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VETERINARY MYOLOGY NOTES

Veterinary Myology Notes: How a Muscle Is Built, Named and Supplied (PDF)

Myology is the anatomy of the muscles — and this page is the layer underneath every muscle list, not the list itself.

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IN SHORT

Myology is the anatomy of the muscles — and this page is the layer underneath every muscle list, not the list itself. These veterinary myology notes cover what a skeletal muscle is actually made of and why its connective tissue **becomes** the tendon, the five ways fibres can be arranged and the trade each one makes between range and force, red and white fibres, what origin and insertion really mean and the case where they swap, what a tendon, aponeurosis, raphe, bursa and tendon sheath each are, the four different jobs muscles do in one movement, why a muscle's nerve is predictable from its embryonic source, how the eight naming rules work, and where the domestic species part company.

KEY POINTS

1. **The connective tissue is not packaging — it is the tendon.** Endomysium, perimysium and epimysium merge at each end of the belly and continue as the tendon, then run on into the periosteum as Sharpey fibres. Muscle and skeleton are one fibrous system.
2. **Two numbers decide what a muscle can do, and they compete.** Fibre **length** sets how far it travels; the aggregate **cross-sectional area** of the fibres sets how hard it pulls. A fibre shortens by only a third to a half of its length, so you cannot have both.
3. **Pennation is the compromise, and it is not free.** Angled fibres pack more force into the same bulk, but only the **cosine** of the fibre angle pulls along the tendon — which is why force is predicted by the physiologic, not the anatomic, cross-section.
4. **That is why a limb is heavy at the top and stringy at the bottom.** Pennate bellies sit close to the trunk and only light tendons run to the digits, so less energy is needed to swing the limb.
5. **Origin and insertion are a convention, not a measurement.** König says so. And Sisson's biceps femoris proves it: it flexes the stifle with the foot off the ground and **extends** it with the foot planted.
6. **A muscle has four possible jobs in a movement** — prime mover, antagonist, synergist, fixator — and they are roles in that movement, not properties it carries around.
7. **A muscle's nerve is predictable from where it came from.** Epimere → dorsal ramus → epaxial; hypomere → ventral ramus → hypaxial, with the transverse processes marking the line; branchial arches keep their cranial nerve, which is why the jaw closers are trigeminal and the facial muscles are not.
8. **Muscle names are the most systematic naming in anatomy.** Eight bases — shape, fibre direction, size, position, action, attachment, head or belly count, and consistency — and almost every muscle uses one or two of them.

About the images

Three figures are reproduced for educational reference: one from Dyce, Sack and Wensing's *Textbook of Veterinary Anatomy*, 5th ed. (Fig. 1.26), one from Sisson and Grossman's *The Anatomy of the Domestic Animals*, Vol. I (Fig. 4–2) and one from König and Liebich's *Veterinary Anatomy of Domestic Animals*, 7th ed. (Fig. 1.39). Each is credited beneath it and copyright remains with the original authors and publishers. The other four figures are diagrams of our own, drawn for this guide from the sources named under them.

01 What myology is, and what this page leaves alone

Myology is the part of anatomy that deals with the muscles. The formal name is *myologia*, from the Greek *mys*, a muscle. König and Liebich give it a description worth keeping, because it places the branch rather than just defining it: the skeletal musculature is **the active part of the locomotor system**. Bones and joints are the passive part. They are levers and hinges, and they do nothing at all until something pulls on them.

What does the pulling is a tissue that **turns chemical energy into mechanical energy, or into heat**. Both outputs matter to a veterinary patient, and the second is the one people forget: shivering is a muscle doing its other job.

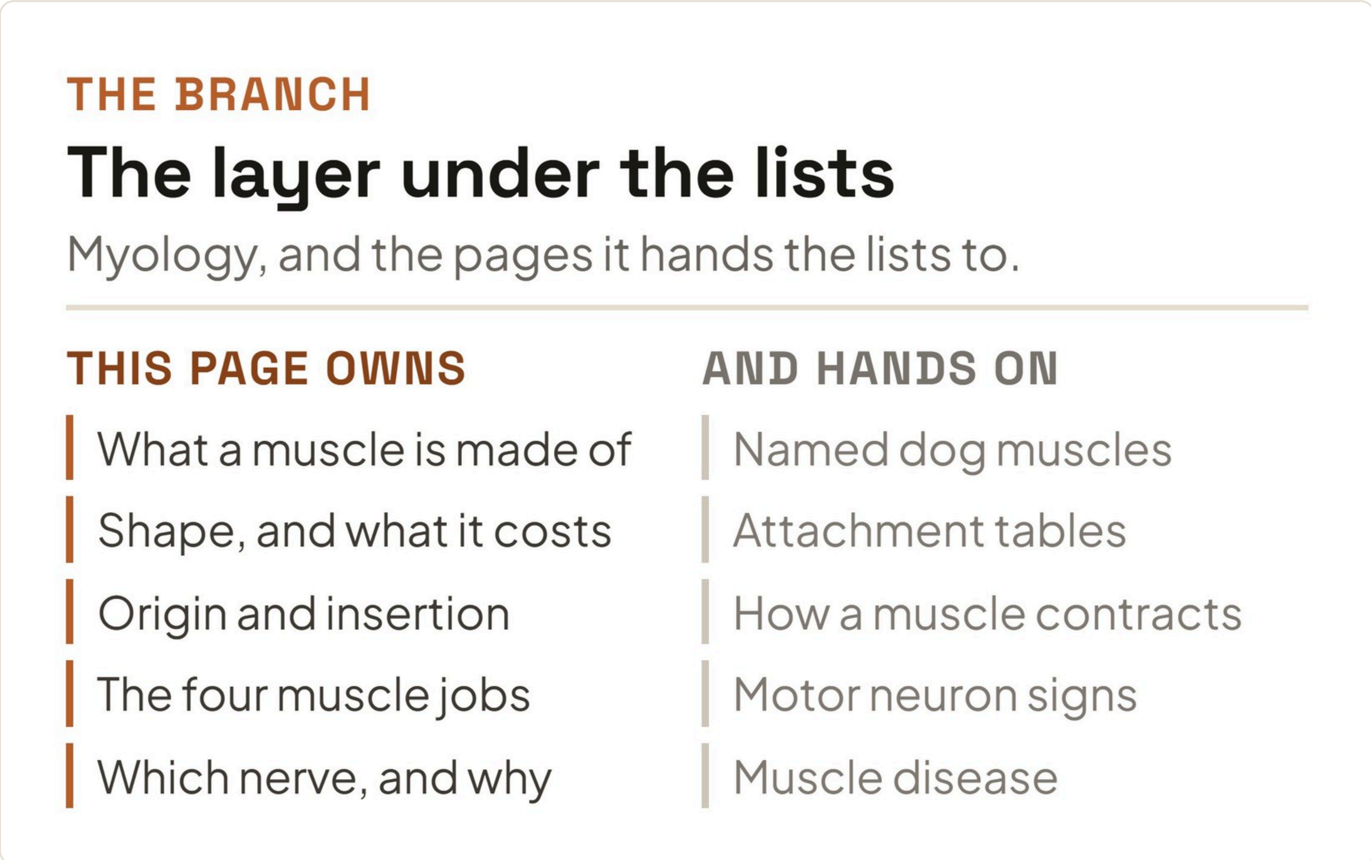

Fig 1 — One branch, and the pages it hands the lists to. Myology is the layer **underneath** every muscle list you will ever be given. It is not the list. Our own guide to the dog's muscles already carries the attachment tables, region by region, and this page exists to make those tables readable — what the columns mean, why the shapes differ, and which nerve to expect.

Diagram — Vet-eBooks.com, drawn for this guide. Data from Sisson S, Grossman JD. The Anatomy of the Domestic Animals, Volume I, 5th ed. W.B. Saunders, ch. 4, pp. 39–46, and König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas, 7th ed. Thieme, §1.4.2, pp. 43–47.

This page is the **general** half of the branch. It is about what a muscle is made of, what shape it comes in and what that shape costs, what a tendon and an aponeurosis and a bursa actually are, what job a muscle is doing in a movement, how its name works, and which nerve supplies it and why. Each of those is a principle rather than a fact about one animal, and each holds broadly across the domestic species; where a species departs from one, it is because of something the animal does, and section 11 collects those.

Where the muscle lists live

This page deliberately contains **no table of origins and insertions**. We already have one, and it is better than a summary would be: our guide to the dog's muscle origins, insertions and nerves runs region by region through the whole animal with the nerve for each muscle. Read that when you need the *answers*. Read this when the answers do not yet mean anything.

