Mackall (L.)

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Louis Mackall.

The Action of the Voluntary Muscles.

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[*Extract from an unpublished work.*]

69. The action of the Voluntary muscles is regulated by the law of nature that we have already stated, (37.) By virtue of this law, the determination of the nerve-fluid to a muscle is immediately followed by the active elongation of its fibres; the contraction of a muscle or of its fibres as immediately follows the withdrawal of the nerve-fluid. In other words, the presence of the nerve-fluid, its cause of action, is, by virtue of this law, always attended by an active elongation of the fibres of a muscle; while the absence of a due portion of this fluid is as constantly attended by the contraction of its fibres.

By the aid of this law of nature, we have explained, I think, in a plain, intelligible, and rational manner, the phenomena presented in the action of the involuntary muscles, that are placed about the walls of the tubes or hollow organs; by the same aid, the phenomena presented in the action of the voluntary muscles may be as rationally and intelligibly explained.

70. The minds of Physiologists of the present day are so fully impressed with the erroneous belief, so long inculcated in the books, that the active state of a muscle is that of contraction, and that the elongation of its fibres, (a state of which they possess a very imperfect and false notion,) which they are pleased to call relaxation, is a passive state, that the converse of this proposition, as presented above, will be at first regarded by them with prejudice and aversion. The true law of nature in relation to this subject, however, when its application is attended to, in the extensive application of it we propose to present, must in time be acknowledged; if truth, as is said, has a tendency to prevail over error in the human mind.

71. When we use the term muscle, it should be understood to embrace both the tendinous and fleshy portions of the organ; the same fibres, we conceive, extend through the whole, and are influenced by the cause of action, the nerve-fluid, as well in the tendon as in the fleshy part. The latter portion differs from the former probably only in the circumstance of being more largely supplied with nerves and blood-vessels, by means of which, when the muscle is in a state of action, the special circulation of the nerve-fluid (43) is established.

72. For the better illustration of their action, it will be found convenient to separate the voluntary muscles into the four following classes, viz: 1st. Such as are attached by one extremity only, having the rest of the muscle free to be extended or retracted at will; 2d. Such as are attached at both extremities, but are capable only of the same motion as the former class, that of direct extension or retraction; 3d. Such as are arranged circularly about the openings of the organs. and serve as sphincters; and 4th. Such as are attached to the bones at both extremities, and act by making use of the bones as levers.

THE ACTION OF THE FIRST CLASS OF VOLUNTARY MUSCLES,

That are attached by one extremity, and have the rest of the muscle free to be extended or retracted.

73. Of the action of this class we will advert to that of the muscles of the tentacles in the lower orders of animals; and among the higher orders, to that of the muscles of the tongue, of the ciliary processes, and of the male Organ of generation.

Perhaps there is no other instance in nature, in which is presented so fairly and clearly, the true condition of a muscle when in a state of action, as in that of the action of the muscles of the organ last mentioned. Physiologists, by a resort to Sophistry, of which we shall speak again, have ignored the action of these muscles, which is the same with that of all other muscles; for the state of erection produced by the action of these muscles is common to all the muscles of the living body when in action. Every muscle when in action is in a state of vital erection; which term should be understood to express simply the active elongation of the fibres, with a due supply of blood and of nerve-fluid to maintain this state. In the Human subject, the true character of the organ of which we are speaking is masked, as it were, by the great development of the blood-vessels and nerves with which it is supplied; but this is not the case in some other species of animals, as in the Horse, the Ox, the Hog, and the Sheep. In these the main body of the organ is composed of longitudinal muscular fibres that may be actively elongated to a length of from twelve to twenty inches. The view of muscular

action heretofore presented may be repeated in connection with the instance before us.

74. The suggestive impressions, appointed to precede the active state of this organ, having been duly received, the anima determines the nerve-fluid, in an extra supply, to its fibres through the sensory and motory nerves of this organ. In consequence, the proper longitudinal and other fibres of the organ become actively elongated, together with the fibres about the walls of the vessels and sinuses, in which there is an increased flow and accumulation of blood. With this accumulation of blood there is established the special circulation of the nerve-fluid to this point; the supply of this fluid is thus further enlarged, and the action of all the fibres is exalted to its extreme limit. This latter state of the organ is expressed by the term "Venereal orgasm."

