tic, and moderately sensitive to pressure. The head is fixed with the face directed straight forward, or, if but one parotid is affected, the head will be inclined to the diseased side. The skin usually preserves its natural color, but may be red and glossy. Slight desquamation may take place after the inflammation has subsided.

More or less fever is always present, lasting, in cases of moderate severity, not more than four or five days, but occasionally it is intense, protracted, and attended with delirium and prostration.

The œdema generally extends internally, affecting to a greater or less degree the mucous membrane of the tonsils and pharynx. The secretion of saliva may not be materially altered in quantity, but dribbles continuously from the half-open mouth.

Tinnitus aurium and earache are often experienced, and there may be a temporary or permanent impairment of hearing. The movements of the jaw are, of necessity, greatly impeded and very painful. Speech is difficult, and the voice is husky or muffled.

Mastication and deglutition are almost entirely suspended, the patient enduring the pangs of hunger rather than undergo the suffering required to satisfy his wants.

Mumps usually affects both parotids, but not simultaneously; the left is most frequently the first to become involved, and in from two to four days afterward, or even when the swelling has disappeared, the opposite gland becomes the seat of disease. Not infrequently the affection is limited to one side.

Very often the submaxillary and sublingual glands are affected conjointly with the parotids. Dr. Penzoldt, of Erlangen, records an epidemic of mumps which fell under his observation, in which there were many cases in which the disease process was almost wholly confined to the submaxillary glands.

The swelling reaches its height in from two to five days, remains stationary about forty-eight hours, and then rapidly subsides, making the duration of the attack from ten to fourteen days.

Complications and Sequelæ.—These relate especially to affections of the nervous and glandular systems. The tendency for the inflammation to invade by so-called metastases other and remote glands is a singular and interesting feature of the disease. As was originally pointed out by Niemeyer, it is probably not a true metastasis. The testes in males and the mamma and ovaries in females are the organs of special election. This complication is much commoner in males than in females, and less common in childhood than in adult life. When the testicle is invaded, it becomes swollen and painful, and there is often effusion into the tunica vaginalis, with œdema of the scrotum. Bruising of the testes is said to invite the disease.

The migration may take place at any period of the parotid swelling, which then usually subsides, but occasionally the two inflammations run their course together. Sometimes the inflammation of the parotid disappears suddenly before the advent of the metastatic affection; in this event, alarming constitutional symptoms are liable to supervene. There may be high fever, headache, delirium, or profound collapse, which promptly disappear on the appearance of the local lesion. The new affection runs a course very similar to that of the original disease, and lasts about the same length of time.

Atrophy of the testicles sometimes results, or their function may become impaired from occlusion of the spermatic duct.

Meningitis is in evidence in a very large percentage of the fatal cases of mumps. Various diseases of the nervous system have been recorded as complications (insanity, neuritis, hemiplegia, facial paralysis), but certainly in many, if not most, instances, they were mere coincidences.

Otitis media is not uncommon and occasionally terminates in permanent deafness. In a few cases a complete loss of hearing in one ear takes place without the slightest evidence of the presence of the inflammation in the corresponding middle ear; thus warranting the belief that the lesion—whatever may be its nature—must in these cases be located in the cochlea or in the auditory nerve at some point in its extra-labyrinthine course.

Albuminuria with convulsions has been noted.

Prognosis.—Mumps is a mild though painful disease, and almost invariably runs a favorable course. The inflammation of the parotid rarely leads to the formation of an abscess, contrasting, in this respect, strongly with the non-specific form of parotiditis which occurs in the course of typhoid fever and other maladies.

Occasionally a hard, painless enlargement of the gland is left, which persists for a variable time and disappears, but which in very exceptional instances may be permanent.

The Diagnosis is rarely attended with difficulty. The disease can scarcely be mistaken for any affection other than the non-specific inflammations of the parotid glands, which occur as complications of various constitutional diseases.

The comparative mildness of the general symptoms, the speedy resolution of the swelling, and the epidemic character of mumps, contrast strongly with the preceding severe illness and the inherent tendency to suppuration which constitute the clinical features of the non-specific or symptomatic parotiditis.

Treatment.—The treatment is purely symptomatic. The disease is self-limited and runs a definite course, uninfluenced by the administration of drugs.

The patient must remain indoors, preferably in bed, even in mild cases, until convalescence is assured.

On account of the difficulty in swallowing, the diet should be exclusively fluid. If there should be high fever, a bath or surface sponging with tepid water will be of service. Should there be much pain or restlessness, an anodyne, preferably Dover's powder or chloral, may be prescribed; otherwise refrigerant diaphoretics, such as a solution of bitartrate or citrate of potash, or the neutral mixture of the Pharmacopœia (see under *Potassium*), will meet all of the indications. External fomentations to the neck are both useful and grateful to the patient. Soap liniment, to which a little deodorized tincture of opium may be added, warm olive oil, or the tincture of belladonna and glycerin (ʒ i.–℥ i.), are eligible preparations for external use.

When metastasis to the testes or other glands takes place, the new affection should be treated in the same manner as if it had occurred independently of the parotid inflammation. The writer has obtained excellent results in orchitis from the inunction of guaiacol (ʒ i.) and lanolin (ʒ iij.–iv.). When it is applied from two to four times daily the pain and swelling usually promptly subside. If the onset of the metastasis is heralded by great prostration, or by alarming symptoms of any kind, stimulants must be freely given and warmth applied to the body.

A course of tonics is advisable should convalescence be tardy.