One distinction is worth having before any of it, because it decides what a muscle is even for. An **intrinsic** muscle lies wholly within the region it moves; an **extrinsic** muscle lies partly outside it and connects that region to the trunk. A limb has both, and they answer different questions — the extrinsic ones are how the limb is attached at all, the intrinsic ones are how it is used once attached.

Two other fences are worth stating at the start. **How a muscle contracts** — the sarcomere, actin and myosin, the cross-bridge cycle, calcium and ATP — is physiology, and our guide to how a muscle contracts covers it. And **muscle disease** is a clinical subject with clinical books. Where a clinical fact does appear below, it is because a piece of *structure* explains a sign, and the structure is the point.

02 Three kinds of muscle, and two ways of counting them

There are three kinds of muscle tissue in the body, and they are separated on two axes at once: whether the fibres are visibly **striated** under a microscope, and whether the tissue is under **voluntary control**.

MUSCLE TYPE	STRIATED?	UNDER THE WILL?	WHERE IT IS, AND HOW IT BEHAVES
Smooth non-striated, involuntary	No	No	Masses of **spindle-shaped cells** in the walls of hollow organs and blood vessels, and in certain glands, the spleen, the eyeball and the hair follicles. Contractions are **weak but sustained**, and usually rhythmic
Cardiac striated, involuntary	Yes	No	The heart wall only. Cross-striated fibres in irregular masses, with **the ends of some fibres contacting the sides of others** — which is why it behaves as one sheet
Skeletal striated, voluntary	Yes	Yes	Bundles of **multinucleated** fibres, with as many as several hundred nuclei per fibre pushed out to the edge of the cell. This is the muscle myology is about, and it is **about half the weight of a carcass**

Notice that the two axes do not give four boxes. Cardiac muscle is striated and involuntary; there is no non-striated voluntary muscle. That is why the three types are usually just listed.

Except that the books do not agree on how to list them. **Sisson & Grossman** gives a flat three — smooth, cardiac, skeletal, side by side. **König and Liebich** gives **two**: smooth tissue and striated tissue, with striated then splitting into skeletal and cardiac. Neither is wrong, and the difference is not trivial: König's version says that cardiac muscle is a *kind of* striated muscle, which is the more useful thing to know when you meet cross-striations on a slide and have to work out what you are looking at.

From here on, this page means **skeletal muscle** whenever it says muscle. That is the convention in all three of the chapters this page is built from, and it is worth saying once rather than assuming.

03 What a skeletal muscle is made of

Start with a fact that fixes the scale. **Skeletal muscle is butcher's meat, and it accounts for about half the weight of an animal carcass** — varying with species, breed, age, sex and how the animal was kept. Whatever else myology is, it is the anatomy of the largest single tissue mass in the body.

A muscle is built of cells that are extraordinary by any normal standard. They run from about **10 to 100 µm across and 5 to 10 cm long**, which is long enough to see with the naked eye once they are teased apart, and it is why they are called **fibres** rather than cells. Each one carries as many as several hundred nuclei, pushed out to the edge of the cell against its membrane.

That membrane has a name of its own — the ***sarcolemma*** — and inside it, running lengthways down the fibre, are the ***myofibrils***, sitting in a matrix of cytoplasm called ***sarcoplasm***. That is as far as this page goes into the cell, and it is the right place to stop: the myofibril is where myology hands over to physiology.

Three sheaths, and why they are not packaging

Every fibre is wrapped in its own delicate covering, the ***endomysium***. Fibres are grouped into small bundles — each one a **fascicle**, or *fasciculus* in Latin, which you will meet in the plural as *fasciculi* — and each bundle is wrapped in a looser layer, the ***perimysium***. The whole muscle is wrapped in a dense sheet, the ***epimysium***.

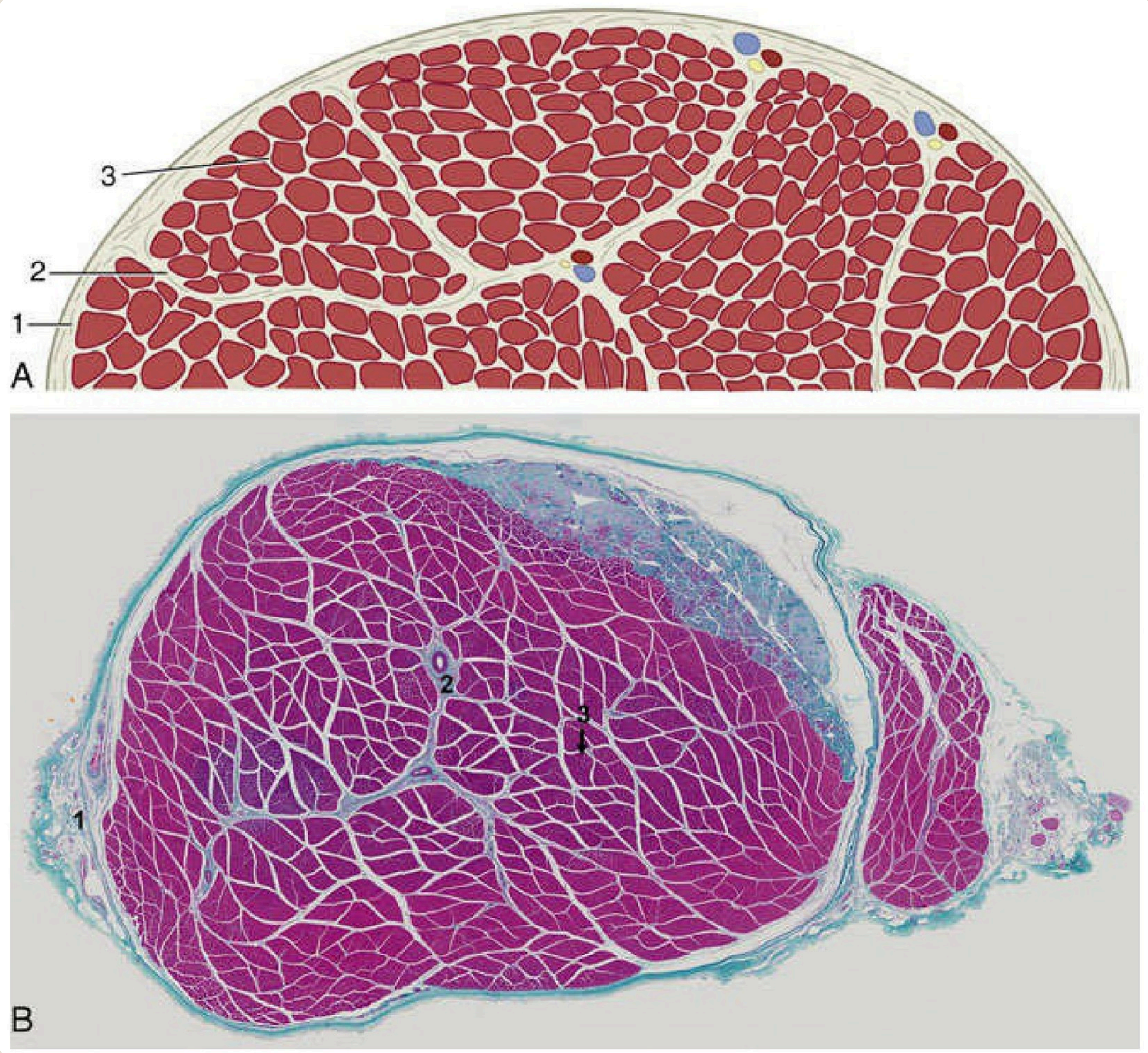

Fig 2 — The same three sheaths, drawn and then photographed. A is a schematic transection with the fibrous tissue emphasised; **B** is a real section stained with **Masson's trichrome**, which colours the cells red and the connective tissue blue. Both carry the same key: **1** the **epimysium** around the whole muscle, **2** the **perimysium** around each bundle, **3** the **endomysium** around each single fibre — and Dyce's key adds where to look for it, *the lightly stained parts inside a fascicle*. Panel B is the one worth staring at — the blue is not packaging between the red, it is a continuous scaffold, and at each end of the belly it becomes the tendon.

Image — Dyce KM, Sack WO, Wensing CJG. Textbook of Veterinary Anatomy, 5th ed. Saunders/Elsevier — Fig. 1.26, schematic transection of a skeletal muscle and a cross-section stained with Masson's trichrome. Reproduced for educational reference.

That much is a list, and a list is not the point. **This is the point:** at each end of the belly those three connective-tissue components **merge and continue as the tendon by which the muscle attaches**. The sheaths are not wrapping around the meat. They are the beginning of the tendon, running all the way in.

The continuity does not stop at the bone either. The epimysium carries on over the tendon as the ***epitendineum***, and where the tendon meets bone its fibres run on **into the periosteum or perichondrium as Sharpey fibres**. There is one uninterrupted fibrous system from the membrane around a single muscle cell to the surface of the bone. A muscle does not attach to a skeleton; a muscle and its skeleton are continuous.