75. In this representation of the action of muscles, there are three points to which we desire to direct attention: the first is, the propriety of regarding the organ in question as a muscle attached at one extremity by two heads to the ossa pubis and ischia; the second is, *the active elongation* of the proper fibres of this muscle; and the third is, the *stiffening or rigidity* of the same fibres when in action. The two latter points are particularly worthy of attention, as they occur in every instance of muscular action, and, what is very strange, have been entirely overlooked by physiologists.

76. The Ciliary processes are the small muscles or bundles of muscular fibres that are attached by one extremity to the margin or verge of the opening into the eye, called the pupil; and are so arranged that by their extension the pupil is diminished or the opening narrowed, and by their retraction the pupil is enlarged or the opening widened. Light is appointed to be the appropriate suggestive impression to precede the action of these muscles. When the eye, in its normal condition in the living body, is withdrawn from the light, the mind, not having received this suggestive impression, does not call into action these muscles, and they are consequently retracted, and the pupil is enlarged; but when the eye is brought into the light and the impression is made, the mind determines the nerve-fluid to these muscles, and they become extended in proportion to the supply of this fluid; by their combined action the pupil is diminished or narrowed, so as to exclude such quantity of light as might be injurious to the optic nerve.

Here again we have a Vital erection, in the essential conditions—the active elongation, and apparently the stiffening of the fibres; and it is worthy of remark here, that in inflammation of these and the adjoining parts, as in iritis, there is established the special circulation of the nerve-fluid to these fibres, and they

become persistently elongated, and the pupil continues to be narrowed even when the eye is withdrawn from the light.

77. The longitudinal muscular fibres of the Tongue (with a view to the elucidation of the action of this organ) may all be regarded as one muscle, that is attached at one extremity, with the other parts free to be extended or retracted at will. The active elongation or extension of these fibres when innervated, or when in action is manifest in our own persons, if we confine our attention to the fibres in question; but this active elongation of the tongue in some of the lower orders of animals is very remarkable. Every one is familiar with the protrusion and elongation of the tongue of some of the domestic animals, as the Dog, the Cow, &c.

This action of the tongue of the Serpent is deserving of particular notice. When the animal is aroused or excited, it erects its head and thrusts out of its mouth its forked tongue, to the extent of several inches. The suddenness and celerity of the motion of the organ forcibly reminds us of the appearance of a flash of Lightning.

It is impossible, I believe, to suggest any rational explanation of this phenomenon, other than that of the innervation and consequent elongation of the fibres of the muscles that belong to this organ. The suddenness and celerity of the motion precludes all other agency but that of the nerve-fluid, passing along the nerves; which alone resembles in its motion that of the Electric fluid.

The action of the tongue of the Frog or toad, when it seizes its prey, is similar to that of the serpent.

78. A notable action of this kind is presented in that of the tongue of the Chameleon. To facilitate its description, this organ may be divided into four parts; first, the anterior bulbous portion, formed by the interweaving of cellular and muscular tissues—with the appearance of the end of the trunk of the elephant, it is furnished like this with a fleshy forceps at the extremity, with which the animal seizes its prey; second, the middle or interior portion, *composed entirely of cellular tissue formed into a number of bands or hoops, having the intervals between them supplied with very loose and extensile meshes of this tissue;* third, the lingual bone, being a process from the centre of the os hyoides, arranged in the direction of the tongue, on which, when the tongue is retracted, the cellular bands and meshes of the second portion, and a part of the bulbous portion, which is hollowed out for this purpose, are stretched or drawn, like the finger of a glove drawn over the finger; and fourth, two well-developed muscles, having their fibres arranged longitudinally, and largely supplied with nerves and blood-vessels. These muscles arise from the cornua of the Os hyoides, one from each,

and being arranged one on each side of the tongue, or of the central cellular portion, are inserted in the bulbous extremity.

When in a state of repose, or when retracted within the mouth, the organ is from an inch to an inch and a half long; but when about to seize its prey, commonly an insect, the chameleon creeps to within seven or eight inches of the object, and then fixing its body, and taking aim, as it were, suddenly, and with the celerity of Lightning, thrusts forward its tongue, and seizes the insect with the fleshy forceps at its extremity. The food thus taken is then drawn into the mouth by the retraction of the organ.