W. J. Conklin.

MUSCARINE. See *Poisonous Plants.*

MUSCLE.—Histology of Muscular Tissue.—Muscular tissue (Lat., *Tela muscularis;* Ital., *Tessuto muscolare;* Fr., *Tissu musculaire;* Ger., *Muskelgewebe*) is the tissue in the animal body the physiological characteristic of which is its power of contracting in one direction, thus giving rise to definite movements. It is composed of structural elements, the length of which is usually much greater than the breadth. Muscular tissue in some form is present in all the groups of animals, except the *Protozoa.**

Anatomically or morphologically, muscular tissue is of two kinds: (A) *Striated or striped muscular tissue,* that in which the structural elements or fibres are marked by distinct transverse, and usually much less distinct, longitudinal striations. The structural elements are uni- or multinucleated (Figs. 3383 to 3405). (B) *Smooth or unstriated muscular tissue,* that in which the structural elements are apparently homogeneous, or marked by fine longitudinal striations only. The elements are mostly uninucleated (Figs. 3406 to 3409).

* Among the *Protozoa,* the striated ectoplasm of some infusoria and the contractile stalk of *Vorticella* are perhaps physiologically muscular tissue, but they can hardly be so considered anatomically, since these organisms are supposed to be unicellular.

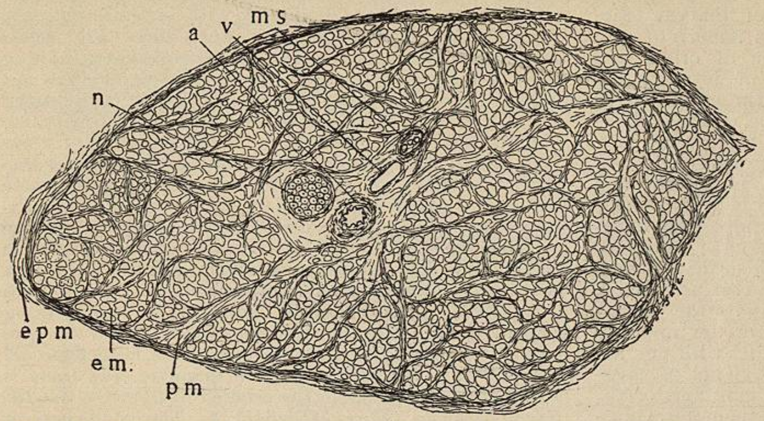

Fig. 3382.—Transection of the Occipitoscapularis Muscle of the Cat, to show the Components of an Ordinary Striated Muscle. The whole muscle and the fascicles were outlined with the camera lucida at a magnification of about twenty diameters. The muscular fibres, the artery, vein, and nerve were not drawn to scale. (Drawn by Mrs. Gage.) *a,* Artery; *em,* endomysium, the connective tissue between the individual fibres; *epm,* epimysium, the connective tissue surrounding the entire muscle and giving off (*pm*) the perimysium, which combines the fibres into bundles of fascicles of various sizes; *ms,* muscle spindle; *n,* nerve; *v,* vein (*cf.* Figs. 3395, 3400).

Striated Muscular Tissue.—This, in man and many of the lower animals, is the so-called flesh or lean meat. It is usually collected into more or less distinct masses, termed *muscles;* and in every case, whether the muscle is in distinct masses or not, it is composed of structural or histological elements, which, when viewed lengthwise under a microscope, are characterized by an appearance of being composed of alternating dark and light segments (Figs. 3383 to 3404); this gives the elements their transversely striated appearance. Physiologically, striated muscle is characterized by the rapidity and energy of its contraction.

Distribution.—Striated muscular tissue is present in all vertebrates and in some members, at least, of all the great groups of invertebrates except the *Protozoa.* Structurally and physiologically, striated muscular tissue in vertebrates is of two kinds: (A) The skeletal, or the so-called muscle of animal life, which is mostly voluntary; (B) the cardiac, or the muscular tissue of the heart, and the other pulsating organs of the blood-vascular system. This is wholly involuntary, and belongs to the tissues of organic life.

Skeletal or Voluntary Muscular Tissue (muscles of animal life).—In man and the mammals, this tissue forms from forty to forty-five per cent. of the entire body weight. Its specific gravity is about 1.058. It is usually collected into distinct muscles, the ends of which are in most cases attached to some firm part (bone or cartilage) by means of fibrous connective tissue.

Distribution: In man and the mammals generally, this tissue forms the muscles of the trunk and extremities, those moving the globe of the eye and all those of the ear, those moving the lips, and those moving the skin (*platysma myoides* in man, the cutaneous muscles over nearly the entire body in many mammals). It is also present in the tongue, pharynx, larynx, the true sphincter of the urethra, and the ectal sphincter of the anus; in mammals possessing them, it is found in connection with Cowper's and the anal glands. In the œsophagus of man, the horse, and some other animals, striated muscle is usually present only in the pharyngeal half; in ruminants, the dog, cat, rabbit, house mouse, rat, and many other animals, it extends to, or nearly to, the stomach; and in the rat it is even continued upon the stomach from the cardiac end of the œsophagus. In many of the lower vertebrates, besides the muscles of the trunk and limbs, striated muscular tissue is found in situations where it is not present in man. *In birds,* in the iris and choroid; *in snakes,* around the poison glands; *in fishes,* in the wall of the stomach of *Cobitis fossilis* and *Syngnathus acus,* and in the intestine of *Tinca chrysitis;* in *amia* it forms a double layer over the surface of the lung-like air bladder, and is present in the trabeculæ-like cords within it; in *lepidosteus,* it is very abundant in the trabeculæ within the air bladder; in *polypterus* there is present an enclosing sheet of muscle for the air bladder as in *amia.*