One consequence is worth knowing even if you never dissect another animal: the **amount and quality of that connective tissue** is a large part of why cuts of meat differ in appearance and in how they cook. The other large part is how much the muscle was allowed to shorten during post-mortem rigor.

Can a muscle repair itself?

Two textbooks, fifty years apart, and they disagree

Sisson & Grossman states plainly that **new skeletal muscle fibres are not formed after birth**, and that when part of a muscle is destroyed the repair is connective tissue. König and Liebich describe **satellite cells** — stem cells that remain in the muscle for life — and say regeneration depends on how many of them survive undamaged. The second account is the current one and it is the one to learn. The first is not carelessness; it is a 1975 textbook written before satellite-cell biology existed, and it is a useful reminder that an anatomy text can be perfectly reliable on structure and out of date on turnover.

What both books agree on is **growth**. A muscle gets bigger by **enlarging the fibres it already has**, and those fibres enlarge further with exercise. Body weight can also rise by fat being laid down within and between the fibres, which is a different thing wearing the same outline.

04 Shape is a machine: what a muscle's architecture costs it

Muscle bellies are not all built the same way inside, and the variation is not decoration. Dyce sets out the whole subject in two sentences that are worth learning as a pair, because everything else in this section follows from them:

The shortening a muscle can show on contraction — about 50% — is a function of the length of its fibres. The power it can develop is a function of the aggregate of their cross-sectional areas.

Sisson gives the same fact from the fibre's end: each fibre contracts to its fullest extent by **reducing its own length by one-third to one-half**. A fibre cannot shorten more than that, so a muscle can only travel further by having *longer* fibres, and can only pull harder by having *more* of them. In a belly of fixed size, those two demands are in direct competition.

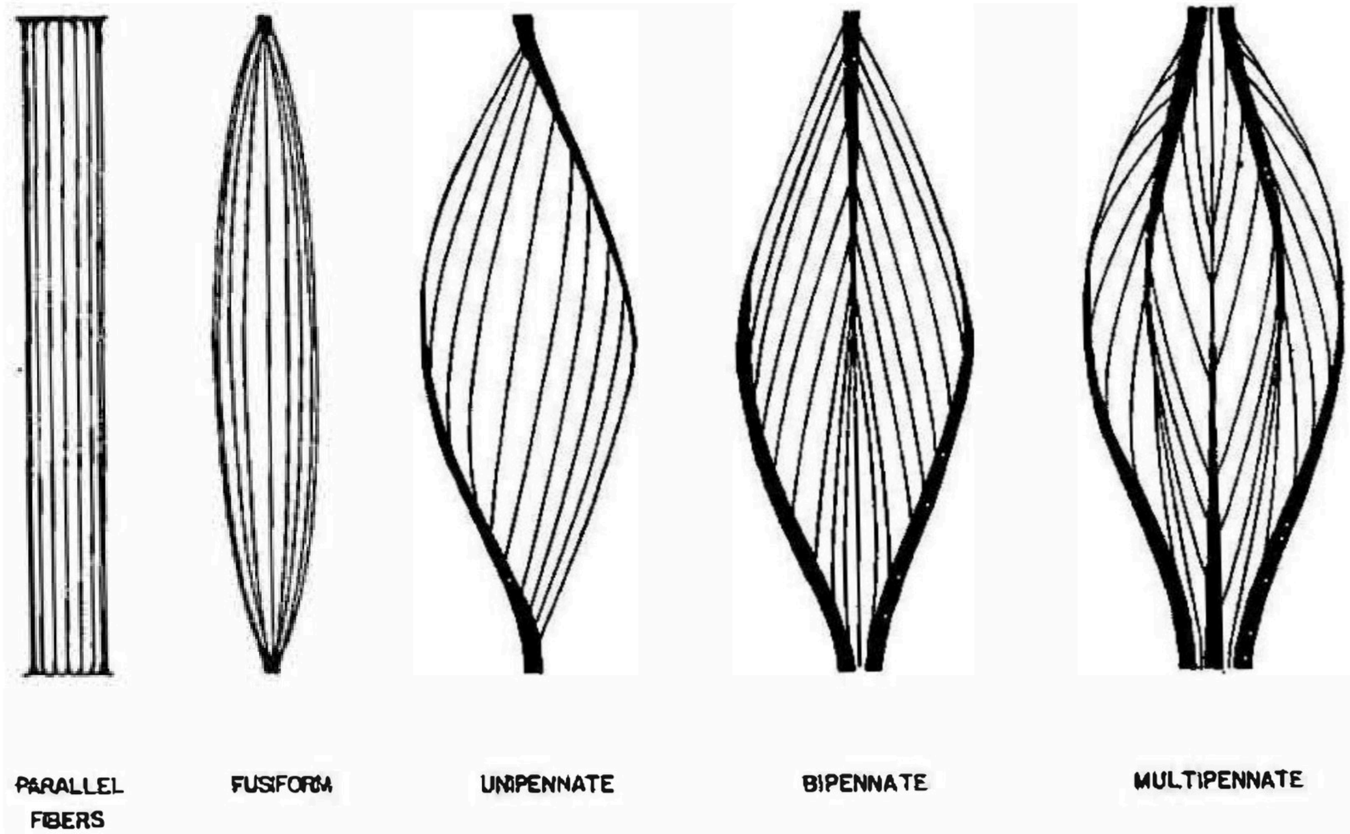

Fig 3 — Five ways to fill a muscle belly. All five are drawn the same way, which is what makes the comparison a fair one: the belly in outline, the fibres inside it, and the tendon they run into. Their names are printed under them. Read it left to right and watch **two things change together** — the fibres get shorter, and the angle at which they meet the tendon opens out. That is the whole trade, drawn: every step to the right packs more fibres into the same belly, and gives up travel to pay for them.

Image — Sisson S, Grossman JD. The Anatomy of the Domestic Animals, Volume I, 5th ed. W.B. Saunders — Fig. 4-2, various arrangements of skeletal muscle fibers, from chapter 4, General Myology, by L. E. St. Clair. Reproduced for educational reference.

Figure 3 is the answer to that competition, drawn five times, and the table below sets out what each of the five buys and what it costs.

ARCHITECTURE	HOW THE FIBRES RUN	WHAT IT BUYS	WHAT IT COSTS
Parallel the strap muscle	Along the long axis, the whole length of the belly, finished by very short tendons	**The greatest travel of any arrangement**	The least force, because only as many fibres fit as the belly is wide
Fusiform *m. fusiformis*, spindle-shaped	Converging on a tendon at **both** ends; thickest in the middle	A compromise, and the commonest shape in a limb	Neither extreme
Unipennate *m. unipennatus*	Meeting the tendon at an angle, from **one** side of it	More fibres in the same bulk, so more force	Shorter fibres, so less travel — and the cosine loss begins
Bipennate *m. bipennatus*	Meeting the tendon at an angle from **both** sides, like a feather	More again	Less again
Multipennate *m. multipennatus*	Meeting **several** tendon sheets at once	The most force for a given bulk	The least travel of any arrangement

Walk it in order. The **parallel** or **strap muscle** has fibres running the full length of the belly, finishing in very short tendons; it produces **the greatest displacement** — and, necessarily, not the force. A **fusiform** or spindle-shaped muscle tapers to a tendon at both ends, its fibres converging on each; it is the compromise, and the commonest shape in a limb. Then the fibres begin to meet the tendon *at an angle*, and the muscle becomes **pennate**: **unipennate** where they join the tendon from one side of it, **bipennate** where they join from both like the barbs of a feather, and **multipennate** where they meet several tendon sheets at once. Each step packs in more fibres and shortens every one of them, so each step buys force and spends travel — and the multipennate muscle at the far end produces the most force it can for its bulk, and moves the least.

ARCHITECTURE

Range or force, not both

A fibre shortens by a third to a half of its length.

Fibre length sets how far it can move

Cross-section sets how hard it can pull

Angled fibres more of them, but pulling off-line

So measure the physiologic cross-section

What the angle costs

Only the cosine of the fibre angle pulls along the tendon's line.

Fig 4 — Why the shape is a machine. Four lines, and each one rests on the one above it. The first two are the pair that compete: **length** buys travel, **cross-section** buys force, and a belly of fixed size cannot have more of both. The third is what pennation does about that — more fibres in the same bulk, at the price of pulling off the tendon's line. The fourth is the measurement that follows, and it is the one most often got wrong: the cross-section that predicts force is the **physiologic** one, which cuts every fibre, and not a slice through the thickest part of the belly.

