fibers are small myelinated ones. Most of the large myelinated fibers pass into the ventral ramus, 327 in all, and the small myelinated fibers out the communicating ramus.

When silver preparations are made the discrepancies on the two sides of the ganglion are even more striking. There is a total of 2,020 fibers in the two roots, and if from that number 883 are subtracted which pass to the dorsal rami there are left 1,137 for the spinal nerve trunk. But a cross section of the spinal nerve reveals 5,277 fibers, or an increase of 4.6 fold. Of these 5,277 fibers 569 continue into the ventral ramus and the remainder enter the communicating ramus. The gray ramus consists of relatively few fibers and is not a complicating factor.

All the "additional" fibers come from the dorsal root ganglion. The spinal ganglion cells were counted on two nerves and the average was 5,220 cells, a number which closely approximates the total number of fibers distal to the ganglion. On the basis of fiber and cell counts it would seem that about 3,500 fibers arise in the dorsal root ganglion from cells which apparently do not have central processes entering the cord. Some alternative interpretations have been considered, namely, branching of dorsal root fibers and a possible failure of the sympathetic ganglion during development to migrate distally away from the dorsal root ganglion, but the evidence for them seems insufficient.

There remains the question, of course, whether all the fibers in the dorsal root were stained and counted. The nonmyelinated fibers, constituting about three quarters of the total number in the dorsal root, are not much above the limits of microscopic visibility. Their diameter is about a quarter of a micron. Confirmation of our counts has kindly been made by Dr. H. A. Davenport on the roots of this material. But are these minute entities single fibers or are they two or three or four compressed together within one neurilemma sheath? Such a condition has been observed by Speidel[3] in the growing peripheral nerves of the frog tadpole and by Nageotte.[4] If we are faced with such a situation here, then the separate fibers forming the group are individually below the limits of microscopic visibility and if single fibers of this type exist separately they could not be seen. To postulate that 3,500 nerve fibers were missed because they were invisible presents such complications for this and other work that one hesitates to apply such an interpretation to these data until other more promising avenues of approach have been exhausted.

[3] C. C. Speidel, *Jour. Comp. Neurol.*, 61: 1–82, 1935.

[4] J. Nageotte, "Cytology and Cellular Pathology of the Nervous System," Sect. 5: 189–239, 1932. Paul B. Hoeber, N. Y.

The physiological aspects of this problem now under examination by Dr. G. H. Bishop have thus far confirmed the neurological data and the suggested architecture of the fourth spinal nerve.

ALFRED M. LUCAS
IOWA STATE COLLEGE
JOHN E. MIKSICEK
WASHINGTON UNIVERSITY
SCHOOL OF MEDICINE

THE THERMOPHILIC AND ANAEROBIC NATURE OF LACTOBACILLUS BULGARICUS

As the "bacillus of long life" of Metchnikoff, *Lactobacillus bulgaricus* has been of considerable general interest, and milk fermented with this organism has been a commercial product of importance. Although it is now known that his idea about the identity of the supposedly beneficial organism was erroneous, the basic conception of Metchnikoff has received substantial scientific support through the investigations of the past twenty-five years—hence the more recent and more justly founded popularity of "acidophilus-milk," prepared with *Lactobacillus acidophilus.*

As a matter of fact, it appears that the true *Lactobacillus bulgaricus* has been isolated only a relatively few times. Most bacteriological laboratories carry one or more supposedly authentic cultures of this organism, but if one makes a collection of these and obtains as much as is available of their histories, it is found that those cultures which have the characteristics of the true *Lactobacillus bulgaricus* trace back to a small number of original strains. Among those who are not especially familiar with the species, it is frequently thought that *Lactobacillus bulgaricus* is the most common lactobacillus of milk. This is not the case; an uncritical approach usually results in the isolation of *Lactobacillus casei,* a more abundant and easily isolated organism, or some of the other lactobacilli, rather than *Lactobacillus bulgaricus.* The true habitat of the organism is not known, and it has not been isolated from nature; it is commonly referred to as a "milk organism," but it is known to occur there in very small numbers, and, so far as we are aware, it has seldom, if ever, been isolated from fresh milk. In common with others, we have frequently isolated *Lactobacillus bulgaricus* from Swiss cheese, but this feat probably represents only the reisolation of the well-domesticated culture which had been used as a "starter" in the making of the cheese. Most of the laboratory cultures of *Lactobacillus bulgaricus* were originally isolated from natural fermented milks, such as jugurt, which are propagated from batch to batch over long periods of time. Although not attaining to a pure culture status, the process becomes highly selective, and we think there is some reason to believe that such culturing brings about some of the same changes as occur when it is propagated in the laboratory in pure culture.