Constituents of Striated Muscular Tissue.—These are: (A) the essential and characteristic, elongated and transversely striated muscular fibres (Figs. 3383 to 3396); (B) blood- and lymph vessels (Figs. 3382 and 3396); (C) nerves (Fig. 3382); (D) muscle spindles (Fig. 3400) (E) a considerable quantity of adipose and connective tissue (Figs. 3382 to 3385.) The connective tissue of a muscle has received special names according to its position in the muscle: (*a*) *epimysium* or *perimysium externum* (Fig. 3382, *ep*). This is the connective tissue which forms a kind of envelope or sheath for the entire muscle, (*b*) *perimysium* (Fig. 3382, *p*). This is the connective tissue which extends into the muscle from the epimysium. It combines the fibres into bundles (*fasciculi, fascicles,* or *lacerti*) of various sizes, and separates the fascicles from one another; (*c*) *endomysium.* This is the minute network of connective tissue extending from the perimysium into the fascicles, and separating the individual fibres from one another. Finally, connective tissue, commonly in dense masses or tendons, serves to connect the muscles to other parts, usually bones or cartilages, which are moved when the muscle contracts.

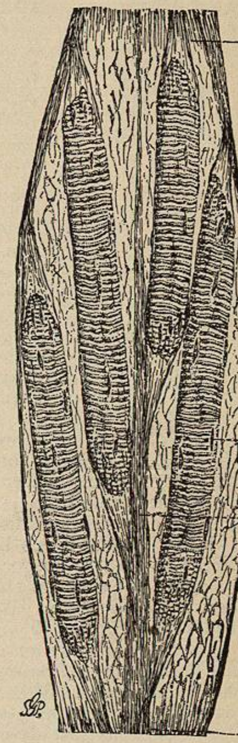

Fig. 3383.—Diagram to show the Arrangement of the Fascicles in a Bipenniform Muscle (*Biceps Brachii* of the Cat). Each fibre represents a fascicle. (Drawn by Mrs. Gage.) *m-c,* Muscle corpuscles; *t-i,* tendon of insertion; *t-o,* tendon of origin; *t′,* tendinous expansion over the surface of the muscle (it is thickest near the tendon of origin); *t″,* extension of tendon through the middle of the muscle. It thickens toward the tendon of insertion.

Fascicles (fasciculi or lacerti) and their Relations in a Muscle.—In some muscles, as the sartorius, the muscular fascicles extend from end to end of the muscle. In such a case, if the muscle has a broad tendon of origin and insertion, the fascicles are usually nearly parallel and of nearly the same length. Where, however, one or both ends are fusiform, as in the biceps brachii and the gracilis of man, the central fascicles are considerably the longer. In penniform and bipenniform muscles the fascicles are placed obliquely to the long axis of the muscle, and extend for a comparatively small part of its entire length. In case of the bipenniform muscles—biceps brachii of the cat (Fig. 3383), rectus femoris of man—the tendon of origin and the tendon of insertion extend along the entire length of the muscle, on the surface, and also in the central part. This arrangement of the tendon in the penniform and bipenniform muscles renders it obviously impossible to expose the muscular substance in dissection so that it shall show to the best advantage. In most muscles the component fascicles are approximately parallel with one another, although not necessarily with the long axis of the muscle. In bipenniform muscles the fascicles are parallel with one another on the same side, but at an angle with those of the opposite side (Fig. 3383); they are likewise oblique to one another in the fan-shaped muscles like the pectorals and the latissimus.

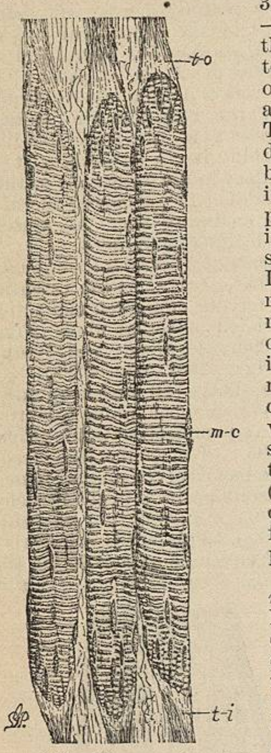

FIG. 3384.—Diagram of a Striated Muscle in which the Fascicles are composed of but One Length of Fibres, which are of nearly Equal Length. It also represents a muscle in which the fibres are parallel and extend from end to end of the muscle. (Drawn by Mrs. Gage.) *m-c*, Muscle corpuscle; *t-i*, tendon of insertion; *t-o*, tendon of origin.

