on the basic level. One American scientist attending said that he had been at most of the space meetings, including that at Warsaw this year, and had never seen such willingness to trade data and explore problem areas.

Certain problems which took high priority at the previous meeting in 1958 seemed less formidable. James A. Van Allen (State University of Iowa) stated that, although the earth's magnetosphere does trap particles, they are of relatively low energy and easy to shield against; he also predicted that a successful Mariner probe will show a similar field of particles trapped in the magnetosphere of Mars. Fred A. Whipple (Smithsonian Astrophysical Observatory), who had previously seen the possibility of meteors bombarding spacecraft, cited the Echo balloon which orbited over the meeting area daily as proof that earlier fears were almost groundless. Solar flares were still seen as a threat by John W. Firor (High Altitude Observatory, Boulder, Colo.), but he said that a study now underway may permit predictions of 14-day safe periods which would be sufficient time for the protection of men in a landing module or in space suits after their landing on the moon.

Moon explorers probably will not need to worry about volcanic eruptions, according to Ewen Whitaker (University of Arizona), one of the key men in the Ranger program; he said that the observed apparent eruptions may be the results of puncture by meteorites of pockets of trapped water vapor and gas. Even the costs of space research were not regarded as prohibitive: Edward Welsh, executive secretary of the President's Aeronautics and Space Council, predicted a continued budget level. Krafft A. Ehricke (General Dynamics/Astronautics) described studies of projected moon and planetary surface exploration to 1978; the peak year would be 1975–76, with a budget of over $8 billion. "Fate has given this nation a chance for remarkable space pioneering," he said. "And it has been done without anyone having to sacrifice one cigarette, one tube of cold cream, or one evening at a night club." Other problems still remain, and the laboratory does not seem to be the place to solve them. Columbus had his egg, but no one was convinced until he came back; scientists on both sides of the Iron Curtain seem to feel that simulation may help, but there is nothing like the real experience of spaceflight.

Juergen Aschoff (Max Planck Institute) indicated that circadian rhythms, unlike faucets, cannot be turned off and on. Among the 50 functions graphed so far, he said, indications are that remarkable changes develop from the maximum in the morning to a minimum reaction time in the afternoon. Efficiency of an astronaut may suffer from these earth-bound mechanisms even when he is in the daylessnightless void of space. Aschoff suggested that a conditioning program based on submultiples of the 24-hour cycle be inaugurated; six 4-hour cycles were suggested. However, only time and space will tell.

The inner ear, which has received much press attention, was still seen as a problem area by Ashton Graybiel (U.S. Navy); he predicted that when previously couch-bound U.S. spacemen have the opportunity to move their heads around, nausea and disorientation may result. He suggested drugs and conditioning as possible remedies.

Confining space suits of U.S. astronauts were criticized by M. Scott Carpenter and Charles E. Yeager, who called for less-confining garments. They were heartened by the report of Herbert H. Reynolds (Holloman Air Force Base) that chimpanzees had withstood vacuum for as long as 15 seconds, which would be enough time to retreat to safety or repair a cabin puncture. The Russian scientists revealed at a press conference that all three men in Voskhod had been in a shirt-sleeve environment from launch to touchdown. Carpenter also called for removable sensors (which the Russians said they had) and less activity for the astronaut, a complaint echoed by the scientists who planned the Vostok and Voskhod flights.

The arrival of the Russian scientists, all members of the staff of the Institute of Normal and Pathological Physiology, caused some concern for the arrangers of the symposium. They had been invited months in advance, but the late grant of visas and the even later knowledge (on arrival at the air-