Diagram — Vet-eBooks.com, drawn for this guide. Schematic, not to scale. Data from Dyce KM, Sack WO, Wensing CJG. Textbook of Veterinary Anatomy, 5th ed. Saunders/Elsevier, pp. 57–58, and Sisson S, Grossman JD. The Anatomy of the Domestic Animals, Volume I, 5th ed. W.B. Saunders, p. 41.

What pennation costs

Angling the fibres is not a free lunch, and this is the part most notes leave out. A fibre that meets the tendon at an angle does not pull along the tendon — it pulls across it as well. Only the component along the line of pull does useful work, and that component is **the cosine of the angle of insertion**. A pennate muscle therefore **wastes a proportion of its strength** and a proportion of its potential displacement, and buys back more than it loses only because it can fit so many more fibres in.

Which leads to a measurement trap. If you want to know how much force a muscle can produce, the obvious cross-section — slice the belly across at its thickest point — is the wrong one. That is the **anatomic** cross-section, and in a pennate muscle it cuts most fibres obliquely and misses others entirely. What you need is the **physiologic** cross-section: the complex plane that cuts *every* fibre transversely. In a strap muscle the two are the same. In a multipennate muscle they are very different, and only the second predicts the force. König calls the same pair morphological and physiological, and Sisson calls the second a composite cross-section — three books, three names, one idea.

Why a limb is built out of pennate muscles on long tendons

Look at a horse's forelimb and the pattern is unmissable: heavy muscle high up near the trunk, and long cord-like tendons running down to the digit with almost no muscle on them at all. That is a direct consequence of the arithmetic above. Pennate bellies deliver the force, and because they are small for that force they can be **placed close to the trunk**. Only the light tendons extend to the joints they operate — so **less energy is required to swing the limb to and fro**. A limb built the other way round, with the muscle mass at the bottom, would cost the animal energy on every stride.

The other shapes, which are not about fibre direction

Two more sets of names describe a muscle's build without saying anything about fibre angle. Muscles arising by two, three or four separate **heads** that join a common tendon are called *biceps*, *triceps* and *quadriceps*. Muscles divided into two **bellies** by an intermediate tendon are **digastric** (König also writes *m. biventer*); more than two makes them polygastric. Muscles arranged in a ring around a natural opening are **sphincters**, and where they form the wall of a tube or cavity they act as **constrictors**. Flat muscles whose tendon is spread into a broad sheet have an **aponeurosis** rather than a cord, an arrangement clearly suited to holding up the abdominal organs.

And one category that exists for a reason nobody guesses: **articular muscles**, small muscles that attach to a joint capsule and whose job is to keep the synovial membrane from being caught between the articulating surfaces as the joint closes.

05 Red and white, fast and slow

Cut into a fresh carcass and the muscles are not all the same colour. The difference is **myoglobin** — the oxygen-binding pigment in the sarcoplasm — and it tracks a real difference in how the muscle behaves.

> **A place where one textbook contradicts itself**
>
> The standard mapping is: **red (dark) muscle is slow, oxidative and built for sustained work; white (pale) muscle is fast, glycolytic and built for a short burst**. Sisson and König both give it that way round. Dyce gives it that way round too — and then, two sentences later on the same page, states the reverse. The chicken settles it without any textbook: the **pale breast** is the burst muscle of a bird that barely flies, and the **dark leg** is the one that holds it up all day. Learn the standard mapping, and read carefully round it.

The two kinds have names of their own, and they are the names a lecturer is most likely to use. Dyce calls them **slow-twitch** fibres — the ones that take their energy from aerobic metabolism, and that belong with red, sustained, postural muscle — and **fast-twitch** fibres, which rely on glycolytic metabolism and belong with pale, burst muscle. Red and white, dark and pale, oxidative and glycolytic, slow-twitch and fast-twitch: four ways of naming the same two columns, and you will meet all four.

The veterinary version of the rule is the useful one, and Sisson states it directly: **muscles that support the body in a standing position tend to have a preponderance of dark fibres**. A muscle that has to hold a posture for hours cannot be built for sprinting. A muscle that has to produce one violent effort and then rest can be.

König gives the structural reason. A pale fibre has proportionately **more myofilaments** in its sarcoplasm and therefore room for **less myoglobin**: great contractile strength, and it tires quickly. A red fibre has fewer myofilaments and more myoglobin, so it stores more oxygen and can keep going.

> **And the hedge that belongs with it**
>
> Dyce adds a warning worth carrying: there are many other structural and physiological differences between fibres, and **the suggestion that there are only these two, sharply distinguished varieties, although convenient, is a misleading simplification**. Two types is a teaching device. Real muscles are mixtures, in proportions that vary with the muscle, the species and what the animal does.

Everything downstream of this — how the two fibre types actually generate their force, and why one runs on oxygen and the other does not — is physiology, and it is covered in our guide to how a muscle contracts.

06 Origin and insertion — and when the distinction stops working

Every muscle has two ends, and anatomy gives them different names. The rule you will be taught first is the functional one: **the attachment that stays more still during the movement is the origin, and the one that moves is the insertion**. For limb muscles there is a shortcut — the proximal attachment is the origin and the distal one the insertion.

König then says something that is easy to read past and is the most important sentence in this section: **the origin and insertion are assigned by convention**. Normally the origin is the proximal end, or the end nearer the centre of the body. That is a naming rule. It is not a measurement of what moved.

THE RULE	WHAT IT SAYS	WHEN IT STOPS WORKING
The functional rule	The attachment that **stays more still** during the movement is the origin; the one that moves is the insertion	The moment the animal changes what it is standing on. Fix the foot and the ends swap
The limb convention	In a limb, the **proximal** attachment is the origin and the **distal** one the insertion — assigned by convention, and used regardless of what actually moved	It is a convention. König says so explicitly, and a table built on it is describing a naming rule, not the animal
The functional pair *punctum fixum / punctum mobile*	The **fixed point** is whichever end is held still by its attachment to the trunk; the **moving point** is the other, and must be the smaller and lighter of the two	It does not stop working — this is the pair that survives the exceptions, which is why it is worth learning alongside origin and insertion

The functional pair worth learning alongside them is König's: *punctum fixum*, the **fixed point**, and *punctum mobile*, the **moving point**. The fixed point is whichever end is held immobile by its attachment to the trunk, and the moving point has to be the smaller and lighter of the two. Those two names describe what actually happens in a given movement, and they can swap between one movement and the next while the labels "origin" and "insertion" stay where the textbook put them.

The example that makes the point unforgettable

Sisson gives a case that no table can express. Take the **biceps femoris** of a dog. When the limb is off the ground, it extends the hip, flexes the stifle and extends the hock. **When the foot is planted firmly on the ground, the same muscle becomes an extensor of the stifle.**

Nothing about the muscle changed. What changed was which end was free to move. A muscle's action is not a property it carries around; it is a result of the muscle, the joint and **what is currently fixed**. This is worth holding onto whenever you read an attachment table, including ours: the "Action" column is telling you the usual case, not a law.

Two more places the tidy picture bends

A tendon can be **so long that the origin and the insertion are separated by several joints**, which is normal in a distal limb and means the muscle's action has to be worked out at each joint it crosses. And a muscle can originate from a broad fascia and insert by a single narrow tendon, or cover a whole region with bundles arising and inserting all the way along, so that almost the entire surface of a bone is an attachment area.

> **One claim that is too strong**
>
> König writes that the ends of a muscle **always** insert in bone or cartilage. Sisson names three places where they do not: some muscles attach to their opposite numbers across the midline — in the **abdominal wall**, the **diaphragm** and the **pharynx** — and others attach to connective tissue inside a soft structure, like the cheek, which becomes rigid when they contract. Take the general rule; do not take the word *always*.

Where the force actually goes

Two details about the attachment itself repay attention. The fibres of a tendon **intertwine**, which distributes the pull evenly no matter which part of the muscle generated it. And at the insertion those fibres **fan out**, so that as the angle between tendon and bone becomes more acute, successive parts of the attachment area take the full force in turn rather than all of it landing on one line.

Leverage does the rest. In a limb, a tendon that attaches close to the proximal end of the next bone produces a **rapid and extensive** excursion of that bone's far end. An insertion further down, spread over a greater area, produces a movement that is **more powerful but slower and less extensive**. Sisson's summary is the one to remember: muscles with broad attachments and a short distance between origin and insertion are **adapted for strength at the expense of speed and range of movement**. It is the same trade as pennation, made at the skeleton instead of inside the belly.

One last constraint, obvious once stated and easy to forget in an exam: **to produce skeletal movement, a muscle must cross at least one joint**. A muscle with both ends on the same bone moves nothing.

07 What a muscle attaches through

Between a muscle belly and the thing it moves there is a small vocabulary of connecting and protecting structures. They are worth separating properly, because several of them are routinely confused with each other.

