just described. Since it requires a greater protrusion, y, of positive needle ($y > .3$ cm) to evoke the anode convection current than the anode spark succession ($y = .10$ to $.14$ cm for darts, $y > .14$ cm for cones), the above inference for bright and dark sparks is not unreasonable. The impression is often made as if the negative glow were transferred to the edge of the positive plate and became a positive surface glow.

Finally, since the negative body acts to extinguish the cathode glow from a definite radius, one may argue, as I have heretofore, that it imposes an effective negative increment of potential throughout the field of the spark gap.

3. *Telescopic anode reactions.* To obtain darts (snapping white linear sparks) from the cathode point in the absence of the anode needle has not been possible. They appear at the anode point (cathode point absent) as an integration of the earlier diffuse spark filaments for the narrow ranges of protrusion y, given, unless there is special stimulation (earthing the cathode, for instance) when darts appear sooner. The positive convection current does not appear until $y = .3$ cm or later, when a mere point of light tips the anode in the dark spark gap. Between these limits the dart degenerates into a purplish diffuse cone with its apex at the anode needle (see fig. 2). In the telescope the divergence is filamentary and scattering. As y ($< .3$ cm) increases, the cone grows narrower and weaker, and in the ear trumpet the crackling runs up into high frequencies. The spark gap is now in a good form for experiment. If, for instance, the negative rod[2] is put in the symmetrical position (1), figure 2, the straight symmetrical axis a of the cone changes to an axis b concave towards the rod, and more so as the rod is nearer. This proves adequately that the emitted rays, a, are positive ions and the method may be useful for measurement. Again let y be further increased until the luminous cone just vanishes and the dark convection current appears. Then it will be found that the negative rod at (2) on the anode side restores the cone a and keeps it; whereas the negative rod at (3) on the cathode side quenches the cone. The test may be repeated indefinitely. The negative rod at (2) or (3) is thus equivalent to a decrement or increment, respectively, of the protrusion y.

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[2] The magnetic field arising from a metal conductor is not convenient. The anode is much more capricious than the cathode. The convection current may strike too soon, or too late, or again not at all. The above data are good averages for the given machine and spark gap. Some control is possible, however, by the methods of § 3. The axial flexure of fig. 2 can not be obtained with the negative convection current.

FACTOR H IN THE NUTRITION OF TROUT

SINCE the time of Magendie, investigators have tried to develop purified rations which would meet all the requirements of the animal body for growth and reproduction. The greatest success in these attempts has undoubtedly been attained with the rat. That even the rat fails to show an optimum growth upon a simplified ration containing all the known elements, is evident from many experiments and especially from the recent reports of Osborne and Mendel,[1] and Palmer and Kennedy.[2]

The fact that many of the discoveries in nutrition that have been made in rearing rats have found ready applications in feeding the higher animals has led to the subtle assumption that the nutritional requirements of all species of animal life are the same. The reflection of such natural philosophy is seen in the wide-spread use of cod liver oil, yeast and other vitamin supplements in the hatcheries of the United States that are engaged in rearing trout. Although Laufberger[3] has stated that fish require vitamins in their food, his work fails to furnish convincing evidence that these are related to any of the known accessory substances required by the higher animals.

In order to furnish a more rational basis for feeding trout we have conducted a series of experiments upon their growth curves when they are fed diets of widely different compositions. These experiments have been performed at the Burlington hatchery in the state of Connecticut. This hatchery is unusually well equipped for such experiments, since it has a constant supply of pure spring water which exhibits very slight temperature variations. Each experimental group of trout contained fifty fingerlings which were confined in separate troughs with individual water supplies and outlets. The efficacy of a given diet was judged by the average growth rate and by the mortality rate.

In our first series of ten experiments we employed nine purified rations made up of casein, boiled starch, salt mixture, cod liver oil and yeast. In four of these the protein was incorporated at various levels from ten to seventy-five per cent. In two, lard was included at twenty-two and fifty-seven per cent. levels varying the other factors to secure adequate salt and protein intake. From one, cod liver oil was omitted; in another yeast was lacking and still another contained no salt mixture. For purposes of comparison a diet of dried skimmed milk was employed. For seven weeks all the fingerlings, except those upon the

[1] Osborne, T. B., and Mendel, L. B., *J. Biol. Chem.*, 1926, LXIX, 661.

