vexed question, and one in the solution of which we have little solid ground to go upon beyond the material changes produced in the brain and the consideration of the time that these might reasonably be supposed to take in their development.

Darwin was inclined to believe that articulate speech came at an early period in the history of the stem-form of man. Romanes gives a realistic picture of an individual decidedly superior to the anthropoid ape, but distinctly below the existing savages. This hypothetical form, half simian, half human, was, according to his sponsor, probably erect; he had arrived at the power of shaping flints as tools, and was a great adept at communicating with his fellows by gesture, vocal tones and facial grimaces.

With this accomplished ancestor in his mental eye, it is not surprising that Romanes was inclined to consider that articulate speech may have come at a later period than is generally supposed.

At the time that Romanes gave expression to these views he was not acquainted with the very marked structural peculiarities which distinguish the human brain in the region of the speech center. I do not refer to the development of the brain in other districts, because possibly Romanes might have held that the numerous accomplishments of his speechless ancestor might be sufficient to account for this; I merely allude to changes which may reasonably be held to have taken place in direct connection with the gradual acquisition of speech.

These structural characters constitute one of the leading peculiarities of the human cerebral cortex, and are totally absent in the brain of the anthropoid ape and of the speechless microcephalic idiot.

Further, it is significant that in certain anthropoid brains a slight advance in the same direction may occasionally be faintly traced, whilst in certain human brains a distinct backward step is sometimes noticeable. The path which has led to this special development is thus in some measure delineated.

It is certain that these structural additions to the human brain are no recent acquisition by the stem-form of man, but are the result of a slow evolutionary growth—a growth which has been stimulated by the laborious efforts of countless generations to arrive at the perfect coordination of all the muscular factors which are called into play in the production of articulate speech.

Assuming that the acquisition of speech has afforded the chief stimulus to the general development of the brain, and thereby giving it a rank high above any other factor which has operated in the evolution of man, it would be wrong to lose sight of the fact that the first step in this upward movement must have been taken by the brain itself. Some cerebral variation—probably trifling and insignificant at the start, and yet pregnant with the most far-reaching possibilities—has in the stem-form of man contributed that condition which has rendered speech possible. This variation, strengthened and fostered by natural selection, has in the end led to the great double result of a large brain with wide and extensive association areas and articulate speech, the two results being brought about by the mutual reaction of the one process upon the other.

D. J. CUNNINGHAM.

PROFESSOR PAWLOW'S RESEARCHES ON THE PHYSIOLOGY OF SECRETION.

THE publication, last year, of the conditions which are to govern the award of the Nobel prizes was followed not long since by the announcement that Professor J. P. Pawlow of St. Petersburg had been designated, with Professor Niels R. Finsen of Copenhagen, as the first recipient of this honor, for the most important discovery in

the department of physiology or of medicine. To those readers of SCIENCE who are not familiar with the details of modern physiological investigation, a brief review of the more important work of this brilliant Russian investigator may be of interest.

Professor Pawlow's researches have, for the most part, been directed to the solution of problems connected with the physiology of secretion. His persistent efforts in this field have been crowned with success to an unusual degree; and physiology owes to him and his coworkers much of the progress which has been made in recent years towards a clearer understanding of the processes of digestion in the animal organism. New experimental methods have been devised, and older ones applied to new purposes.

With reference to the nitrogenous metabolism of the salivary glands, Pawlow showed (1888) by direct chemical analysis, that anabolic and katabolic processes are coincident in the secreting organ. This observation, usually overlooked by physiologists, was in itself an important contribution to the theory of secretion. The extensive series of experiments on the innervation of the gastric and pancreatic glands—researches which have had their origin in Pawlow's laboratory—have evoked the widest attention. In this study of gastric secretion the improvements in the general technique consisted primarily in the simultaneous introduction of an ordinary gastric fistula (in dogs) and a division of the œsophagus in the middle of the neck. The cut ends were attached to openings in the neck so that swallowed food passed out at one opening without reaching the stomach; and, through the other, food which it was desired should enter the stomach could be passed in. The more important facts ascertained by the use of this method were, that when food is eaten a flow of gastric juice is started; inasmuch as under the experimental conditions referred to the ingested material fails to reach the stomach, the reflex character of the impulses which provoke the secretion can thus be demonstrated. The paths along which the reflex stimulation reaches the gastric glands were shown to be the vagus nerves; for while section of the splanchnics does not interfere with the reflex secretion, this reaction entirely disappears after division of the vagi. To make the proof complete, Pawlow showed that artificial stimulation of the peripheral end of a cut vagus will incite a flow of active gastric juice.