The connectors

A **tendon** is the cord-like continuation of the muscle's own connective tissue, and it is what the previous section described. Inside it, fine connective tissue — the *endotendon* — runs between the strands, and loose areolar tissue around it, the *paratendon*, lets it glide. Blood vessels reach it through both. One detail explains a great deal about tendon injury: **at friction points, where the tendon has become cartilage-like, virtually no blood vessels exist**.

An **aponeurosis** is the same tissue as a flat sheet instead of a cord — "an especially thick sheet of connective tissue" giving origin or insertion to a muscle. The abdominal wall is built out of them.

A **raphe** is a connective-tissue seam where paired muscles from either side meet on the midline, either lying against it or arising from it.

Fascia is the broader envelope. **Deep fascia** is sparse over the flat muscles of the trunk except where it gives origin to a muscle, or where elastic tissue has been added to help support the abdominal viscera. **Superficial fascia** is often fat-laden, and in places it is associated with cutaneous muscle. Between the sheets, and between them and the muscles, lies loosely packed **areolar** tissue — the medium in which muscles and tendons slide over one another. Our first-dissection survival guide is where that arrangement stops being an abstraction.

Fascia does one more thing, and it has a name of its own. Where a tendon crosses the extensor or flexor surface of a joint, the deep fascia thickens into a **ring-like band** that the tendon passes under — a ***retinaculum***, or *retinacula* in the plural, which is what König calls it. It holds the tendon down against the joint it crosses, and by doing so strengthens the joint itself. Dyce draws one: in Fig. 1.28 the tendon runs over the bone and *under* the retinaculum, inside its sheath. A student who has met a "flexor retinaculum" in a lecture has met a piece of deep fascia doing that job.

The protectors, and the pair everyone confuses

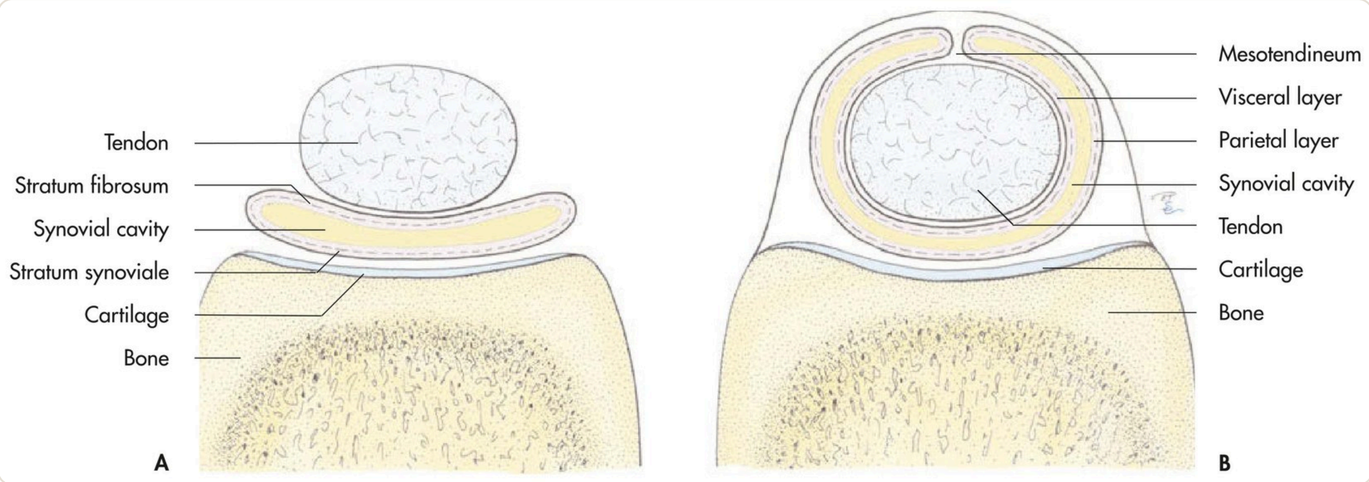

Fig 5 — A bursa and a sheath, in section, side by side. The difference is one of geometry, and seeing them together is the fastest way to fix it. **A** is a **synovial bursa**: a flattened sac that sits *between* a tendon and whatever it rubs against, labelled with the tendon, the **stratum fibrosum**, the synovial cavity, the **stratum synoviale**, the cartilage and the bone. **B** is a **tendon sheath**: the same sac wrapped right around the tendon to make a tube, so it now has a **parietal layer** outside, a **visceral layer** against the tendon, and a fold joining the two — the **mesotendineum**, which carries the tendon's blood supply.

Image — König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas, 7th ed. Thieme — Fig. 1.39, accessory structures of muscles: synovial bursa and tendon sheath. Reproduced for educational reference.

A **synovial bursa** is a flattened closed sac that sits *between* a tendon and whatever it would otherwise rub against. A **synovial tendon sheath** is the same idea taken all the way round: as Sisson puts it, it is constituted as though a bursa were **wrapped about the tendon to make a**

tube, one side contacting the tendon and the other the surrounding structures.

Because the inner and outer parts of that tube are continuous, the connecting portion is double, and it has its own name: the ***mesotendon***. It carries the tendon's blood supply in. Where movement and pressure are greatest it thins away or survives only as threads, the *vincula*. More than one tendon may share a sheath.

One asymmetry inside a sheath is worth knowing because it is not intuitive: the **proximal** pole contains a sickle-shaped fold that glides along the tendon, letting the sheath stay a closed cavity while the tendon travels. There is nothing equivalent at the distal pole, which is why the mesotendon is much longer proximally than distally.

Finally, **sesamoid bones**. These are small bones of various shapes developed in association with certain tendons, and they do two jobs: they **glide in grooves over prominences to change the direction of the tendon's pull**, and they protect the tendon where it is pressed against bone. The **patella** is the one every student already knows: Miller and Evans call it the largest sesamoid bone in the body.

08 Four jobs, not one: how muscles work in teams

A natural movement is never one muscle. Sisson puts it as many muscles acting simultaneously or one after another, and the useful question is not "what does this muscle do?" but **"what is this muscle doing in *this* movement?"** There are four answers.

ONE MOVEMENT

Four jobs at once

One movement, four different jobs being done.

Prime mover produces the movement

Antagonist opposes it, and controls it

Synergist helps, or cancels a side-effect

Fixator holds another joint still

Which is which is not fixed

The smaller muscles around a joint usually act in fixation.

Fig 6 — Four jobs, happening at once. In any real movement, several muscles are working and they are not all doing the same thing. One produces the movement, one opposes and therefore *controls* it, one helps or cancels an unwanted side-effect, and one holds a joint the prime mover crosses still so that the movement happens where it is wanted. **These are roles in a movement, not properties of a muscle** — the same muscle takes a different one in the next movement.

Diagram — Vet-eBooks.com, drawn for this guide. Schematic, not to scale. Data from Sisson S, Grossman JD. The Anatomy of the Domestic Animals, Volume I, 5th ed. W.B. Saunders, p. 42, and König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas, 7th ed. Thieme, p. 47.

ROLE	WHAT IT IS DOING	IN ONE EXAMPLE: FLEXING THE ELBOW
Prime mover also called the agonist	Produces the characteristic movement at the joint	The elbow flexors shorten
Antagonist	Opposes the movement — which is not obstruction. Its graded resistance is what makes the movement smooth and stops it overshooting	The elbow extensors pay out under control
Synergist	Works with the prime mover: adding to the pull, or cancelling an unwanted second action the prime mover would otherwise produce	A muscle that would also rotate the limb is opposed just enough to leave pure flexion
Fixator	Holds **another** joint still so that the prime mover's pull is spent where it is wanted — and it is the role students most often forget a muscle can be playing	The shoulder is stabilised, so the flexors move the forearm and not the whole limb

One word, two completely different meanings

If you have read our pharmacology pages you have met **agonist** and **antagonist** as drug words — a molecule that activates a receptor, and one that blocks it. In myology they mean something unrelated: the muscle that **produces** a movement and the muscle that **opposes** it. Nothing about receptors is involved. The two senses share nothing but the Greek, and an exam question will not tell you which one it means.

The role that repays the most thought is the **antagonist**. It is easy to picture as a brake fighting the prime mover, and that is the wrong picture. Its graded resistance is what makes a movement controlled rather than a lurch. Most natural movements — breathing, walking, trotting, galloping — are **a rhythmic cycle of contraction and relaxation in antagonistic groups**, and neither group is the useful one.

The **synergist** is the role with two quite different jobs under one name, which is why it is the hardest of the four to pin down. It can simply add its pull to the prime mover's. Or — and this is the version worth understanding — it can exist to **cancel something the prime mover would otherwise also do**. A muscle that flexes a joint may rotate it at the same time, because of where its tendon lies; a synergist opposes the rotation just hard enough to leave clean flexion. Nothing about that shows up in an attachment table, and it is a large part of why real movements are smooth.

