The fourth generation required only 10 lessons. The last generation which I saw before leaving Petrograd learned the lesson after 5 repetitions. The sixth generation will be tested after my return. I think it very probable that after some time a new generation of mice will run to the feeding place on hearing the bell with no previous lesson.

It is well known that a chicken when it just comes from the egg immediately begins to pick up any black spot on the floor, trying to find some grain, thus showing that it has an inborn reflex from the eye to the food reaction. Why should we not build up the same reaction, not from the eye but from the ear as indicated in the case of the white mice?

The experiments in this direction with sound show very great progress. We obtained a great many results in a very short time. Similar experiments were made on men, with analogous results. We do not see any future difficulties, and at the same time the subject is of very great importance.

My firm belief is that the best way to a knowledge of the mechanism and the laws of our subjective world lies in the direction of the pure physiology of the hemispheres. In this way, in trying to estimate the influence of physiology in human life, we often acquire an unexpectedly large view.

All the rules for education and development ought to be taken from physiology. This opinion I have endeavored to support in this lecture by a short description of some of my experiments.

I. P. PAWLOW

PETROGRAD, RUSSIA

ON THE FUNCTION OF THE CEREBELLUM

IT is now ninety-nine years since Magendie taught that the function of the cerebellum is to regulate our bodily equilibrium. Flourens (1842) emphasized the fact that it helps to bring our complicated muscle-action into harmonious relation and that cerebellar symptoms are purely motor and not based upon any form of sensory disturbance; Lussana regarded it as the central organ of muscle-sense. Until that time these authors had confined their studies to the well-ordered higher work of the cerebellum; later it was analyzed with regard to elementary function.

After twenty years' experiments (1884–1904) Luciani found, after removal of the cerebellum, three important functions missing, the loss of which he designated as atonia, asthenia and astasia. Directly after extirpation of the cerebellum there appear hypertonia of the muscle in the form of opisthotonus, and later hypotonia or atonia, or, in the inclusive terminology of Lewandowsky, cerebellar dystonia. This leads to dysmetria and by oscillation and jerkiness of the body to astasia.

In the opinion of Babinski, atonia is an unimportant symptom, a simple matter of muscle softness, and asthenia is not a true weakness, but simply the result of the violence of distorted movements. André-Thomas, who has combined experimental and clinical researches, regards atonia as of rare occurrence and asthenia as not cerebellar in origin.

Gordon Holmes, who has studied the cerebellar symptom-complex of the acute lesions produced by gunshot wound, agrees with Luciani that atonia, asthenia and astasia are fundamental defects of functions in cerebellar lesions, but he interprets them somewhat differently from Luciani. Babinski proposed to give the designation "adiadochokinesis" to the loss of the faculty of voluntarily executing rapidly alternating movements when the simple component movements are carried out with normal celerity. Holmes defined atonia as the diminution of that slight constant active tension which is characteristic of normal muscle, and regards it as a factor in the production of Babinski's adiadochokinesis. Luciani applies the term "dysmetria" to the violent and disordered movements in walking, involving excessive expenditure of energy, which are noticeable in a dog without cerebellum. He explains it as the premature relaxation of the extensors during the flexion phase of the step, and conversely premature relaxation of the flexors during the extension phase, so that the foot is lifted too high, or planted on the ground with a stamp. In Holmes's theory it depends upon a faulty combination of muscular contractions and is due to delayed muscular relaxation or ill-proportioned range and force of movement. Babinski calls it *gaspillage d'énergie* or waste of energy, assuming that the arresting action of the cerebellum upon muscular contractions is destroyed by extirpation or disease.

In the complex combination or sequence of several simultaneous movements, there is another disturbance which we call "asynergia." According to Holmes, it is the absence or disturbance of that proper synergic association in the contraction of muscles which assures that the different components of an act follow in proper sequence, at the proper moment, and are of the proper degree, so that the act is executed accurately and with the least possible expenditure of energy. In his opinion adiadochokinesis depends upon atonia, asynergia, dysmetria and delayed contraction and relaxation of muscles, while André-Thomas regards it simply as a natural result of dysmetria.