Fibres and their Arrangement in a Fascicle.—It was long supposed that the individual fibres forming a fascicle were coextensive with it, and therefore, except with the penniform and bipenniform muscles, with the muscle itself. It was shown, however, by Rollett,[1] Herzig, and Biesiadecki,[2] that the fibres may end within a fascicle, being attached to a tendon at but one extremity, or at neither. It is now believed that a fibre rarely exceeds from 40 to 100 mm. in length, while a muscular fascicle may be, in some cases, ten or twenty times that length, or even longer. In man and some of the larger animals Felix[6] has isolated fibres from 120 to 130 mm. in length, although he found the majority of the fibres much shorter. If the fascicle is not over 40 mm. long, the fibres usually extend parallel with one another from end to end of the fascicle; and where the fascicle is parallel with the long axis of the muscle, and the muscle itself does not exceed 40 mm., the individual fibres likewise extend its entire length (Fig. 3384), as in the occipitofrontalis and many other muscles of the cat, the stapedius, intercostals, and some other muscles in man. Where, however, the fascicles considerably exceed 40 mm. in length, the fibres which originate in the tendon of origin or insertion by blunt ends, terminate by fusiform ends at different levels within the fascicle (Fig. 3388, *A*). Where the fascicles greatly exceed 40 mm. in length, part of the fibres originate and terminate as just described, while those which fill the intervening space are tapering and slender at both ends (Fig. 3388, *B*). In most cases in which the fibres become tapering and end within a fascicle, each tapering end is applied closely to a fibre of full size (see Fig. 3388, and below, under Termination of the Fibres).

In small animals, like the common mouse and bat, in which none of the muscles attains a length of 40 mm., one would naturally expect all the fibres to extend the entire length of the muscle; but from an extended investigation of the house and field mouse, of the mole and bat and English sparrow, it was found by Susanna P. Gage[7] that while many of the fibres did extend the entire length of the muscle, many others ended within it either with simple tapering points or with several branches, and even by anastomoses with other fibres (Fig. 3389). Herzig and Biesiadecki found in the muscles of the frog some of the fibres extending the entire length of the fascicle, while others terminated within it. As stated above, the fibres in a fascicle are approximately parallel, and the fascicles, composed of but one length of fibres (Fig. 3384), show the same number of fibres in transection at any level, and each fibre is of nearly the same diameter throughout its entire length, except at the extreme ends (Fig. 3384). In a fascicle composed of two or more lengths of fibres, the number of fibres varies in transections made at different levels, and the same fibre is not of uniform diameter throughout its entire length (Fig. 3388). Independently, however, of the tapering ends of the fibres in fascicles composed of two or more lengths of fibres, the several fibres of a fascicle in all forms of muscles vary greatly in diameter, and there is also a great difference in the number of fibres in the different fascicles (Figs. 3382, 3411). The coarseness or fineness in texture of a muscle to the naked eye, depends mostly on the relative abundance of the perimysium and the *number and the size* of the fibres in the component fascicles (Figs. 3382, 3410).

TERMINATION OF STRIATED MUSCULAR FIBRES.—(A) *Termination in Tendon.*—The most common mode is in a dense, usually rounded or flattened mass of connective tissue called a tendon. This is always less bulky than the muscle, and consists of a continuation of the connective tissue of the muscle, and of the special minute tendinous prolongations of the individual fibres which reach the tendon (Figs. 3383 to 3385). All muscular fibres ending in tendon, or apparently directly upon some hard part—bone or cartilage—terminate as just described, without

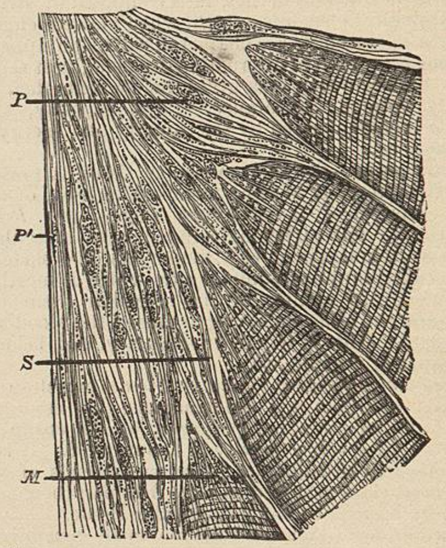

FIG. 3385.—To show the Attachment of Muscle to Periosteum (apparent direct attachment to bone), also an Oblique Muscular Attachment. From the scapula of a cat. Magnified 500 diameters. (Heitzmann.) *M*, Tendinous ends of a striated muscular fibre (four are shown); *P*, perimysium; this intermingles with the periosteum, and with the short tendinous prolongations of the individual fibres, serves as a tendon; *P'*, periosteum; the perimysium and tendinous prolongations of the muscular fibres intermingle with the fibres of the periosteum and become lost in it; *S*, sarcolemma; apparently continued as part of the tendinous prolongation of the fibre.

regard to the angle of attachment; there is simply a difference in the length of the tendinous prolongations of the fibres (Fig. 3385).

When a muscular fibre reaches a tendon, the sarcous substance (see below) ends bluntly (Figs. 3383 to 3388). In some cases the end is divided into several short finger-