The possibility of obtaining pure gastric juice uncontaminated with the products of digestion was thus accomplished in a way never before equaled. It remained, however, to observe the production of the secretion and its properties during the course of actual digestion. Heidenhain had already developed a method of isolating one portion of the stomach from the rest, so that it was possible to keep animals in this condition under observation for a long period. In his operations, however, the nerve supply to the isolated portion was undoubtedly seriously interfered with. Pawlow improved the method, so that there remained an undisturbed nerve distribution, the functional importance of which he clearly showed. Secretion in the isolated portion could thus be followed while digestion was proceeding in the adjoining parts of the stomach.

Along similar lines our knowledge of the work of the pancreas and the production of the bile has been largely added to by Pawlow and his pupils. The introduction of a successful method for obtaining permanent fistulas has been followed by a study of the secretory activity of the pancreatic gland. The reflex character of the ordinary stimuli has been demonstrated, and the paths through which the impulses reach the gland ascertained. The existence of inhibitory

nerves for the secretory glands has been made more probable by Pawlow. The true significance of this discovery lies in the fact that it has enabled us to appreciate more clearly the mechanism by which the secretory glands, like other organs, adapt themselves so perfectly to the work which they have to accomplish at different times.

With pure digestive juices made thus readily available, it is not surprising to find interest in the study of their composition renewed. The way has been opened for more purely chemical investigations, such as the recent one of Professor v. Nencki—a colleague of Professor Pawlow—on the character of the enzymes of the gastric juice. From the general biological point of view, one of the most interesting aspects of the work of the St. Petersburg school is the demonstration of the purposeful character of secretion into the alimentary canal. Quantitatively and qualitatively the work of the glands varies with the character of the substances upon which they exert their action at different times. Changes in diet bring variations in the character of secretion. Pawlow has broadly expressed this view in summarizing his contributions to our knowledge of the specific excitability of the digestive glands. He writes: "Our results have, we trust, dispelled from our domain, once for all, the unfruitful idea that the alimentary canal is excitable by any agent whatsoever, mechanical, chemical or thermal, without regard to the peculiarity of each specific digestive task. At present, agencies such as these, vigorously applied, must be regarded merely as favoring or inhibitory influences, not as the normal and determining factors which excite secretory activity. In place of gross uncertainty (Scheinwissen) we now see the outlines of an artistic mechanism which, like everything that we understand in nature, exhibits an unusual degree of exactness and utility in her processes."

It remains to speak of Pawlow's work (in cooperation with v. Nencki and others) on the functions of the liver. Here again a brilliant operative technique—the Eck fistula, by which the portal blood is diverted directly into the vena cava without entering the hepatic capillaries—has inaugurated progress. The splendid researches on the seat of urea formation in mammals have modified and shaped the current teaching of this subject and other aspects of intermediary metabolism. What light they may throw upon the pathogeny of certain abnormal states, such as uræmia and diabetes, can scarcely be foretold.

Among the comparatively recent contributions to physiological literature no book has exerted a more stimulating influence than Pawlow's 'Die Arbeit der Verdauungsdrüsen' (J. F. Bergmann, Wiesbaden, 1898). It summarizes in suggestive chapters the main achievements of the author in his chosen field of work. Its original treatment of the problems in this domain has aroused the interest of both physiologists and physicians; and the work has already served in fulfilment of the author's hope, to further physiological science by promoting a more active interchange of ideas between the practitioner and the laboratory worker. Pawlow's work has demonstrated what Sir Michael Foster has written in another connection: that "the heart of physiology is in the laboratory. It is this which sends the life-blood through its frame; and in respect to this, perhaps, more than anything else, has the progress of the past years been striking."

LAFAYETTE B. MENDEL.
SHEFFIELD SCIENTIFIC SCHOOL
OF YALE UNIVERSITY.

SCIENTIFIC BOOKS.

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