79. If what we have suggested be admitted to be the true law of muscular action—if innervation, or the determination of the nerve-fluid to a muscle, is attended with the active elongation of its fibres, there is no difficulty whatever in comprehending or in offering a rational explanation of the phenomenon before us. The animal, it will be understood, determines its nerve-fluid to the lingual muscles, and the tongue is extended to the distance mentioned, simply by the active elongation of these muscles. The food is also drawn into the mouth by the retraction of the same muscles, caused by the withdrawal from them of this fluid.

But what explanation of this phenomenon can be given without the aid of this law? We will give the only one we have met with worthy of any notice, that of Mr. John Hunter, in his own words, taken from the "Illustrated Catalogue of the Hunterian Museum."

"This length of tongue, its extension and contraction, are very singular, and, if well understood, most probably very curious.

"The cause and mode of the contraction of its length are not uncommon. The elongation of the tongue in this animal is perhaps like nothing that we are acquainted with in an animal body.

"The apparatus for this purpose is a small rounded body which passes from the apex of the os linguæ (glosso-hyal) to the bulbous part, and then through the centre of the bulb. The part between bone and bulb consists of two different substances, one a whitish substance, which is the firmest, and appears to be capable of keeping its form; the other is softer and more transparent. That part which passes through the bulb consists only of one substance, and appears to be a sheath for the reception of the os linguæ." The reader will please recollect that the apparatus, here described by Mr. Hunter, is nothing more than the bands and meshes of *cellular tissue* of which we have spoken above. But let him proceed:

"The first of these (*i. e.* the whitish, firmer substance) appears to be composed of rings or something similar placed obliquely in contrary directions, so as to appear to be two spirals crossing one another. Whether the other or softer substance" [the cel-

lular meshes. L. M.] "has any direction of fibres I could not observe, but I suspect it is muscular. If I am right in my conjecture of this structure, and of its disposition, it will be no difficult thing to show how it may be elongated; for if these rings are placed transverse, they may be brought so near to one another as to shorten the whole very considerably; and if they allow of being placed almost longitudinally, they must of course lengthen it very considerably, and this position can easily be produced by muscles, which I take the pulpy substance to be.

"The contraction of the tongue is owing to a degree of elasticity; but this appears to be only in the cellular membrane, acting as an assistant to the muscular. The muscular contraction is owing to two muscles, one on each side of the tongue; each arises from the os hyoides on the inside of the os linguale, and passes along the side of the tongue to its bulbous part; but before it gets to the bulbous part it spreads itself all round.

"In the centre of each of these two muscles passes a considerable nerve to the bulbous part, and also two arteries. When the two muscles act, they draw the tongue back upon the os linguale, which, as it were, passes through the middle elongator, then through the centre of the bulb, till the whole tongue is retracted. Although this middle body is drawn upon the os linguæ, yet it does not appear to be a hollow like a pipe; it rather appears to be filled with a very ductile cellular membrane, as in every part of the elongating division of the tongue, in order to allow of the great difference in the situation of parts with respect to one another." (Hunterian manuscript.)

80. The Ant-eater (Myrmeco-phaga) furnishes a remarkable instance of the action of the muscles of this class. The tongue of this animal is composed of two distinct muscles having different origins, and a different disposition of fibres. To simplify the subject, we may say one of these muscles arises from the sternum, and passing along through the muscles on the anterior surface of the neck, terminates at the tip of the tongue—its fibres being all arranged longitudinally; the other muscle arises from the os hyoides, passes around the former longitudinal muscle in close spirals, forming a sort of case or sheath for it, and terminates with it, at the end of the tongue.

When quiescent, or in a state of inaction, the tongue of the Ant-eater is probably about six or eight inches long; but when thrust into the ant-hills to secure its prey, Naturalists tell us, it is elongated or protruded to the extent of *seventeen* or *eighteen* inches.*

The object attained by this curious arrangement of the muscles, in accordance with our view of muscular action, is evidently,

* Curvier's Animal Kingdom, edited by Griffith, vol. iii, p. 300.

the free and unimpeded extension of the longitudinal muscle to its full capacity, by preserving its fibres, nerves, and blood-vessels from external pressure, while threading the narrow passages of the ant-hill through which it is forced. This object is fully accomplished by the action of the spiral muscle, which tends to dilate these passages, or, at least, to enlarge and keep open the space enclosed by it, in which the longitudinal muscle acts.