like processes, and in most cases the supply of nuclei in the muscular and tendinous substance is abundant. Whatever the form of the terminal part of the sarcous substance, the fibre appears to be directly continued by a bundle of tendinous tissue, which soon loses itself in the general mass of the tendon (Figs. 3383 to 3388). This appearance is clearly seen in the dead muscular fibres of all the animals examined, both in sections and in isolated fibres. When the muscle is stained with acid fuchsin and picric acid, the muscular substance is yellow and the tendinous substance pink. The appearance is then that the tendon fits into all the crevices at the end of the terminating fibre as if the muscle end with its terminal processes had been inserted into a plastic tendinous substance. The tendinous substance is also extended along the sides of the fibre and merges into the endomysium (Fig. 3387). It was long held by most histologists that this appearance indicated that at its termination in a tendon the sarcous substance merges directly into tendinous substance, and with the sarcolemma (see below), forms the tendinous insertion of the fibre. At the present day, however, many histologists believe that the sarcolemma of a muscular fibre is continued around the end of the fibre, and that the tendon is simply cemented to it (Fig. 3386). The sarcolemma has never been separated from the tendon, so that, if this view is correct, the connection between the sarcolemma and tendon is more intimate than that between the sarcolemma and sarcous substance. This interpretation is a natural, and almost necessary, outgrowth of the cell doctrine of Schwann[18] and his followers, which teaches, above all things, the independence of the individual structural elements. And these writers consider the sarcolemma a kind of cell wall; it must, therefore, necessarily entirely enclose the fibre, and the tendon be cemented to it at the end of the fibre. To the constantly increasing number of biologists who believe, not in the independence, but in the interconnection of the structural elements of the body, there seems no inherent improbability in the view that muscle may merge into tendon, and the sarcolemma become continuous with, and form part of, the tendon. The appearances obtainable by treating dead muscular fibres with various reagents, and by the study of living fibres, give, in the present state of knowledge, justification to either interpretation.

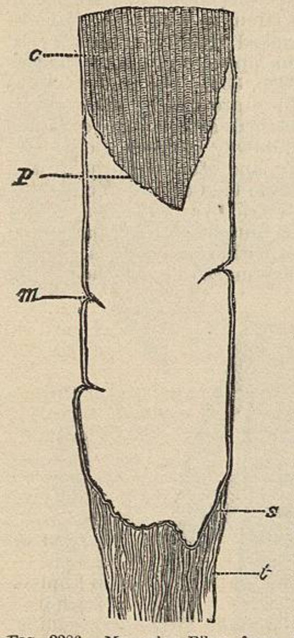

FIG. 3386.—Muscular Fibre from the Gastrocnemius of the Frog, to show the Termination of a Muscular Fibre in Tendon. Magnified 140 diameters. (Ranvier.) *c*, Muscle columns; *m*, a fold in the empty sarcolemma; *p*, retracted conical termination of the sarcous substance; *s*, sarcolemma reflected over the end of the fibre and adhering to the tendon; *t*, tendon.

(B) *Termination of Fibres within a Muscle.*—The statements of histologists concerning the termination of fibres within a muscle and the relations of the terminal ends are so various, or directly conflicting, that some of the more positive statements will be given before stating what seems, according to the writer's observations, to be the condition. Frey, 1880: "While it was formerly supposed that every transversely striated fibre continued throughout the entire length of its muscle, more recently numerous exceptions to this have been observed; that is, muscular fibres which terminate in a point, or some other form, at a greater or less distance from the tendinous extremity. Such primitive fasciculi have their connection with the tendon, to a certain extent, in the interstitial connective tissue." Klein, 1883: "The individual fibres have only . . . a relatively limited length, so that, following an anatomical fascicle from one point of its insertion to the other, we find some muscle fibres terminating, others originating. This takes place in the following way: The contents of a fibre suddenly terminate, while the sarcolemma, as a fine thread, becomes interwoven with the fine connective tissue between the muscular fibres." Landois, 1885: "Within a short muscle, *e.g.*, stapedius, tensor tympani (of man), or the short muscles of a frog, the fibres are as long as the muscle itself. Within longer muscles, however, the individual fibres are pointed, and are united obliquely by cement substance with a similar bevelled or pointed end of another fibre lying in the same direction." Schaefer, 1882: "In a long fasciculus a fibre does not reach from one tendinous attachment to the other, but ends with a rounded extremity, invested with its sarcolemma, and cohering with neighboring fibres."

According to the writer's observations on many different muscles of cats at all ages, and less extended observations upon human muscles and on those of the house mouse, the fibres which terminate within a muscle always do so with a very tapering end, the extremity becoming thread-like, and losing its striation. The muscle corpuscles (see below) are also numerous near the end, and in some cases the fibre seems to terminate as a branched corpuscle (Fig. 3388, *C*). Small lateral branches, some of them striated, were also present in many cases (Fig. 3388, *C*). Where the fibres were apparently undisturbed in their relations, the terminal part, for a considerable distance, was parallel and closely connected with a fibre of full size, the tapering end following accurately the outline of the fibre to which it was applied, curving outward over a muscle corpuscle (Fig. 3388, *m-c*), or when the large fibre was corrugated, following the curves accurately. Herzig and Biesiadecki[9] describe long lateral branches, some of which even anastomose in the intramuscular endings of fibres in the horse.

As shown in Fig. 3389, branched and even anastomosing terminations are not uncommon in the smaller animals, as the house mouse.

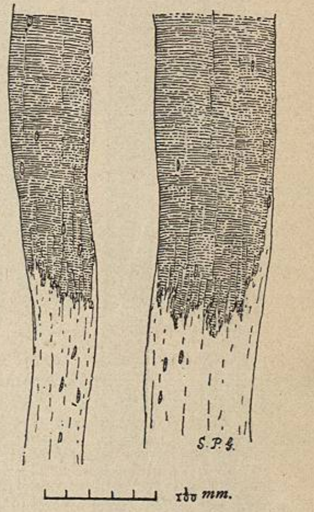

FIG. 3387.—Two Adjoining Striated Muscular Fibres from the Proximal or Upper End of a Human Sartorius to show their Tendinous Connections. (Drawn by Mrs. Gage.) Magnified about 350 diameters. The tendon in each case seems to be a direct continuation of the muscular fibre, and to extend up on the side of the fibre for a short distance (*cf.* Fig. 3386).

