other compounds before solution. With the study of such crystal masses, it should be possible to determine the effects of various enzyme systems which may make for changes in the rate of solution. The persistence of the crystal deposits because of slow solution suggests that local therapeutic results may also persist for some time. This is borne out by our recent studies.

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Comments and Communications

Scientific Communication

JACQUES AVIAS' letter (SCIENCE, **115**, 250 [1952]) persuades me to state my own conviction that access to world literature is the next practical problem to be attacked in the art of scientific communication.

Nuclear Science Abstracts points the way. Every article published should be abstracted promptly at a central institute. Abstracts should be given serial numbers, each number unique. Authors and abstractors should list the words under which the article should be indexed, using single words for rare subjects, but using one or several modifying words for usual subjects. The ideal should be a bulky alphabetical subject index leading to the word (concept) desired, however deeply embedded, and without recourse to the title. The index of the *Encyclopaedia Britannica* is something on the order I have in mind, but it does not have enough modifiers on the index words to lead one directly enough to the few places where that word is used in the connection the researcher desires. The art of such indexing would have to be developed.

At present books are indexed by title, and there is no way of knowing from the indexing what the several chapters contain. It would be worth while to give each chapter an abstract, with its own unique number.

The power of such an index would be enormous. It would be attainable because the reference for every index heading would be only the bare abstract number, not the entire journal, volume, page, and year.

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The Teaching of Specific Dynamic Action

THE phenomenon of specific dynamic action seems to be a source of misunderstanding and perplexity to a great many students and to many teachers of biochemistry and physiology. I would like to suggest that the reason is the way the subject is usually presented by lecturers and in textbooks.

The student is likely to be told that the ingestion of protein equivalent to 100 kcal gives rise to 130 kcal. He may be told that carbohydrate and fat also have specific dynamic action, but in smaller degree. He will probably be told that, to allow for this, extra kilocalories must be added to the food intake that meets basal and activity requirements. An obvious way to think about these statements is that, if kilocalories are required to release those of the food, their release in turn must depend upon the expenditure of other kilocalories. How, then, can the effect ever be overcome? How can there be caloric equilibrium, or positive balance, or growth, and why do we not waste away because we eat? This seems to be a common complication of thought concerning specific dynamic action, and one can hardly believe that in such cases it is given credence.

Specific dynamic action as a topic merits only brief consideration in a general or elementary course, but the more briefly a subject is treated, the greater is the necessity of presenting the essentials clearly. This applies whether the course provides the student's only encounter with the subject, or whether it serves as preparation for more advanced study. The important thing in this particular case is that specific dynamic action has been demonstrated, and what it is and what it implies should be outlined. The following proposal provides a means of doing this without leading to perplexity. It depends upon stressing the relationship of specific dynamic action to the basal metabolism, which is more important than its relationship to the food.

When food is given to an animal under basal conditions, there is a subsequent period when the metabolic rate is higher, even though the same conditions are maintained. The length of this period and the degree of elevation above the basal depend principally upon the kind and quantity of the food. For any one food or food mixture the total increment is proportionate to the amount fed. Foods high in protein have the greatest effect. It follows that under such conditions, if the caloric value of the food given does not exceed the basal expenditure plus the increment, there will be negative caloric balance.

Quantitatively, the specific dynamic action is the energy increment to the basal which results from food utilization. The importance of the relationship of specific dynamic action to the basal metabolism must be realized for a proper understanding of the phenomenon. This is developed in the following example:

Suppose that an individual under basal conditions expends 60 kcal/hr. He is given food with a caloric

value of 200, as a result of which during the next 5 hr he expends not 300 but 320 kcal, at the end of which time the metabolic rate has returned to the basal level, and extra kilocalories equivalent to 10% of those provided have been expended. The basal expenditure of this individual is 1440 kcal/day. If just the basal requirements are supplied by this particular food, therefore, there will be an expenditure of 10% more, or 144 extra kcal; and even if the individual remains under the same conditions his total energy requirements will not be met. In this hypothetical case they will just be met, however, by 1600 kcal (1440 plus 10% of the ingested), and there will be positive caloric balance with anything over 1600—e.g., a surplus of 45 calories from 1650, of 810 kcal from 2500, etc.—which could be used to support activity over the basal. Such a presentation should be suitable and adequate to explain what specific dynamic action is without leading to any misunderstanding, and would occupy no more time than should be devoted to the subject in a general or elementary course.

