quantity, and the number of meals necessary in twenty-four hours are of the utmost importance. A logical answer as to the number of meals we should take in twenty-four hours can only be given after making a thorough examination of the digestive and motor functions of the stomach; and it follows, therefore, that no absolute rule can be laid down which can be applied indiscriminately to every individual. It has been shown by experimentation that the average healthy individual digests the quantity of food required in twenty-four hours, more effectually and thoroughly, when it is divided into a number of meals than when it is taken at one time, and we also have learned by practical experience, as one would *a priori* expect, that in the stomach patient with weakened digestive action, this is even more true than in the healthy individual.

Further experimentation and observation will undoubtedly prove that the requisite albumin quantities necessary to maintain normal nitrogen equilibrium will more closely approach the figures of my experiments than those of Voit.

The occurrence of various digestive and metabolic abnormalities and deviations, both pathologic and physiologic, however, should warn us against an irrational acceptance and application of the minimal albumin figures.

I come in contact with scores of individuals who require large quantities of albumin to combat certain gastric abnormalities; and others, again, who likewise require an increased albumination in consequence of the existence of digestive and metabolic disturbances which make the normal fat and carbohydrate quantities inadmissible and injurious.

Again, there is another class of individuals which requires forced albumin feeding in consequence of the existence of some temporary or permanent condition of inanition.

It is evident, therefore, how fallacious an indiscriminate acceptance of the minimal albumin figures would be.

In fine, it may be said that while the experiments on minimal albumin quantities prove that the average individual may and usually does eat too much albumin; and while probably 60 to 80 grams of albumin are nearer the normal requirement than the 118 grams of Voit, we should bear in mind that individual cases may require even much larger quantities of albumin than those called for in the Voit formula.

THE FATIGUE OF COLD-BLOODED COMPARED WITH THAT OF WARM-BLOODED MUSCLE.*

FREDERIC S. LEE, PH.D.
NEW YORK CITY.

Our knowledge of the physiology of muscle has been obtained chiefly through the study of cold-blooded animals. Especial stress has thus far not been laid on the fact that the muscles of certain animals are subjected throughout life to a moderately high and fairly constant temperature, while with others the temperature is usually much lower and variable.

The question has hardly been raised as to whether such different physical conditions connote different physiologic characteristics. *A priori* we might expect such to be the case, and the observations here reported actually demonstrate a difference in one respect, namely, in some of the physical phenomena of fatigue.

It is commonly believed that the main physical characteristics of the fatiguing, as distinguished from the fresh muscle, are a slowing of the whole process of contraction, which is manifested by a lengthening of the descending portion of the muscle curve; and a diminution in the lifting power of the muscle, which is manifested by a decrease in the height of the curve. This belief arose from a study of frog's muscle, where both these phenomena are pronounced.

Several years ago I called attention to the fact that the slowing in the process of contraction was shared in part by the phase of shortening of the muscle, as well as by that of lengthening. This phenomenon is manifested graphically on the ascending portion of the muscle curve by a progressive increase in the horizontal distance between the point of beginning and the apex and is most pronounced long before exhaustion has begun. It is far more prominent in turtle's muscle than in frog's, being there almost equally evident with the two other phenomena mentioned. At the same time I showed that a different picture is presented by the fatiguing muscles of the cat, inasmuch as with them neither the phase of shortening nor that of lengthening is slowed, as the lifting power is diminished. Here was a marked difference between the muscles of two cold-blooded animals on the one hand and those of a warm-blooded animal on the other.

The present paper deals with the question whether this difference is directly due to the temperature to which the muscles are customarily subjected.

Of cold-blooded animals, the frog and the turtle have again been studied, the gastrocnemius, the sartorius and the gracilis major of the former, and of the latter the coraco-antebrachialis profundus, the dorso-occipitis, the coraco-radialis superficialis, the pubo-tibialis, the ileo-fibularis, the ischio-caudali-tibialis. Some of these muscles are red and some white in color. In all cases the muscles were excised, suspended in a moist chamber, attached to a writing lever, subjected to a constant temperature, and stimulated electrically by single induction shocks, while the contraction curves were recorded by strictly isotonic methods. No fundamental differences were manifested by curarized and non-curarized muscles. In general, two temperatures were employed, a high and a low, of approximately 12 C. and 34 to 37 C., the latter being as high a temperature as can safely be employed without coagulating the muscle proteids. At the low temperature the customary phenomena of fatigue are present: Slowing of the phase of shortening, which is slight in the frog and pronounced in the turtle; slowing of the phase of lengthening, which is marked in both species; and diminution of the lifting power. The result is not fundamentally different when the muscles are subjected to the higher, practically mammalian, temperature. The two phases of the contraction process are quickened by the heat, but their slowing in fatigue is still present, phenomenally so in the turtle's muscles. These phenomena of fatigue are, therefore, in cold-blooded muscle independent of temperature. Furthermore, inasmuch as curarized and non-curarized muscles do not differ in these respects, the inference is justified that the phenomena in question belong to the muscle protoplasm rather than to the intrinsic nerve tissue.