The fibres arising from the same tendon and terminating within a muscle may be of various lengths; in such a case the longer ones may apply their tapering ends to fibres of full size coming from the opposite tendon (Fig. 3388, *A*, 3389), while the shorter ones may either apply themselves to fibres from the opposite tendon, or to the longer fibres from the same tendon. In the latter case the shorter fibre has always been observed to terminate before the longer one commenced to taper. When a fascicle is three or more fibres in length, the fibres may be of various lengths, as stated above, but the fibres not joined to the tendon of origin or insertion are tapering at both ends. All the fibres lap sufficiently to apply their tapering end to fibres having their full diameter (Fig. 3388, *B*). In all the numerous preparations observed by the writer, the muscular fibres terminating within a muscle were always very slender and tapering at their termination

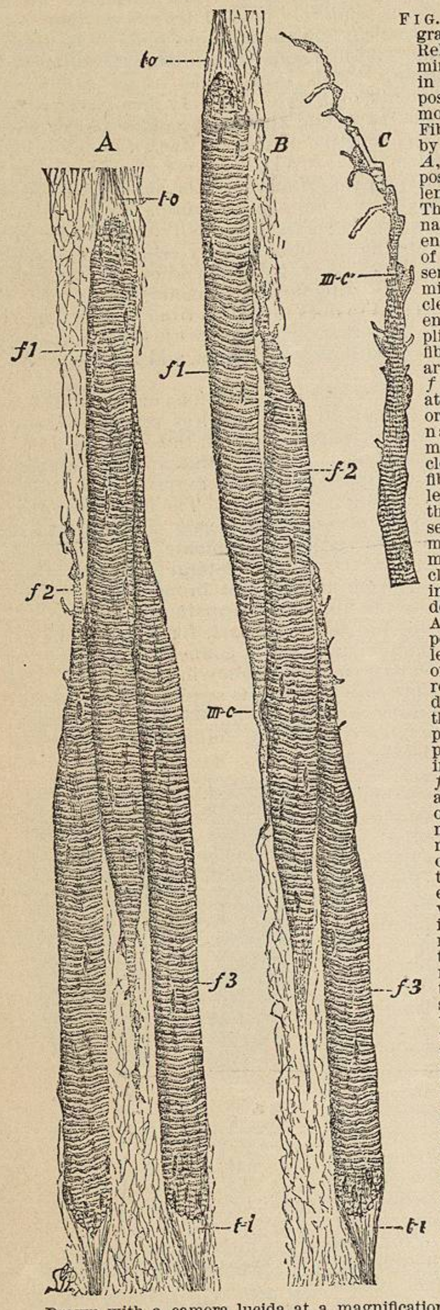

FIG. 3388.—Diagrams to show the Relation and termination of Fibres in Fascicles composed of Two or more Lengths of Fibres. (Drawn by Mrs. Gage.) *A*, Fascicle composed of two lengths of fibres. The fibres terminate by rounded ends at the tendon of origin and insertion, and in the midst of the muscle by tapering ends which are applied to the other fibres, where they are of full size. *f* 1, Fibre arising at the tendon of origin and terminating in the midst of the muscle; *f* 2 and *f* 3, fibres of different lengths arising at the tendon of insertion and terminating in the midst of the muscle; *t-i*, tendon of insertion; *t-o*, tendon of origin. *B*, A fascicle composed of three lengths of fibres; only the ends reaching the tendons are rounded, the others are tapering and are applied to neighboring fibres, as in *A*. *f* 1, Fibre arising at the tendon of origin and terminating in the midst of the muscle; *f* 2, fibre with two tapering ends, both of which terminate in the midst of the muscle; *f* 3, fibre terminating by a rounded end in the tendon of insertion, and by a tapering end in the midst of the muscle; *m-c*, muscle corpuscle. This one projects beyond the surface of *f* 2, and the tapering end of *f* 1 curves over this corpuscle. A similar condition is shown in *f* 1, *A*; *t-i*, tendon of insertion; *t-o*, tendon of origin. *C*, The terminal part of a fibre ending within a muscle. Drawn with a camera lucida at a magnification of 425 diameters. The details of structure were determined with a $\frac{1}{18}$ homogeneous immersion objective, and added free-hand. *m-c*, Muscle corpuscle. The one to which the line extends projects markedly, and is in the angle formed by a lateral branch. The lateral branches are numerous, and some of them show distinct transverse striations. Just beyond the corpuscle to which the line extends the transverse striation ceases on the fibre. At the end is an enlargement or corpuscle, with a thread-like continuation.

(Fig. 3389) and two tapering ends were never seen to lap and be cemented together; but the slender termination of one fibre was almost invariably applied to a fibre of full size, and terminated before the supporting fibre commenced to taper. The apparent termination of a fibre by a rounded end within a muscle is due, in many cases at least, to the tearing and retraction of the sarcous substance, and sometimes also of the sarcolemma. In the great majority of cases observed, in which a fibre was in its natural relations to the other fibres, and seemed to end by a blunt or rounded extremity within the fascicle, the empty sarcolemma was traced to the other broken end. When the hollow sarcolemma appears of about the size of a muscular fibre (Figs. 3386, 3391), the true relations of the broken ends of the fibre are readily determined; but in many cases the stretched sarcolemma collapses and tapers to a point about midway between the severed ends of the sarcous substance, and often both the broken ends cannot be seen in the same field of the microscope.