The **fixator** is the one students most often miss entirely. If a muscle crosses two joints and you want movement at only one of them, something has to hold the other still, or the pull simply moves whichever end is easier to move. Sisson's observation is a good rule of thumb: **the smaller muscles around a joint usually act in fixation**.

Two ways to describe what a contraction is doing

Before movement can begin, the prime mover has to overcome both the tonus of its antagonists and the force of gravity. That gives two named states. A continuing rise in tension **without any change in the muscle's length** is an **isometric** contraction — what a postural muscle does all day, and what happens in the moment before a limb moves. Once the tension is high enough the muscle shortens, and that is an **isotonic** contraction. Real movements alternate between them constantly.

Why an anaesthetised animal goes floppy

Even at rest, every muscle carries a small standing tension — **muscle tonus** — and it is not the muscle's own doing. It is maintained by a constant reflex stimulus arriving from the muscle spindles. Anaesthesia interrupts that reflex, which produces a **hypotonus**. The limpness of an anaesthetised patient is the absence of a reflex, not the absence of muscle.

How many joints a muscle crosses, and the trap in it

Muscles are also classified by the number of joints they act on: **uniarticular**, **biarticular** or **polyarticular**. That sounds like bookkeeping and it is not, because it has a direct consequence. If one muscle crosses two joints, then contracting it moves **both** — König calls these **obligatorily linked joints**, as opposed to joints that move together only in particular circumstances, which are **facultatively linked**. It is the reason you cannot always isolate a movement, and the reason a fixator is needed as often as it is.

09 Where a muscle's nerve comes from, and why you can predict it

Innervation is usually taught as a column in a table — muscle, origin, insertion, nerve — which makes it look like a list of arbitrary facts to be memorised. It is not arbitrary. The nerve a muscle has is a consequence of **where that muscle came from in the embryo**, and once you know the four sources the map becomes predictable.

WHICH NERVE

Where the muscle came from

Its embryonic source predicts its nerve.

Epimere → dorsal ramus → epaxial

Hypomere → ventral ramus → hypaxial

Landmark the vertebral transverse processes

Arch 1 → trigeminal → the jaw

Arch 2 → facial → the face and skin

Arches 3, 4, 6 → the pharynx and larynx

Preotic → CN III, IV, VI → the eye

Fig 7 — Where it came from tells you what supplies it. Four rows, four embryonic sources, and each one keeps its nerve for life. That is why the innervation map is learnable rather than arbitrary: a muscle dorsal to the transverse processes is **epaxial** and takes a **dorsal ramus**; one ventral to them is **hypaxial** and takes a **ventral ramus**; the muscles that came from the branchial arches keep the cranial nerve of their arch, which is why the jaw closers are trigeminal and the facial muscles are not; and the eye muscles, which came from neither, have three cranial nerves of their own.

Diagram — Vet-eBooks.com, drawn for this guide. Schematic, not to scale. Data from Sisson S, Grossman JD. The Anatomy of the Domestic Animals, Volume I, 5th ed. W.B. Saunders, pp. 45–46, and König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas, 7th ed. Thieme, p. 44.

Source one and two: the somites, and the line that divides them

The myotome cells of each somite migrate ventrally to form a **myomere**, and each myomere then splits into two: a smaller dorsal ***epimere*** and a ventral ***hypomere***. The epimere goes on to form the **epaxial** muscles — the deep intervertebral muscles and the long muscles of the neck and back. The hypomere forms the **hypaxial** muscles, the deep flexors of the vertebral column, and the muscles of the thoracic and abdominal walls; a ventral extension of it produces the ventral abdominal muscles and the muscles of the limbs.

And here is the payoff, which is worth learning as one sentence: **the epimere's muscles are supplied by the DORSAL ramus of the spinal nerve and the hypomere's by the VENTRAL ramus, and the transverse processes of the vertebrae mark the boundary between the two groups.**

That is a landmark you can put a finger on. Dorsal to the transverse processes: epaxial muscle, dorsal ramus. Ventral to them: hypaxial muscle, ventral ramus — and since the limbs are a ventral extension of the hypomere, limb muscles sit on the ventral-ramus side of that line, which is why the limb plexuses are built out of ventral rami.

Sisson adds a caveat in the very next sentence, and it is worth keeping. The ventral extension of the hypomere produces the ventral abdominal muscles and those of the appendages — but **some of these may develop from regional or local somatic mesoderm** rather than from the hypomere itself. The rule holds; it simply has a footnote, and a student who knows the footnote can defend the rule in front of someone who knows it too.

The rule also splits in a way that makes the intrinsic-and-extrinsic distinction pay for itself. The **extrinsic** muscles of a limb — the ones running from the trunk to the limb, and there are many more of them on the thoracic limb than on the pelvic — are supplied **segmentally**, nerve by nerve, because they are still lying across the segments they grew out of. The **intrinsic** muscles, lying wholly within the limb, take their nerves from the trunks of the **brachial and lumbosacral plexuses** instead. So the distinction is not just descriptive tidiness: it tells you which of the two supply patterns to expect before you look anything up.

Source three: the branchial arches, and why the jaw and the face differ

In the head there are no somites in the usual sense. The muscles there arise instead from mesenchyme in the **branchial arches**, and each arch keeps the cranial nerve it developed with:

Arch 1 gives the muscles that close the jaw, plus the mylohyoideus, the rostral belly of the digastricus and the two tensors — and its motor nerve is the **mandibular branch of the trigeminal**. **Arch 2** gives the stylohyoideus, the occipitohyoideus, the caudal belly of the digastricus and the stapedius, and — as secondary derivatives — the **mimetic muscles of facial expression, including the cutaneous muscles**; its nerve is the **facial nerve**. **Arch 3** gives the stylopharyngeus and some of the pharyngeal constrictors, on the **glossopharyngeal**. **Arches 4 and 6** are supplied by the **vagus and accessory** nerves, the vagus taking the larynx, pharynx, striated oesophagus and most of the soft palate.

That is the answer to a question every student asks. The muscles of mastication are trigeminal and the muscles of facial expression are facial not because someone decided so, but because they are derivatives of two different arches. Two muscle groups lying side by side on the same skull, and their nerves were settled before either group existed. It also explains the digastricus, which is famously supplied by two different cranial nerves — one belly came from each arch.

Source four: the preotic mesoderm, and the muscles of the eye

One group in the head comes from neither the somites of the trunk nor the arches. Sisson notes that some mesoderm of somite origin remains in the head — the **preotic mesoderm** — and it is what the **eye musculature** develops from. Its nerves are the ones that go with it: the **third, fourth and sixth** cranial nerves.

It is worth having as a fourth source rather than an exception, because it is the reason the extraocular muscles do not fit the pattern the rest of the head follows. They are not arch muscles, so they do not take an arch nerve; they have three cranial nerves of their own, which is a fact students are asked for directly and which looks arbitrary until you know where the muscles came from.

The unit of innervation

Below the level of the named nerve is the level that actually does the work. A motor nerve cell branches its axon so that it supplies **many** muscle fibres, each branch ending on one fibre. That cell, its axon and all the fibres it supplies are one **motor unit**. Every muscle fibre is innervated by at least one motor axon, and the contact between them is the ***motor end-plate***, a specialised synapse whose transmitter is acetylcholine.

The size of a motor unit is where the precision comes from. Muscles with **many motor units for a given number of fibres are capable of more precise action**; the large muscles have fewer motor units, each controlling many fibres. A muscle that must be finely graded is wired in small parcels; one that must simply pull hard is wired in large ones. Our guide to upper and lower motor neuron signs follows what happens when that wiring fails.

> **What a muscle does when its nerve is cut**
>
> The muscle atrophies, and the window is not indefinite: **unless the nerve regenerates without great delay, the muscle fibres are replaced by connective tissue**. An actively used muscle is richly supplied with blood vessels; an atrophied one is pale. This is anatomy rather than clinical medicine, but it is the anatomy that decides what a nerve injury costs.

Two smaller facts complete the picture. **Antagonistic muscle groups are usually supplied by different nerves**, even where those nerves arise from the same segments of the spinal cord — which is what makes reciprocal control possible. And the muscle's **blood and lymphatic vessels** carry their own autonomic supply, sympathetic and parasympathetic, keeping the blood supply and drainage matched to what the muscle is doing.

10 Reading a muscle's name

Muscle names look like the worst memorisation task in anatomy, and they are the opposite: they are the most systematic naming in the whole subject. Sisson states the principle plainly — the names **are usually based on some structural or functional feature**, and they are expressed in Latin with the appropriate declension and case endings.