In the absence of this view, Physiologists have been forced to adopt the very absurd supposition, that the tongue of the Ant-eater is protruded by the *contraction* of its *spiral muscle!*

81. The Woodpecker, as is well known, feeds on the grubs that burrow into the limbs and bodies of trees. The burrows are first exposed by pecking through the bark with its strong, sharp bill, and then the long tongue, like a flexible probe, is thrust in, as the Ant-eater's into the ant-hill, and the grub being harpooned, as it were, is dragged forth.

To adapt the organ to the purposes mentioned, the anterior portion of the tongue—I refer more particularly to that of the species called the Flicker, (Picus aureatus)—is composed of a horny, spear-shaped, barbed point; from this point there arise two muscles, tendinous at each extremity, but with fleshy bellies or middles—their fibres longitudinal; these muscles pass around the base of the cranium, one on each side, and then rest with free extremities in a groove or closed passage formed between the skin and cranium, and extending over the middle of the head from behind forward until it reaches the base of the upper Mandible. Besides these, two other muscles arise, one from the ramus of the lower mandible on each side, and pass around the longitudinal muscles, forming a sheath for them through their whole length. The arrangement of these muscles are strikingly similar to that of the muscles of the tongue of the ant-eater, and doubtless their functions are the same. When the longitudinal muscles are innervated and elongated, the upper bill, which is then applied to the tree, becomes the basis or point of resistance, from which the tongue is projected into the burrows; the other or spiral muscles acting, as suggested, when speaking of that of the ant-eater, to preserve the freedom of the motion of the former, by protecting from external pressure the blood-vessels and nerves with which they are largely supplied.

The notion suggested by some, that the tongue is jerked forward by the contraction of the last-mentioned muscles, is absurd; as the means suggested are clearly inadequate to the end proposed. The contraction of any portion of these muscles could not effect a motion of the tongue to the extent of one inch, but, if contracted, the portions anterior to their origins would draw the tongue back, and counteract the effect of the contraction of

the portions of these muscles that are posterior to their origins, so that no effect of the kind suggested, could result from the contraction of these muscles. The tongue is thrust into the burrows, probably to a distance of from five to eight inches, judging from the extensibility of the organ in the living or recently killed bird.

The longitudinal muscles of the tongue are commonly regarded as the cornua of the os hyoides, but I think it more rational to regard them as muscles (as their appearance clearly indicates) belonging to this class, attached at one extremity with the rest of the organ free, to be extended or retracted at will.

82. The "Aij-Aij" is an animal whose habitat is confined to Madagascar. It presents several points in its natural history closely resembling those of the woodpecker. Like this, it feeds on a grub that burrows in the bodies of trees in that island; and it exposes these burrows by tearing off the bark with its teeth. The animal then introduces a long flexible probe, and pulls out the grub. This probe, however, is not the tongue; but one of the fingers of one of the fore-paws, which is curiously adapted in its structure to this purpose. The anatomy of this organ is not generally known, but I presume, from the office it is said to perform, that it is similar to that of the tongues of the Ant-eater and of the Woodpecker that we have just described. In its retracted state it may present the appearance of a "shrunken" or "atrophied" member, as is represented; but its muscles are, I doubt not, well developed, with large blood-vessels and nerves, and capable of an extensive action of elongation.

83. The Tentacles of some of the lower orders of animals are so similar in structure, in their action, and in the purposes they subserve, to the tongues of the higher orders, that we are induced to regard them as their analogues. These organs are composed of muscles with longitudinal fibres, that are attached by one extremity around the outer margin of the mouth, and are extended or actively elongated for the purpose of collecting and of bringing into the mouth, the food or prey that may be floating in the element these animals inhabit. When the animals are reposing, or not feeding, these organs are retracted; but when engaged in taking their food, the tentacles are innervated, and actively elongated or extended. In some instances, as in the Physalus, the Enychoteuthis, &c., this extension is carried to a distance of six feet or more.* For a more minute account of the structure and office of these organs, I refer to the works on comparative Anatomy and Physiology. Our theory of muscular action offers to the intelligent student a number of suggestions that will be found of great use to him in his efforts to understand

* General Structure of the Animal Kingdom, by T. Rymer Jones.

the more complicated structure and action of some of these organs.

THE ACTION OF THE SECOND CLASS OF VOLUNTARY MUSCLES,

That are attached at both extremities; but their action is that of extension and retraction, simply.