(C) *Termination of Muscular Fibres in the Skin.*—The attachments of the cutaneous muscles to hard parts, and the terminations of the fibres within a muscle, are as described above for the ordinary muscles. At their cutaneous termination the fibres (in the cat at least) taper somewhat gradually, lose their transverse striation, and, finally, become indistin-

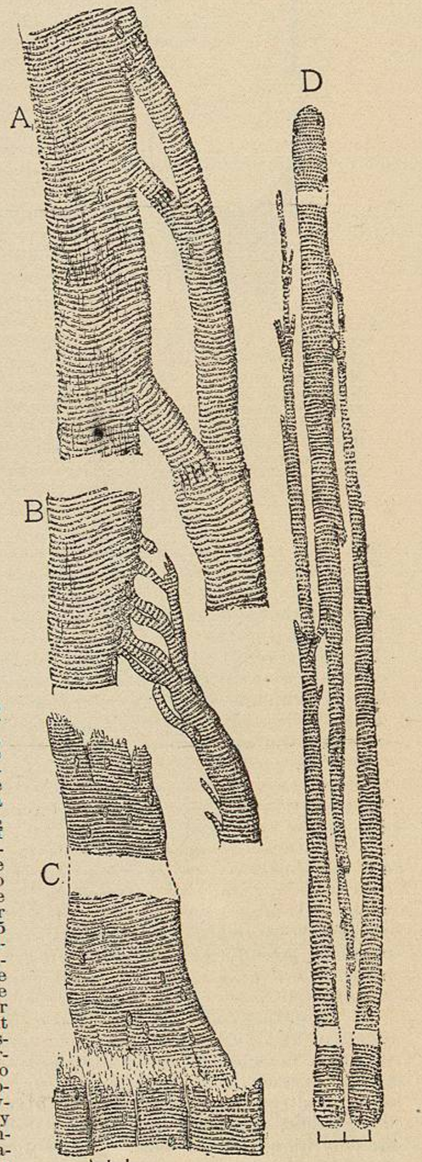

FIG. 3389.—Figures showing the Relations of Muscular Fibres in Small Animals. (From Susanna P. Gage.) *A*, An anastomosis of two fibres in the connecting branches of which are seen a number of longitudinal clefts. The smaller fibre ends with the upper branch. The larger fibre has its maximum size at the upper end, and from the lower part was traced 4 mm. to its tapering, branched intramuscular end, one of the branches forming an anastomosis with another fibre. (From the biceps femoris of a house mouse.) *B*, Termination of an intramuscular end by anastomosis. Anastomosing branches were given off for a whole millimetre, that is for the whole length of the tapering part. (From the biceps femoris of a house mouse.) *C*, Tendinous ends of the rectus abdominis of a house mouse. The two tendinous ends are shown in the upper fibre, which was 5 mm. long. Opposite the lower tendinous end of the large upper fibre are four smaller fibres from the next segment. *D*, Anastomosis of one tapering fibre with two others from the opposite tendon, showing in a typical way the relations of anastomosing, intramuscular ends to one another. The part between the breaks was 3 mm. long, while the whole muscle was 17 mm. long. The intramuscular ends are branched and two of them, after anastomosing, seemed to end freely. (From the biceps femoris of the house mouse.)

guishable from the white fibres of the corium. In some animals, as the rat, the fibres at their cutaneous termination, in the lips at least, divide into several branches, which taper gradually or somewhat suddenly, lose their striation, and in some cases appear to terminate in connective-tissue corpuscles; in others they become indistinguishable from the white fibres of the corium (Fig. 3390).

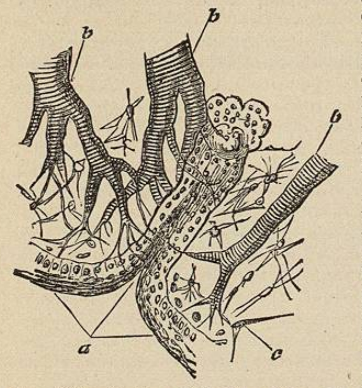

FIG. 3390.—Section of the Lip of the Rat through the *Musculus Levator Labii Superioris*, to show the Branching of the Fibres and their Termination in the Corium. (Busk and Huxley.[5]) *a*, Epidermis and aperture of a sebaceous gland; *b*, muscular fibres branching and terminating in the corium after tapering and losing their transverse striations; *c*, connective-tissue corpuscle.

(D) *Termination of Muscular Fibres in Mucosa.*—If one end of the muscle is attached to some hard part, or if the fibres terminate within the muscle, the attachment of the fibres to the tendon, and the termination within the muscle are as described above for the ordinary skeletal muscles. The ends of the fibres terminating in the mucosal corium, taper, sometimes branch, always lose their striation, and are lost in the fibrous tissue of the mucosa.

(E) *Termination of Striated Muscular Fibres in Hollow Viscera, and in Connection with Unstriated Muscular Fibres.*—In the œsophagus, urethra, etc., where the fibres for the most part have no connection with a definite tendon of origin or insertion, they end by tapering extremities, the tapering part being joined to fibres of full size, as the ordinary skeletal muscles (Fig. 3388). Where the striated fibres mingle with, and are gradually replaced by, unstriated fibres, as at the gastric or lower end of the œsophagus, the long tapering ends of the striated fibres are surrounded on all sides by the unstriated fibres, to which they seem to be cemented as the unstriated fibres are cemented to one another (Fig. 3406).