Of warm-blooded animals, the cat, the rabbit, the white rat, the white mouse, the guinea-pig and the woodchuck have been studied, the muscles being the gastrocnemius and the extensor longus digitorum. It was found possible to treat the muscles in the same way as those of the cold-blooded animals. Since their nerves

* Read in the Section on Pathology and Physiology of the American Medical Association, at the Fifty-sixth Annual Session, July, 1905.

die very quickly, no curare was employed. Their muscle substance remains irritable for a sufficiently long time to enable excellent fatigue records to be obtained. At the temperature of the body there is a progressive diminution in the height of the curves, with no lengthening of either the ascending or the descending portion. If, instead, the muscle be cooled to 12 C., and then fatigued, essentially the same result is obtained. There is, however, a broadening of the upper portion of the curves, indicating a tendency of the cooled tissue to linger in the contracted state; and this phenomenon, besides those above mentioned, is the most marked feature of the record of fatigue of the cooled mammalian muscle. While constantly present in the muscles studied, it is not sufficient to amount to a lengthening of the contraction process as a whole, with the single exception of the gastrocnemius of the white rat. In eight of the ten experiments performed with that muscle, careful measurement showed a slight lengthening, amounting in the maximum case to barely 0.7 of the original curve. This is almost a negligible quantity in comparison with the much greater lengthening exhibited by the muscles of both the frog and the turtle.

In view of the above facts, the following conclusions seem to be justified:

1. There is a physiologic difference between cold-blooded and warm-blooded animals in the mode of fatigue of their excised, voluntary muscles.

2. One of the characteristic phenomena of fatigue of the excised voluntary muscles of cold-blooded animals is a pronounced slowing of the whole contraction process manifested by a lengthening of the muscle curve. This is most pronounced at low temperatures. It is diminished, but not obliterated, at high temperatures.

3. The excised voluntary muscles of most warm-blooded animals fatigue without a slowing of the contraction process as a whole. At low temperatures there is observable a broadening of the muscle curve, caused by fatigue, which, in individual cases, may result in a minute lengthening of the curve as a whole.

4. The above facts suggest that the general physiologic differences between the muscles of cold-blooded and of warm-blooded animals are not due to immediate differences of temperature. The existence of a homo-thermal condition and the constant subjection of the skeletal muscle system to a uniform temperature, seem to impress on that system distinctive physiologic peculiarities.

College of Physicians and Surgeons.

LANDRY'S PARALYSIS.

WITH REPORT OF CASE.*

ROBERT MCGREGOR, M.D.

SAGINAW, MICH.

To the pathologist and clinical observer, acute ascending paralysis is a malady of more than ordinary interest. For nearly fifty years it has been known and studied, yet little light has been thrown on the essential pathologic process which is the basis of this remarkable disorder. Since Landry, in 1859, wrote his classic treatise on the subject, many efforts have been made to work out a solution of the perplexing problem, but with far from uniform results. Reasoning from the association of a flaccid paralysis, with preserved electric irritability and absence of trophic symptoms, Gowers ad-

vanced the theory of a toxin acting on the arborizations of the pyramidal fibers in the anterior horns of the spinal cord in a manner analogous to the effect of curare on motor-nerve terminations in muscle. This hypothesis, however, has never been reinforced by the conclusions of other investigators.

There are good grounds for believing that bacteria or the products of bacteria or toxic elements elaborated within the body having a selective action on motor neurons play an important rôle in the causation of this disease. Streptococci, staphylococci, diplococci and rod-like bodies resembling those of anthrax and typhoid have been noted by competent observers in the spinal cord in typical cases. It is quite conceivable that a variety of toxins may have in common the property of exerting a more or less profound influence on motor neurons, just as there are several well-known substances, organic and inorganic, which possess this singular power. The precise way in which these toxins affect the integrity of the motor elements has not been definitely determined. Considerable difference of opinion has always existed as to whether the motor structures in the cord or in the peripheral nerves were the parts primarily subjected to the morbid change. Some authorities, notably Ross, have maintained that the affection is a peculiar form of multiple neuritis. This view is based, not on the clinical manifestations, but on the finding of degenerative changes in the peripheral nerves in certain cases. Such findings, however, are by no means frequent, and in many cases the most careful scrutiny has failed to disclose any histologic alterations in either the peripheral nerves or spinal cord. Perhaps the most constant features found postmortem in typical cases are acute enlargement of the spleen and engorgement of the lymphatic glands, especially those of the mesentery, conditions which clearly indicate the invasion of the system by a toxic principle. As far as the nervous system is concerned, wherever the primary point of attack may be, it is evident that the pathologic change is an extremely subtle one; and of late the assumption has been gaining ground that in all typical cases this change affects the gray matter in the anterior horns of the spinal cord. It is probable, also, that in cases in which the toxicant is exceptionally virulent involvement of the anterior roots may follow, and a neuritic condition be induced in the peripheral nerves as a later and secondary consequence.

In the last score of years many important advances have been made in our knowledge of the physiology of the nervous system. In the light of this knowledge we are often enabled to reason from symptoms to the exact site of the pathologic process. The light gleaned from such knowledge in typical cases of acute ascending paralysis leads us to suspect that the motor cells of the anterior cornua of the spinal cord are primarily, and perhaps in most cases solely, concerned in the morbid action, and that with improved staining technic it will yet be possible to render apparent cellular changes which can not now be made manifest. It is probable that whatever changes the motor cells undergo are of a transitory character and of a nature to affect temporarily their function only, since the majority of patients who recover do so completely. Etiologic facts support in a striking way the theory of a toxic state or dyscrasia as an essential and antecedent condition. By far the greater number of recorded cases have followed in the wake of sundry infectious diseases, local or systemic disturbances of a septic character, or have been

* Read in the Section on Nervous and Mental Diseases of the American Medical Association, at the Fifty-sixth Annual Session, July, 1905.