84. For the plainest instances of this action, we must again have recourse to some of the inferior orders of animals. The land Terrapin furnishes several instances of this character, in the protrusion of its head, in the opening of its valves, &c.

From that part of the interior of the Carapax or top shell that corresponds to the lumbar vertebræ, arise two large muscles—one on each side of the vertebræ. Each of these muscles has three distinct heads or bundles of longitudinal fibres, the longest of which arises from the most posterior vertebra, and extending along on the side of the dorsal and cervical vertebræ, is inserted into the Occiput; the other two bundles of fibres arise a little in advance of this, and are inserted into the two cervical vertebræ nearest the head. Any one, who understands this arrangement of the muscles, and who has become acquainted with our view of muscular action, will readily comprehend how the head of the Terrapin is protruded, simply by the innervation and consequent elongation of these muscles; and he will as readily comprehend how the head, when protruded, can be retracted within the shell, by the withdrawal of the nerve-fluid from these muscles.

85. In order to protrude the head, the Terrapin must first open its shells for this purpose. This it does by pushing down the anterior valve of the Plastrum or bottom shell, by which the space between the shells is closed. To enable it to do this, it is provided with two muscles, arising one on each side of the anterior dorsal vertebræ, which, passing down on either side of the neck, are inserted into the front edge of the anterior valve. By elongating these two muscles the valve is pushed down and the shells opened. The limbs of this animal are protruded and retracted by a similar arrangement of muscles, destined to this end.

86. The Snail (Helix nemoralis) presents some remarkable instances of the action of muscles that belong to this class. The soft parts of this animal consist mostly in a large bundle or mass of longitudinal muscular fibres, with which the several parts, as the head, the foot, &c., are protruded from the helix or turbinated shell; that is, by the active extension of these fibres.

The eyes of the Snail may be observed, when the animal is in motion, at the extremities of two fleshy tubes, or horns as they are commonly called, projecting from the head. From the mass of longitudinal fibres, two separate bundles or distinct muscles arise, and passing through the visceral cavity and traversing the horns, are inserted, one around the base of each eye, at the ex-

tremities of these horns. When the Snail is at rest, the Ophthalmic muscles are retracted, the horns inverted, and the eyes are thus securely packed away in the visceral cavity; but when it is aroused, and protrudes its head and foot, it also determines its nerve-fluid to the ophthalmic muscles, and by elongating them, pushes forth its eyes. The horns are tubes supplied with muscular fibres placed spirally about the walls; and when the longitudinal muscles are extended these fibres are also extended; and in this way the calibres of the horns are enlarged, and thus allow a free action of the internal muscles with their nerves and blood-vessels.

It will be observed that there is a striking resemblance in the arrangement and action of the muscles in this instance to those in the instance formerly mentioned of the tongue of the Ant-eater. The explanations given by Physiologists of these two phenomena are the same, and both are equally absurd. They say, the eye of the Snail is everted by the contraction of the spiral muscle of the horn! The longitudinal muscle, they suppose, is intended and used solely for the purpose of retracting the eye!

87. We will advert to but one other instance of the action of the muscles of this class; it is to that of the muscles of the body of the Leech. This animal is possessed of two fleshy discs, one at each extremity of the body, by means of which it attaches itself to the surface on which it crawls; the discs acting as cupping-glasses, and taking a firm hold wherever applied.

The walls of the body of the Leech are mainly composed of muscular fibres, that are arranged in three distinct layers. The fibres of the outer layer are disposed circularly, those of the middle layer spirally; but the fibres of the internal layer are all arranged longitudinally. By means of the latter layer of fibres the progression of the leech is effected. When stationary, the discs are attached to a surface near each other; but when about to move forward, the leech first detaches the anterior disc, and then extending its body by elongating the longitudinal muscles, it again attaches this disc to the surface on which it is crawling, or to some near object. When this anterior disc is fixed, the posterior one is detached and brought up, by the retraction or contraction of the same muscles, to be attached again near the former. In this manner the leech moves from point to point in its progress, sometimes with considerable celerity. In the same manner, the progression of all crawling animals, Annelidans, Serpents, &c., is effected. They first fix some part of the body, and from this point the body is extended by the elongation of the longitudinal muscles, when they again fix the forward portion of the body, and by contracting these same muscles by withdrawing the nerve-fluid from them, they draw up their length from behind.