[2] Palmer, L. S., and Kennedy, C., *J. Biol. Chem.*, 1927, LXXV, 619.

[3] Laufberger, V., *Physiol. Abstracts*, 1926, XI, 221.

ten per cent. protein diet, grew normally practically doubling their weight. Those upon the lowest protein level refused to grow but ate their ration readily and remained active.

At the end of seven weeks all groups commenced to die except those upon the low protein diet and those upon the dried skimmed milk. The latter continued to grow until at the end of sixteen weeks they averaged five times their initial weight. At this time they ceased to grow and began to die. The entire fifty had died at the end of the twentieth week.

At the end of the fourteenth week those upon the low protein diet began to die. This continued at a regular rate until the twentieth week when only seventeen remained alive. They were now divided into two groups. One of these received raw liver and the other remained upon the purified ration with the low protein level. Those fed raw liver immediately assumed an optimum growth rate and in nine weeks tripled their weight. Those kept upon the low protein diet did not grow and all died in the course of the next five weeks.

From these experiments we must conclude that raw meat contains some factors which is neither vitamin A, B or D and which is an unrecognized dietary factor essential for the growth of trout. Dried skimmed milk contains a small amount of this factor but not enough to permit continued growth for long periods, Furthermore trout require a diet containing more than ten per cent. protein for normal growth. In case they are stunted by a protein deficiency the power or resuming growth is not lost even at the end of five months. In the course of these experiments it was observed that trout which are stunted by protein deficiency do not develop the spots commonly observed upon this species of eastern brook trout while those that are allowed to grow develop these spots quite normally. The development of these is a function of growth and not of age.

In a second series of experiments twenty different rations were employed. One of these was a purified feedstuff of casein, starch, salt mixture, cod liver oil and yeast modeled after those previously used and commonly employed in work upon rats. This was accompanied by a ration of the same composition except that it contained orange juice. The trout showed a reaction that duplicated our previous experience. They displayed a slight initial growth followed by failure. Hence we must conclude that the unknown factor H which is found in raw meat is not vitamin C.

In this second group of experiments attempts were made to determine if this factor were sensitive to heat like that described by Dr. Wulzen[4] in her studies upon planaria. Comparative studies were made between raw liver and that which had been cooked and dried for other experiments upon blood regeneration, by the senior author.[5] Dried liver gave no response while fresh liver gave the usual excellent growth. From this, one must conclude that the factor in liver responsible for growth in trout is destroyed by heat. Furthermore it is an entirely different factor than that responsible for blood formation since the same cooked, dried liver produces excellent blood regeneration in rats, but fails to promote growth in trout. We have studied two commercial dried meats and find both of them entirely lacking in this growth stimulating power.

Two other diets which have been studied may be worthy of record. We have fed trout Sherman's stock ration for rats which consists of whole wheat, dried whole milk, calcium carbonate and sodium chloride. Trout consume this ration readily, but do not grow. From this we may infer that factor H is not related to vitamin E.

In order to determine whether the growth secured upon dried skimmed milk was the result of its composition or some extra factor which it contained, we prepared a synthetic product of casein, lactose and salt mixture and fed this supplemented with cod liver oil and yeast. Only slight growth resulted from this ration and the trout began to die at the end of the fifth week. This experiment is being repeated with part of the protein furnished by lactalbumin. We must conclude that natural dried skimmed milk contains factor H and "synthetic milk" lacks it.

Both the yeast and the cod liver oil employed in these experiments were products of tested potency.

The discovery of factor H to which we have called attention must be credited to those pioneers in the rearing and propagation of fish who long before our generation found that trout required raw meat for proper growth and would fail upon the dried products.

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The complete data with growth curves will appear in the *Transactions* of the American Fisheries Society for 1927.

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[4] Wulzen, R., SCIENCE, 1927, LXV, 331.

[5] McCay, C. M., *Am. J. Physiol.*, 1928, LXXIV, 16.