There are **eight** such features — shape, the direction of the fibres, size, position, action, attachment, the number of heads or bellies, and **consistency**, meaning what the muscle is made of, as in *semimembranosus*, half membranous. Almost every muscle in the body is named from one or two of them.

THE NAME TELLS YOU	WORD PIECES TO LOOK FOR	A MUSCLE THAT IS NAMED THAT WAY
Shape	*deltoideus* triangular · *rhomboideus* diamond · *quadratus* square · *teres* round	*M. deltoideus* — named for its triangle, and the name is the shape
Direction of the fibres	*rectus* straight · *obliquus* oblique · *transversus* across	*M. obliquus externus abdominis* — the fibre direction is the name
Size	*major / minor* · *longus / brevis* · *profundus / superficialis*	*M. flexor digitorum profundus* and *superficialis* — the deep and superficial of a pair
Position	*supra-* above · *infra-* below · *inter-* between · *lateralis / medialis*	*M. supraspinatus* and *M. infraspinatus* — above and below the scapular spine
Action	*flexor* · *extensor* · *abductor* · *adductor* · *levator* · *tensor* · *sphincter*	*M. extensor carpi radialis* — action, then what it acts on, then where it lies
Attachment	Two bones, in order: origin then insertion	*M. sternocephalicus* — sternum to head. The name is the attachment
Number of heads or bellies	*biceps / triceps / quadriceps* heads · *digastricus / biventer* two bellies	*M. triceps brachii* — three heads, on the arm
Consistency or make-up	*membranosus* · *fibrosus* · *carnosus*	*M. semimembranosus* — half membranous

Once you know the eight, most names decode on sight. *M. extensor carpi radialis* is action, then the joint it acts on, then which side it lies on. *M. sternocephalicus* is simply its two attachments in order. *M. obliquus externus abdominis* is fibre direction, depth and region. Nothing has to be remembered except the pieces.

Two practical notes. In the **Nomina Anatomica Veterinaria** the muscles are arranged **by region**, not alphabetically and not by function, and the synovial structures associated with muscles and tendons are listed with them — so if you cannot find a muscle in the index, look under where it is. And when a muscle has been substantially modified in one species, the nomenclature deliberately **keeps the basic name** rather than inventing a new one, so that the homology stays visible. Our guide to veterinary anatomy terminology takes the same word-piece method across the rest of anatomy.

11 Where the species differ

Almost everything above holds across the domestic mammals. This section is the part that does not — and each entry is a case where the general plan was **modified by what the animal actually does**, which is the only interesting kind of species difference.

SPECIES	WHAT IS DIFFERENT	AND WHY IT MATTERS
Horse and other ungulates	**The supinators and pronators are absent**, or survive doing a different job as extensors or flexors of the carpus and digits	The power to rotate the forearm has been lost, so the muscles that did it had nothing to do. It is why those two words barely appear in equine anatomy
Horse	The **middle interosseous muscle** — the suspensory ligament — **hardly contains muscle tissue at all** and functions as a tendon	A muscle that became a spring. It stores elastic strain energy as the limb loads and returns it in the second half of the step; under extreme load it stretches until the fetlock touches the ground
Horse, ox, dog	The **interosseous muscles** reduce progressively as the number of digits falls	The polydactyl-to-monodactyl series is visible in one muscle group. As digits go, muscles either disappear or survive as ligaments
All quadrupeds	**No clavicle** — the muscle portions that attach to it in primates are represented in the neighbouring muscles instead	The position of the thoracic limb makes a collar bone unnecessary. The limb is slung in muscle rather than braced by a strut
Grazing animals	**Elastic ligaments** support the head, and assist in supporting the abdominal wall	Holding a heavy head down for hours is a job for elastic tissue, not for muscle that would have to keep contracting

Two opposite processes are at work in that table, and both repay expanding.

A muscle that became a spring

The horse's **middle interosseous muscle** — what everyone calls the suspensory ligament — is described by König as a long fibrous cord that closely resembles a tendon and **in fact hardly contains muscle tissue at all**. It functions as a tendon, and specifically as a spring: as the limb takes weight it is stretched and **stores the energy as elastic strain energy**; in the second half of the step, as the load comes off, it shortens and gives that energy back. Under an extreme load it can stretch far enough that the fetlock touches the ground with each stride. Our guide to the horse's hoof and distal limb covers the apparatus this sits at the top of.

That is a muscle whose contractile tissue was traded away for elastic tissue, because in a standing, walking, grazing animal a spring is worth more than a motor.

Muscles that were made redundant

Three of the other rows are one story told at three stages, and the story is short: **a muscle survives as long as there is work for it.** Take the work away — the digits it moved, the rotation it produced, the strut it attached to — and the muscle does not simply persist unchanged. It is lost, reduced to a ligament, or left doing a different job under the same name.

The **interossei** are the clearest case, because one muscle group shows all of it at once. Follow them from the dog to the ox to the horse and you are watching the same muscles disappear or turn into ligaments in step with the toes they used to move. Sisson illustrates the whole series in one figure.

Then there is a fourth outcome, and it is the reverse of a muscle being lost: the job is handed to tissue that never has to contract. Holding a grazing animal's head down, hour after hour, is work for **elastic ligaments**, because a muscle doing it would have to keep contracting for as long as the animal keeps eating. Our comparative anatomy guide and our guide to the horse's bones, muscles and landmarks carry these differences further into the species that show them.

A general point comes out of them, and Sisson states it as a list rather than leaving it to be inferred. Turning the embryonic muscle sheets into an adult animal's muscles can involve **a change in the direction of the fibres within a myomere, longitudinal splitting, tangential splitting, fusion of portions, migration of primordia, or degeneration of muscle parts to be replaced by connective tissue**. The four species differences above are that list at work: the ungulate supinators are a muscle left doing another job, the interossei are degeneration and replacement, the suspensory ligament is replacement by elastic tissue, and the primate clavicular muscles are portions that migrated into their neighbours.

Which is the thing to take from this page as a whole: **a muscle is not a fixed part inherited unchanged.** The name stays, so that the homology stays visible; the tissue does what the animal needs.

12 Test yourself

Forty-seven questions across every section above. Cover the answers first — looking at an answer is not the same as retrieving it, and only one of the two is revision.

1 **What is myology, and what does it call the skeletal musculature?**

> ANSWER Myology (*myologia*) is the branch of anatomy dealing with the muscles. König calls the skeletal musculature **the active part of the locomotor system** — bones and joints being the passive part, which do nothing until something pulls on them.

2 **Muscle tissue converts chemical energy into what? Name both outputs.**

> ANSWER Into **mechanical energy** and into **heat**. The second is easy to forget and matters clinically: shivering is a muscle doing its other job.

3 **Name the three kinds of muscle tissue on the two axes that separate them.**

> ANSWER **Smooth** — non-striated, involuntary. **Cardiac** — striated, involuntary. **Skeletal** — striated, voluntary. There is no fourth box, because there is no non-striated voluntary muscle.

4 **Two textbooks count the muscle types differently. How, and does it matter?**

> ANSWER **Sisson & Grossman** gives a flat three, side by side. **König** gives **two** — smooth and striated — with striated then splitting into skeletal and cardiac. It matters a little: König's version says cardiac muscle is a *kind of* striated muscle, which is the more useful fact when you meet cross-striations on a slide.

5 **Describe smooth muscle: its cells, where it is, and how it contracts.**

ANSWER Masses of **spindle-shaped cells** in the walls of hollow organs and blood vessels, and in certain glands, the spleen, the eyeball and the hair follicles. Its contractions are **weak but sustained**, and in most places rhythmic. It is not under the control of the will.

6 **How big is a skeletal muscle cell, and why is it called a fibre?**

ANSWER About **10–100 μm in diameter and 5–10 cm long** — long enough to be **visible to the naked eye** when teased apart, which is why its size and shape earned it the name fibre rather than cell. Each carries up to several hundred nuclei, pushed out to the edge of the cell.

7 **Name the three connective-tissue sheaths of a skeletal muscle, outermost first — and then say the thing that actually matters about them.**

ANSWER **Epimysium** around the whole muscle, **perimysium** around each bundle (*fasciculus*), **endomysium** around each single fibre. And the point: at each end of the belly those three **merge and continue as the tendon**. The sheaths are not wrapping around the meat — they are the beginning of the tendon, running all the way in.

8 **Trace the fibrous continuity from a single muscle cell to the surface of a bone.**

ANSWER Endomysium → perimysium → epimysium → they merge at the end of the belly and become the **tendon** → the epimysium continues over it as the **epitendineum** → at the attachment the tendon fibres run on into the periosteum or perichondrium as **Sharpey fibres**. One uninterrupted system: a muscle does not attach to a skeleton, a muscle and its skeleton are continuous.