But why do I say this of all *crawling* animals? when the same mode of progression is common to *all* animals; as will be explained further on.

ACTION OF THE THIRD CLASS OF VOLUNTARY MUSCLES.

88. The shincters or sphincter muscles that belong to this class are composed of fibres arranged circularly around the openings about which they are placed, as the Orbiculares palpebrarum, the Orbicularis oris, &c. In a state of rest or of repose these muscles are moderately contracted, and the openings are closed: they may be more forcibly contracted and the openings more firmly closed by an intentional, persistent withdrawal of the nerve-fluid from their fibres. But when it is designed to bring into use the eyes or the mouth, the sphincter muscles are innervated, their fibres become actively elongated, and the openings are dilated or expanded.

The error that has prevailed in relation to the action of these muscles has arisen from the difficulty in distinguishing the consciousness that attends the innervation of the muscles from that that attends the withdrawal of the nerve-fluid from them. The early physiologists mistook the one consciousness for the other; and this mistake has continued in the books to the present time. They supposed that innervation was attended with the active contraction of the muscles and the closing or shutting of the openings. The really active state of the muscles they called relaxation, and supposed it was the result of inaction, or of an absence of the cause of action.

89. The instances of the action of the voluntary muscles we have already presented, are so plain, and the explanations given of the phenomena attending such action are so simple, intelligible, and rational, that, it appears to me, they must produce in every well-ordered, unsophisticated mind that considers them, a full conviction of the truth of the law of muscular action that we have suggested.

The absurdity of former explanations of some of the above phenomena we have pointed out in passing; but there are, besides, explanations of others of these phenomena, given in accordance with the old theory, equally absurd and unphilosophical, to which we have not adverted. The explanations to which we allude are founded in sophistry, and are clearly traceable to this source.

Finding it utterly impossible to furnish a rational explanation, with the received theory, of phenomena such as are presented in the protrusion of the tongue of the Serpent, above referred to, the Sophist, to get around this difficulty, *invented a new term*, by which all the facts of the case are obscured, covered up, and ignored. The organs, the action of which he could not explain,

were said to be composed of *erectile tissue*. He did not stop to demonstrate even to himself this particular tissue, which in reality has no existence, (for these organs, like all the other soft parts of the animal body, are possessed only of the cellular, the muscular, and the nervous tissues.) This was no part of his design, his sole object being accomplished by the invention of the *term* that would serve, as it has served, to deceive the unwary and unreflecting. It is thought by these, to be a sufficient explanation of all such phenomena to say, that the organs concerned, are composed of erectile tissue, and become erected when actively elongated.

The idea commonly attached to this state of these organs is, that they are injected with blood, and are in this way extended. The fallacy of this idea is easily shown, however, by calling to mind the facts, that these organs are elongated before receiving their extra supply of blood; and that, in many of these instances, the celerity of the motion of the organ, as in the case before us, entirely precludes this idea. The blood could not, by any possibility, be transmitted through the vessels, with a velocity to correspond with the motion of the tongue of the serpent, as indicated above.

ACTION OF THE FOURTH CLASS OF VOLUNTARY MUSCLES,

That are attached at both extremities, but make use of the bones as levers.

90. It is more difficult to convey a just conception of the action of this than that of any other class of voluntary muscles; because the means employed to produce the results are, here, much more complicated. The bones of the limbs to which these muscles are attached, and which are made use of as levers, are provided with two distinct sets of muscles, one on each of the two surfaces towards their line of motion; and their motion is not produced by the action of either set of muscles exclusively, but is caused by forces exerted by both sets at the same time. I repeat, the movement of the limbs of animals is not due exclusively to the action of either of the two sets of muscles with which they are supplied, but each movement is effected by the action or active elongation of one set, and by the contraction of the opposing set.

91. Before entering upon the explanation of the action of this class of muscles, it will be well to call to mind three important truths, that are essential to a clear understanding of this action. These are, First, that the action and the contraction of a muscle are both vital phenomena, to be met with only in the living body, and are not represented elsewhere in any part of the economy of nature. These states of the muscle in the living body are *sui generis*, and no proper idea or conception of them can be gained by comparing them to those of a cord or pulley of any kind or

of any condition, whether as wet or dry, elastic or inelastic, &c. Second, that the contraction of a muscle is as much the result of the operation of a law of nature depending on the abstraction of the nerve fluid, as the active elongation of a muscle is the result of the law of nature depending on the presence of, or the determination to it, of this fluid; and Third, that the operation of a law of nature is always attended with an exhibition of power, and consequently, the contraction of a muscle is attended with force or power, as well as its action or active elongation.

