positron and neutrino, then there exists a finite probability that the positron will be excited to a higher level of the energy continuum. In this excited state the positron can either escape from the neutron or drop to its original energy state with the emission of radiation. In its ground state it is again possible for the positron to reunite with the neutron to form a proton. Now it is quite possible for the radiation process to take place in either one or many steps. On this picture it is this multiple process which is the origin of the spray of photons found in showers. A calculation of the ratio of the probability of the emission of $n+1$ photons to that of n photons during the descent of the positron from its excited state to the ground state has been carried out. This ratio is $\left(\frac{2}{137\pi}\right)\frac{(\log W)^2}{n+1}$, where W is the ratio of the energy of the electron after the $n+1^{th}$ transition to $m c^2$. Now this ratio is greater than the classical value 1/137 for those values of the energy ratio W which are greater than exp. $\sqrt{\frac{(n+1)\pi}{2}}$. For electrons with a smaller amount of energy in the final state the reverse is true. It is the possibility of a value, larger than 1/137, for this ratio, which is the significant feature of this explanation of shower production.

An estimate of the energy of the photons can be determined from the expression for the probability of emission of a single photon. If ν is the frequency of the photon emitted then an approximate value of this probability is $\left(\frac{2}{137\pi}\right)\frac{c^2 \log W}{\nu}$; here c is the velocity of light. According to this expression the emission of a relatively soft photon is the most probable event. Thus a shower should be composed of a spray of low energy photons $2 m c^2$.

Besides the production of showers of photons, this process should be accompanied by the emission of a single positron. This production of a positron by the dissolution of a proton is quite a different process from that in which it appears as one member of a pair.

Finally, if the Oppenheimer conditions are applied to this process, an upper limit for the energy $\varepsilon m c^2$ of the electron capable of producing showers is found again just as in the Born theory, ε max. $(137)^2/Z^{1/3}$.

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NERVE CELLS WITHOUT CENTRAL PROCESSES IN THE FOURTH SPINAL GANGLION OF THE BULLFROG

THE frog is favorable material for a neurological study of visceral innervation and particularly the relation of sympathetic to spinal nerves because its vertebral column is so shortened that only ten spinal nerves exist and thus the elements contributing to the celiac plexus reveal an exaggerated concentration into a limited locus. The fourth spinal nerve (fifth in early development) carries over half the fibers contributing to the celiac nerve. The two conclusions of particular interest and significance which have come out of this study are, (1) that practically all the neurons whose fibers pass out the communicating ramus to the celiac nerve have their cells of origin in the dorsal root ganglion and (2) that nearly all these neurons lack central processes extending to the spinal cord by way of the dorsal root.

The evidence upon which these conclusions are founded is derived from serial sections of the fourth spinal nerve, roots, ganglion, adjacent sympathetic trunks, rami and celiac nerve stained by silver and osmic methods.

In osmic preparations the myelinated fibers were counted on several nerves and the counts from a representative example are given in Fig. 1. The dorsal

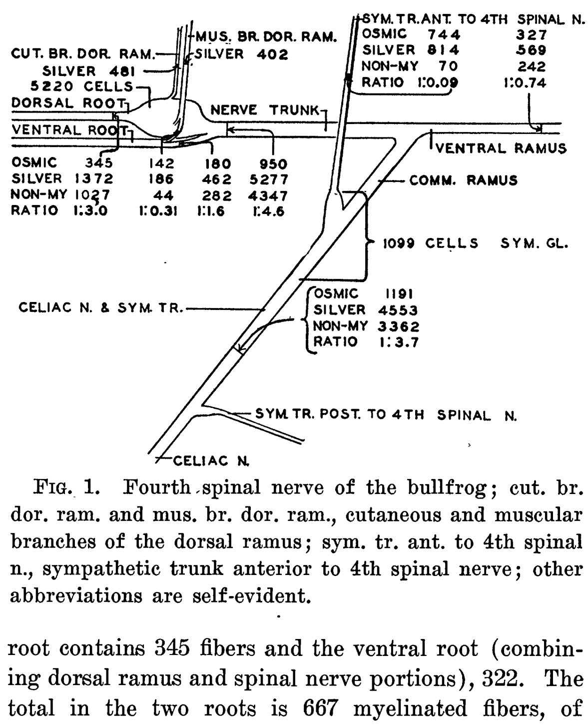

FIG. 1. Fourth spinal nerve of the bullfrog; cut. br. dor. ram. and mus. br. dor. ram., cutaneous and muscular branches of the dorsal ramus; sym. tr. ant. to 4th spinal n., sympathetic trunk anterior to 4th spinal nerve; other abbreviations are self-evident.

root contains 345 fibers and the ventral root (combining dorsal ramus and spinal nerve portions), 322. The total in the two roots is 667 myelinated fibers, of which it is estimated at least 259 are distributed to the dorsal rami, leaving 408 fibers for the spinal nerve distal to the ganglion. In the spinal nerve trunk, however, there are 950 myelinated fibers. The existence of more myelinated fibers in the spinal nerve than in both roots has previously been described by Hardesty[1,2] in *Rana virescens*. The "additional"

[1] I. Hardesty, *Jour. Comp. Neurol.*, 9: 64–112, 1899.
[2] I. Hardesty, *Jour. Comp. Neurol.*, 10: 323–354, 1900.

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.

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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