The opinions of these different authors are so far asunder that, as Walshe has said in his summary of the reports, "the hypotheses are couched in such vague and general terms as to be little more than restatements of an unsolved problem, while the analyses are diverse and do not reach the fundamental

factors of cerebellar ataxy." Nevertheless, we regard adiadochokinesis, dysmetria, asynergia and ataxia as important symptoms in the diagnosis of cerebellar affections, and they render good clinical service. Of course we shall not cease to seek better signs to enable us to perceive the functions and pathology of the cerebellum.

The localization of function is less well known in the cerebellum than in the cerebrum. What Bolk supposed on the ground of comparative-anatomical study, and what Rynbork, Rothmann and others made probable by experiments on animals was proved in the human cerebellum by Barany's physiological and clinical research, that there are areas of the cerebellar cortex which correspond to the extremities. In the first place, the muscles of the extremities are represented in the cerebellum by directions of movements, that is to say, there exist four centers, those for right, left, upward and downward. In the case of rest there goes from the four centers to the muscles of the extremities a tonising impulse; and thus equilibrium is maintained. If, for example, the left center is suddenly destroyed, the right extremity moves vertically to the right side, because the left center having disappeared, the right becomes overweighted. If the upper center is destroyed the extremity moves in a horizontal direction in analogous manner downward. The centers for all these movements are localized on the cerebellar hemispheres in the *lobus semilunaris superior et inferior* and in the *lobus biventralis*. Only the site of the center for upward movements of the arm is unknown. The action of these centers is like that of two bridles, the relaxation of one causing the overweight of the other.

If we now examine the cerebella of fish, we find that the apparatus for maintaining equilibrium of the body in the amphioxus, cyclostome and plagiostome is not yet well developed. The Teleostei have, in the medulla oblongata, large cells called Mauthner's cells, which have the function of maintaining equilibrium. Moreover, in this class of fish the "back-cerebrum" is also well developed, corresponding to the cerebella of other animals. We see further that the cerebellum is almost absent in a variety of skate which stays at the bottom of the sea practically motionless, while in the common variety which swims, it is well marked. It is also very interesting to see that the cerebella of fish have several different, sometimes very curious, shapes: standing up straight or lying down forward or backward, according to the species. The largest cerebellum is to be met with in Mormyridae, to which belong *Mormyrus kanume, Petrocephalus sp.* and *Gnathonemus cyprinoides,* inhabitants of muddy water and swimmers in thickets of water-plants. They do not swim quickly, but are very nimble and vivacious with constant movements of fins, as they wind their way between the aquatic plants. The cerebellum of the Mormyridae is most hypertrophic and overlies all other parts of the cerebrum in the same manner as the human cerebrum is excessive in growth compared with that of other mammals.

Let us consider the cerebella of mammals which live in water, such as the whale, the seal, the otter, etc. As compared with fishes they all have a much better developed cerebellum, especially the seal, which is less accommodated to life in water and whose nimble movements we all know. Life in water leads, generally speaking, to atrophy of the cerebellum and particularly of the vermis or middle lobe, while the hemispheres remain in good condition.

The human cerebellum is well developed for the purpose of upright walking, because it is much more difficult to maintain bodily equilibrium on two feet than on four. Moreover, in the human being it regulates the coordination of speech. Not only the movements of tongue, lips and vocal cords must be well coordinated, but also the superficial and deep sensibility of mouth, throat and larynx must be well developed. Great orators need not only a well-developed center for articulate speech in the cerebrum, but also a well developed cerebellum, so that the cerebellum shall work under the control of the cerebrum and vice versa.

KINNOSUKE MIURA
IMPERIAL UNIVERSITY OF TOKYO

WORK OF THE NATIONAL RESEARCH COUNCIL

(Continued)

Division of Research Extension.—The council's division of research extension, which is especially interested in the promotion of industrial research, has been the special representative of the council in connection with its relation to the organization of the Crop Protection Institute, the Horological Institute and the important committees on corrosion problems, alloys problems, textiles research, the making and use of scientific instruments, etc. The officers of this division have also the special function of the active solicitation of funds from industrial concerns and other organizations and men for the support of any and all of the council's special projects which relate to the applications of science, whether these projects are directly under the control of the division of research extension or of other divisions, as those of physics, chemistry and chemical technology, biology and agriculture, etc.

The division has been specially active during the past year in arranging for certain important conferences, in promoting the financial support for the International Tables of Critical Constants and for the