Force, it must be admitted, is exerted in connection with the contraction of a muscle; but it is all important that we should not associate in our minds the force, with this state of the muscle, and then call this state of contraction the state of action of the muscle. This is the grand mistake committed by Physiologists, that has led them to overlook entirely the true state of action of a muscle, together with the force that is also exerted in connection with this state; and this mistake has led to their confusion of thought, and defective and erroneous views on the subject of muscular action.

I must repeat, the active state, or the state of action of a muscle, is a state of active elongation of its fibres; and in connection with this state, force or power is always exhibited.

92. With the knowledge of the above truths, the explanations we proceed to give of the action of this class of muscles will be rendered intelligible. The instances we shall select for this purpose will be such as are plainest and most familiar; that is, those that are to be observed in the action of the muscles of the limbs, upper and lower, of the human subject.

The action of these muscles are so misunderstood by physiologists, and so misrepresented in the books, that the technical terms employed to designate them are calculated to mislead. I shall, therefore, discard these terms as much as possible from our present consideration, and substitute others. In doing this, let it be understood, that those I propose are suggested only for a temporary use—to simplify the subject to the general reader, and to elucidate the principles involved. I hope, however, that some new terms for these muscles may be permanently adopted that will be more expressive of the true facts of the case than those now employed.

93. The muscles on the anterior surface of the Humerus or bone of the upper arm, embracing the Biceps and Brachialis anticus, we shall regard as one muscle, and call it, from its position, the Præ-humeral muscle; and that on the posterior surface of this bone, the triceps, we shall designate as the Post-humeral muscle.

The Præ-humeral muscle, then, arises from the shoulder blade (scapula) near the joint of the shoulder, and from the bone of

the upper arm, and passing along its anterior surface is inserted into the upper portion of the bones of the fore arm.

The Post-humeral muscle arises also in part from the scapula, and in part from the humerus, and passing along the posterior surface of this bone is inserted into a process of one of the bones of the fore arm, called the Olecranon process, that projects behind the joint at the elbow.

94. When the whole arm is extended or straightened out from the flexed position, the mode in which this extension is effected by means of the muscles just mentioned, after what has been said above, is plain and palpable. In this movement, the anterior or Præ-humeral muscle is actively elongated by the determination to it of the nerve-fluid; and at the same time the posterior or Post-humeral muscle is contracted by having the nerve-fluid withdrawn. The motion, it will be observed, is produced by both muscles, the anterior and the posterior; but the former only is in action, or is influenced by the cause of action—the nerve fluid—it is in a state of vital erection; while the latter is thrown into a peculiar condition, that of contraction, by the abstraction of the cause of action. Both of these conditions, that of active elongation and that of contraction, in the opposing muscles, are essential and indispensable in every movement of the limbs, and each of these conditions being the result, as we have seen, (87) of the operation of a law of nature, such movements are executed with a double force, or with two forces, one of which is derived from the operation of each of these laws of nature.

The opposite movement of the arm—the flexing it at the elbow from the straight position—is produced by an opposite condition of the muscles engaged. In this movement, the posterior muscle is innervated and elongated, while the anterior muscle is contracted. This action of the posterior muscle is better shown, however, in the following instance:

95. The action of the muscles by means of which the fingers are moved, will be best shown by regarding them as two muscles, one on each surface of the bones of the fore arm, from which they arise. We will call them for the present, the Præ-brachial and the Post-brachial muscle, each term embracing the long muscles that go to the several phalanges of the fingers on its respective surface.

The anterior or Præ-brachial muscle arises from the bones of the fore arm towards the elbow, on the inner surface, and extending along in front, passes with its long tendons across the palm of the hand, to be inserted into the several bones of the phalanges of the fingers on their inner surface.

The posterior or Post-brachial muscle in like manner arises from the upper portion of the same bones, but from their outer surface, and passing along on this surface, and with their tendons

over the back of the hand, are inserted into the bones of the phalanges of the fingers on their outer surface, extending along even to the extremities of these bones.