We have recently isolated more than 200 cultures of *Lactobacillus bulgaricus* from fresh milk and have thus obtained a more adequate picture of the group as a whole than was heretofore available. What have been considered the prime distinguishing characters of this organism stand out in even bolder relief in these freshly isolated cultures. In a few characteristics, however, they vary from the conventional laboratory strains. For example, the new cultures do not grow as rapidly in milk, but this point should not surprise those who have given any thought to the subject of bacterial ecology.

With the application of proper selective methods, followed by dilution transfers, it was easy to obtain the cultures in substantially, if not strictly, pure cultures. Upon plating to obtain colony isolation, in the majority of cases, growth was not obtained either on aerobic plates or on those incubated anaerobically. At the suggestion of Professor Georges Knaysi, .05 per cent. sodium sulfite was added to the agar medium and the plates were incubated aerobically. All cultures yielded colonies on this medium and pure culture isolations were easily made. Probably the colony isolations could have been made by the conventional anaerobic methods—perhaps our technique was faulty—but, with such competent expert advice ready at hand, it was not necessary to lose further time with the more cumbersome methods. Although this rather strongly anaerobic nature of *Lactobacillus bulgaricus* appears to have been missed in the past, it is not especially surprising. The lactobacilli as a group are facultative with a distinct preference for anaerobic conditions on the part of a number of the species. Some of the other lactobacilli also behave as true anaerobes when freshly isolated and become facultative upon continued laboratory culture.

The more interesting new point about *Lactobacillus bulgaricus* is its thermophilic nature. Old laboratory cultures of this organism usually have maximum temperatures of growth around 50° C. A majority of the freshly isolated strains grow at 60° C., and vigorously at 55° C. While only a small proportion of the newly isolated cultures have failed to grow at these higher temperatures, out of a small collection of 18 strains, which were isolated and carried in the laboratory for about a year before testing, only six can grow at temperatures substantially above 50° C. This may be a coincidence, but we think not. Of three stock cultures of *Lactobacillus bulgaricus* which have been under artificial cultivation for many years, only one is now able to grow at 50° C.

For certain technical applications the thermophilic nature of newly isolated strains of *Lactobacillus bulgaricus* has an important significance.

J. M. Sherman
H. M. Hodge

Cornell University

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A HIGH SPEED CRYSTAL INK WRITER

Various oscillographs in use for following transient electric potentials depend on photographic recording, with the attendant trouble and delay of developing the record and the expense of equipment and film. This latter is especially serious when long-continued records are desirable, as in recent electrical studies of the brain. Ink writers, in turn, have been limited to relatively low frequency signals, the best so far described giving responses of approximately correct amplitude only below fifty cycles per second.

The instrument here described is novel in that a piezo-electric crystal, rather than an electro-magnet, drives the pen. Besides improved frequency characteristics, this "Crystograph," as we have called it, possesses other advantages: no polarizing current or voltage is required; efficiency is high, a quarter of a watt of power giving deflections of two centimeters; a high impedance permits direct resistance-capacity coupling to the output of any amplifier supplying sufficient voltage (about 500 R. M. S. maximum) and power; its impedance characteristic also permits

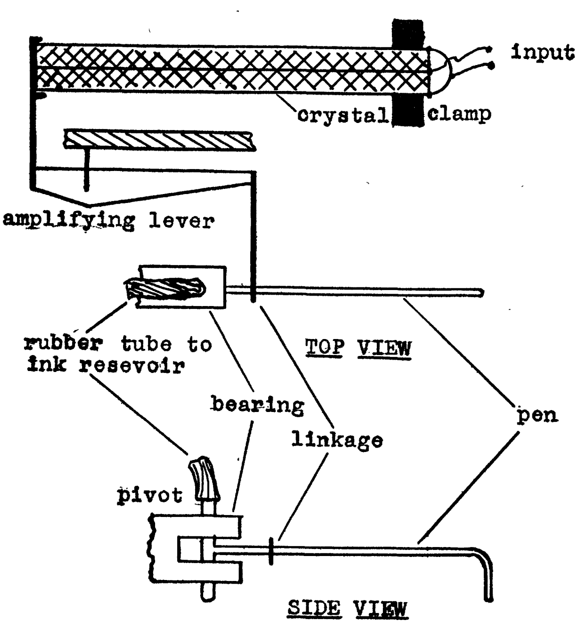

Fig. 1. Diagram of Crystograph.