At this stage, however, the student might be aided in evaluating specific dynamic action as a metabolic phenomenon by the following facts. Practically all our knowledge of specific dynamic action has been derived from studies of animals kept warm in the fasting state, but otherwise under basal conditions. Practically nothing is known about it in human beings under ordinary conditions of activity and everyday living, and under normal food consumption at the usual intervals. Ten per cent of the basal used to be regarded as the allowance to be made for specific dynamic action in human energy economy, but it probably should be smaller. The supposition that, because of its greater specific dynamic action, a high-protein diet is particularly beneficial in a cold environment has not received experimental support.

Our knowledge of the etiology and mechanism of specific dynamic action is at a stage where nothing more than brief reference should be made until students have gained considerable knowledge of intermediary metabolism.

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Transportation of Live Materials for Research

MANY papers have been published regarding the value of live materials for instruction and research. Numerous specific reports of results of research projects, based on the ready availability of live animals, may be found in any scientific or medical periodical, In many instances the researcher may have had to collect the animals himself, spending his time and money transporting them home with his effects and equipment after solving the difficulties of collecting them in the field.

In other research programs, particularly in physiology, parasitology, pharmacology, and in innumerable projects directed toward public health, fresh, specific live materials are required on a series of delivery dates, as needed in the course of experiments, in the conduct of which the researcher has to have such facilities as pertinent literature, equipment, and qualified assistants to be sure of getting satisfactory results. Under these circumstances he must depend on the performance of a reliable supplier. For 12 years the writer has supplied specimens from the subtropical zone of Florida on a business basis, and many institutions have depended on his services.

Transportation handicaps beyond our control are critically interfering with our supply effort. Fast, dependable transportation is no longer available. Live materials are perishable. They are expected to arrive fresh and not *just* alive, for they may be used for weeks, or even months. We are confronted with embargoes of air express on shipments of live materials of any kind. They were put into effect first by a few airlines three years ago and are now applied by most American airlines with scheduled service, thus eliminating the most efficient and, all factors considered, the most economical way of shipping. Canadian airlines have no such embargo.

For all practical purposes there is an embargo on air parcel post, because of a ruling that admissible live materials should be so packed that they can be put into canvas mail sacks during transit, and this would result in suffocation. Small mammals are excluded from air parcel post. This service used to be excellent and economical. We used it for numerous shipments without any loss. A recent further restriction prohibits acceptance by first-class post offices of air parcel post in excess of 20 pounds. Acceptance up to 70 pounds is allowed by any second- or third-class post office. This rule forces us to take our shipments miles out of town to a second-class post office, which sends the packages back by rail to the first-class post office here in town, where acceptance was originally refused.

We have what practically amounts to an embargo of railway express service. When restrictions were placed on the competitive transportation services of air express and air parcel post, the Railway Express Co. priced itself out of the market for shipment of live materials, first by raising the basic rates, then by raising rate classifications and charging for live materials twice the first-class rate, by giving deficient service in transit, and finally by refusing claims.

It is difficult to see how this rate can be justified for any small-animal shipments, because they do not require extraordinary attention, such as feeding, watering, and cleaning of cages. As a matter of fact, these are not wanted. From 1939 to 1951 we rarely had any losses, although thousands of research animals were handled during this period. Our packages are clean, without any noticeable odor, and the animals are in uniform, patented, individual wire cages. The rates charged can only be considered penalties on animals shipped for research, because live tropical