96. The great difficulty in realizing the true action and agency of the muscles we have just spoken of, arises from the fact mentioned above, when speaking of the sphincters; namely, that few minds are capable of distinguishing the consciousness or the mental sensation that attends the determination of the nerve-fluid to a muscle, that causes its action, from the consciousness or sensation that attends the abstraction of this fluid, that causes the contraction of a muscle. To make this distinction, it requires a patient education and training of the mind, more especially in those who have given some attention to physiology, and who have their minds pre-occupied with erroneous views of muscular action. This mental preparation, however, is what few or none have set about; but when this difficult task is accomplished, it will be observed, that,

97. In flexing the hand, as in forcibly shutting it, or in grasping any object firmly, a determination of the nerve-fluid is made to the posterior or Post-brachial muscle; and its fibres becoming actively or forcibly elongated, tend to produce the movement indicated; at the same time, the nerve-fluid is withdrawn from the anterior or Præ-brachial muscle, and its fibres becoming forcibly contracted, the act of shutting the hand, or of grasping, is perfected and completed.

The opposite states of these muscles—that is, the innervation and extension of the anterior, and the enervation and contraction of the posterior muscle—it is evident, would produce the contrary movement of the fingers, the extending or straightening themout.

98. If I have succeeded in explaining to the satisfaction of the reader, the action and agency of the muscles engaged in effecting the movements of the upper extremities, there will be no difficulty whatever in his comprehending the action and agency of the other muscles of this class that are concerned in the various voluntary movements of the living body. In all such movements, we repeat, two sets of muscles are concerned, whose action is opposed, the one to the other; but the position established is the result of the agency, mainly of the set that is in a state of action, although in some measure attributable to the contraction of the opposing set. Thus, in assuming and maintaining the erect position of the body, the muscles, on the anterior surfaces of the lower extremities, of the spinal columns, and of the walls of the abdomen and thorax, are brought into action, and the result is accomplished, principally by the agency of these muscles, but in some measure also, by the contraction of those on the opposite surfaces. Again:

99. In locomotion, of the biped, for example, it is true, the hinder foot is brought up to the advanced position; and, again,

the foot is raised to be carried forward by the contraction of one set of muscles; but the progressive motion—the extending the leg and foot in advance, and the projecting forward of the whole body—is effected by the action, the active elongation, or extension of the other set; or the opposite conditions of the same muscles may be employed for both of these purposes.

The mode of progression, we have said, (87) is the same in all animals. In all, a portion of the body is advanced from a fixed point by the action or extension of certain muscles, and in all, a portion of the body that is behind this point is brought up by the contraction of certain muscles. In this respect the halting gait of the biped—that is to say, when, in walking, he keeps the same foot always in advance, bringing up the hinder foot to it, and then moving the front foot forward again—is the same with the natural gait of the snail; and, again, the snail would imitate the natural gait, or the continued progressive motion of the biped, if, instead of attaching its hinder disc in the rear of the front one, it could carry it along forward, and attach it in an advanced position, and so continue its motion, carrying its discs alternately forward.

100. The arrangement of the muscles, however, in the lower extremities is somewhat different from that of the upper. The extension of the leg on the thigh is effected by the action of the muscles on the posterior surface of the thigh bone or femur, while the leg is flexed on the thigh by the action of the muscles on the anterior surface of this bone; and, again, the action of the tibialis anticus, and of the anterior longus digitorum on the anterior surface of the leg or tibia, tends to extend or straighten out the foot on the leg; and of the latter, to flex the toes on the sole of the foot; while the action of the muscles on the posterior surface, the Gastrocnemius, the Soleus, and the posterior longus digitorum, &c., tends to flex the foot upon the leg anteriorly at the ankle—that of the two former by pressing down the os calcis as a lever, and of the latter by extending and directly raising the toes.

A curious circumstance, confirmatory of the correctness of this view of the action of the muscles of this region, is mentioned by Mr. John Hunter, who suffered from a fracture of the tendon of the gastrocnemius, called the tendo Achillis. When this fracture occurred, he experienced, he says, the greatest difficulty in raising the toes from the floor, in walking across the room.

Nothing has been said of the contraction of the opposing sets of muscles which assists materially in the movements just mentioned, because that will, of course, be inferred from what had been said above; and to avoid encumbering the subject, relating to the physiological principle here advocated, we have omitted altogether the consideration of the mechanical principles of the Lever and Pulley that are involved in all the movements of the extremities.