In all cases (skin, mucosa, hollow viscera, and in the interior of muscles where the fibres gradually taper to thread-like terminations), the sarcolemma, if present on the tapering ends, is so closely connected with the fibre that it is exceedingly difficult or impossible to demonstrate it; and near the end of the fibre the striation is so gradually lost that it is difficult or impossible to locate the exact termination of the sarcous substance and the beginning of the tendinous substance—if it may be so called. No one has ever been able to show a relation of the non-striated termination of the tapering fibres to the sarcolemma, anything like that shown in Fig. 3386; and according to Busk and Huxley,[5] such tapering fibres with non-striated endings furnish conclusive proof that the sarcous substance merges directly into tendinous substance. According to Beale, fibrous degeneration of the sarcous substance points in the same direction.

BRANCHING OF STRIATED, SKELETAL, MUSCULAR FIBRES.—In the invertebrates striated muscular fibres frequently branch and anastomose, especially in the walls of the alimentary canal. In vertebrates these fibres rarely divide, except when terminating in mucosa or skin. Kölliker described tree-like branchings in the mucosal ends of the muscular fibres of the frog's tongue; and Herzig and Biesiadecki have described and figured muscular fibres from the frog's tongue which possess tree-like branches at both ends. According to Klein, branching fibres have also been found in the tongue of the newt, bat, sheep, goat, cat, and man. Salter[17] could not demonstrate them in man. Branched terminations in the tongue of mammals are certainly greatly in the minority, and are much more difficult of demonstration, than in the tongue of the frog. In the skin of the rat's lip branching fibres have been described by Busk and Huxley (Fig. 3390). Finally, the ordinary skeletal muscular fibres are sometimes dichotomously divided. This is especially evident in the tapering ends of fibres terminating within a muscle (Fig. 3388, *C*). Short finger-like divisions at the tendinous ends of fibres are common (Fig. 3387).

STRUCTURE OF A STRIATED MUSCULAR FIBRE (*Primitive Fasciculus or Fascicle*).—The striated muscular fibres are the structural or anatomical elements of the skeletal or voluntary muscular tissue. They are cylindrical or prismatic in form, and rarely extend the entire length of a muscle, most of them being considerably shorter. In diameter, the general average in man is from 30 μ to 65 μ, being somewhat larger in the male than in the female; in the cat 25 μ to 90 μ; in mammals below man 45 μ; in birds 31 μ; in reptiles and amphibia, 56 μ; in fishes 100 μ; in insects 63 μ. The variations in size in the same animal are very great, *e.g.*, in man some of the fibres are 125 μ, while others are only 10 μ in diameter.*

Structurally, most of the fibres are composed of two very different parts—an enclosing membrane, sarcolemma, and the contractile or sarcous substance, which includes the muscle corpuscles.

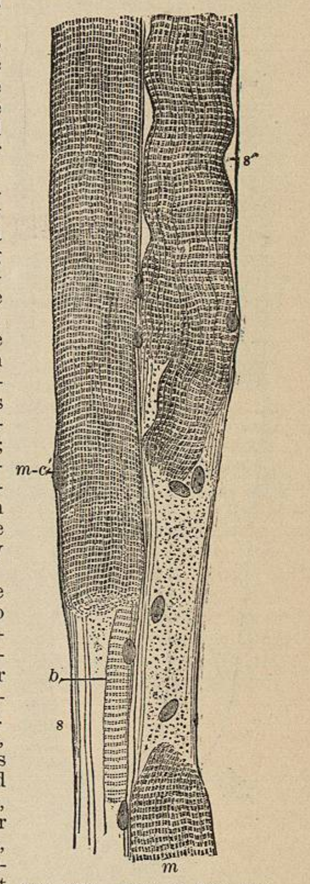

FIG. 3391.—Parts of Two Muscular Fibres from the Adductor Magnus of a Dog, to show the Sarcolemma between the Broken and Retracted Ends of the Sarcous Substance. Magnified 270 diameters. (Ranvier.) *b*, A thin layer of sarcous substance adhering to the sarcolemma. This sometimes adheres all the way around and gives a striated appearance to the sarcolemma; *m*, sarcous or muscular substance; *m-c*, muscle corpuscle. In the fibre at the right some muscle corpuscles have been separated from the fibre and remain in the empty sarcolemma; *s*, sarcolemma; *s'*, opposite a space between the sarcous substance and the sarcolemma.

Sarcolemma (*Myolemma, Primitive Sheath*).—It was shown by Bowman[4] and Schwann,[18] independently, that most striated muscular fibres are covered by a thin, elastic, and transparent membrane, comparable if not identical with, a cell membrane. It has not been demonstrated in the striated muscular fibres of amphioxus and petromyzon (Balfour), nor in many of the fibres of the tongue of man and other animals (Busk and Huxley[5]), nor in fibres of the eyelid and eyeball, nor in most of those of the myelo-hyoid of the green tree frog (Beale[3]). According to some writers it is not present in developing fibres, except near the end of development. In its chemical and physical nature the sarcolemma is quite similar to elastic tissue, so that when the dead fibres are dissected with needles, either before or after special chemical treatment, the sarcous substance (see below)

* It is not stated by the authors from whom the above figures were taken (Kölliker and Bowman) whether, in obtaining the diameter of the fibres, the cut ends, as seen in transections, were measured, or whether isolated fibres were measured, nor whether care was taken to avoid tapering ends of fibres terminating within a muscle. In the measurements given for the fibres of the cat by the writer, only isolated fibres were measured, and care was taken to measure them only where they were of full size.