9 **Two textbooks fifty years apart disagree about this. Does skeletal muscle regenerate?**

ANSWER **Sisson & Grossman (1975)**: new skeletal muscle fibres are **not** formed after birth, and destroyed muscle is repaired by connective tissue. **König (7th ed.)**: a number of stem cells remain in the muscle for life as **satellite cells**, and regeneration depends on how many survive undamaged. **The second is the current account and the one to learn** — the first is a textbook written before satellite-cell biology existed. Both are reliable on structure.

10 **How does a muscle get bigger?**

ANSWER By **enlarging the fibres it already has**, which enlarge further with exercise. Body weight can also rise by fat being deposited within and between the fibres, which is a different thing wearing the same outline.

11 **The two-sentence principle the whole of muscle architecture rests on. State it.**

ANSWER The **shortening** a muscle can show on contraction — about 50%% — is a function of the **length of its fibres**. The **power** it can develop is a function of the **aggregate of their cross-sectional areas**. In a belly of fixed size those two demands compete directly, which is why there is more than one muscle shape.

12 **By how much can a single muscle fibre shorten?**

ANSWER To **one-third to one-half** of its own length, contracting fully. That is the ceiling, so a muscle can only travel further by having **longer** fibres — not by trying harder.

13 **What lies inside a single muscle fibre, and where does myology hand over to physiology?**

ANSWER Longitudinally arranged **myofibrils**, sitting in a matrix of **sarcoplasm** and bounded by the fibre's own membrane, the **sarcolemma**. The myofibril is the hand-over point: what happens inside it — actin, myosin, the cross-bridge cycle — is physiology.

14 **Give the two names for each fibre type that an examiner is likely to use.**

ANSWER **Slow-twitch** = red = dark = oxidative = sustained. **Fast-twitch** = white = pale = glycolytic = burst. Most muscles are a **mixture** of the two in varying proportions, which is why the two-type scheme is a convenient simplification rather than a fact.

15 **What is a retinaculum, and what does it do?**

ANSWER Where a tendon crosses the extensor or flexor surface of a joint, the deep fascia thickens into a **ring-like band** that the tendon passes under — König's *retinacula tendinum*. It holds the tendon down against the joint it crosses and, in doing so, **strengthens the joint itself**. Dyce's Fig. 1.28 draws one, with the tendon running over the bone and under the retinaculum inside its sheath.

16 **Distinguish an intrinsic from an extrinsic muscle.**

ANSWER An **intrinsic** muscle lies wholly within the region it moves. An **extrinsic** muscle lies partly outside that region and connects it to the trunk. In a limb the extrinsic muscles are how the limb is attached at all; the intrinsic ones are how it is used once attached.

17 **Name the five fibre arrangements, and say what the sequence is trading.**

ANSWER **Parallel** (the strap muscle), **fusiform**, **unipennate**, **bipennate**, **multipennate**. Left to right the fibres get shorter and more numerous, so the muscle trades **travel for force**: the strap muscle produces the greatest displacement and the least force, the multipennate the most force for its bulk and the least travel.

18 **What does pennation cost, in one word, and what follows from it?**

ANSWER **Cosine.** A fibre meeting the tendon at an angle contributes only the cosine of that angle to the pull along the tendon, so a pennate muscle wastes a proportion of its strength and its potential displacement. What follows is a measurement rule: force is predicted by the **physiologic** cross-section — the complex plane cutting every fibre transversely — not by the **anatomic** one that slices the belly at its thickest point.

19 **Why is a horse's forelimb heavy at the top and almost all tendon at the bottom?**

ANSWER Because pennate bellies produce their force in a small bulk, so they can be **placed close to the trunk**, and only the light tendons need to run down to operate the joints. **Less energy is required to swing the limb to and fro.** A limb with its muscle mass at the bottom would cost the animal on every stride.

20 **Distinguish a digastric muscle from a biceps.**

ANSWER Different things are being counted. **Biceps** counts **heads** — two separate origins joining a common tendon (triceps three, quadriceps four). **Digastric** counts **bellies** — two fleshy units separated by an intermediate tendon. A muscle can be both.

21 **What is an articular muscle for?**

ANSWER To keep the **synovial membrane from being caught** between the articulating surfaces as the joint closes. A small muscle attaching to the joint capsule, with a job nobody guesses.

22 **Give the standard mapping of red and white muscle — and say why the chicken settles it.**

ANSWER **Red (dark) muscle is slow, oxidative and built for sustained work; white (pale) muscle is fast, glycolytic and built for a short burst.** The colour is **myoglobin**. The chicken settles it without a textbook: the **pale breast** is the burst muscle of a bird that barely flies, and the **dark leg** is the one holding it up all day. Sisson adds the veterinary form of the rule — muscles that support the body in a standing position tend to have a preponderance of dark fibres.

23 **Why should you not present the two fibre types as a clean dichotomy?**

ANSWER Because the source that sets it out says not to. Dyce writes that there are many other structural and physiological differences between fibres, and that **the suggestion that there are only these two, sharply distinguished varieties, although convenient, is a misleading simplification**. Real muscles are mixtures in varying proportions.

24 **Define origin and insertion — and then give the qualification that matters.**

ANSWER The attachment that **stays more still** during the movement is the origin; the other is the insertion. In a limb the proximal attachment is called the origin and the distal one the insertion. The qualification is König's, and it is easy to read past: **origin and insertion are assigned by convention**. It is a naming rule, not a measurement of what moved.

25 **The one that separates a memorised answer from an understood one: the biceps femoris flexes the stifle. When does it extend it?**

> ANSWER **When the foot is planted firmly on the ground.** With the limb lifted it extends the hip, flexes the stifle and extends the hock; plant the foot and the same muscle becomes an **extensor of the stifle**. Nothing about the muscle changed — what changed was which end was free to move. A muscle's action is a result of the muscle, the joint and **what is currently fixed**, which is why the Action column of any attachment table is the usual case and not a law.

26 **What are the *punctum fixum* and *punctum mobile*, and why learn them as well?**

> ANSWER The **fixed point** is whichever end is held immobile by its attachment to the trunk; the **moving point** is the other, and must be the smaller and lighter of the two. They are worth learning alongside origin and insertion because **they describe what actually happens in a given movement** and can swap between one movement and the next, while the labels origin and insertion stay where the textbook put them.

27 **Do all muscles insert on bone?**

> ANSWER No, and one textbook overstates this. König writes that the ends of a muscle **always** insert in bone or cartilage; Sisson names the exceptions. Some muscles attach to their opposite numbers across the midline — in the **abdominal wall**, the **diaphragm** and the **pharynx** — and others attach to connective tissue inside a soft structure such as the cheek, which becomes rigid when they contract.

28 **A tendon attaches close to the proximal end of the next bone. What does that buy, and what does it cost?**

> ANSWER It buys a **rapid and extensive excursion** of that bone's far end. An insertion further down and spread over a greater area gives a movement that is **more powerful but slower and less extensive**. Sisson's summary: muscles with broad attachments and a short origin-to-insertion distance are **adapted for strength at the expense of speed and range** — the same trade as pennation, made at the skeleton instead of inside the belly.

29 **Distinguish a synovial bursa from a synovial tendon sheath.**

> ANSWER Geometry. A **bursa** is a flattened closed sac sitting *between* a tendon and whatever it rubs against. A **sheath** is the same sac **wrapped right around the tendon to make a tube** — so it has a parietal layer outside, a visceral layer against the tendon, and a double fold joining the two, the **mesotendon**, which carries the tendon's blood supply in. Where movement and pressure are greatest the mesotendon thins away or survives only as threads, the *vincula*.

30 **What are sesamoid bones for?**

> ANSWER Two things: they **glide in grooves over prominences to change the direction of the tendon's pull**, and they protect the tendon where it is pressed against bone. Miller and Evans call the patella **the largest sesamoid bone in the body** — a dog book's claim, so say it as they say it rather than as a survey of the species.

31 **Why do tendons heal so badly at some points along their length?**

> ANSWER Because of where the blood is. Fine vessels reach a tendon through the **paratendon** around it and the **endotendon** between its strands — but **at friction points, where the tendon has become cartilage-like, virtually no blood vessels exist**.

32 **Name the four jobs a muscle can have in a single movement, and say what a fixator does.**

> ANSWER **Prime mover** (agonist) produces the movement; **antagonist** opposes and therefore controls it; **synergist** adds to the pull or cancels an unwanted second action; **fixator** holds **another** joint still so the pull is spent where it is wanted. Sisson's rule of thumb: **the smaller muscles around a joint usually act in fixation**.

33 **Why do the words *agonist* and *antagonist* need care on a veterinary site?**

> ANSWER Because they mean two unrelated things. In pharmacology an agonist activates a receptor and an antagonist blocks it. In myology the agonist is the muscle that **produces** a movement and the antagonist the muscle that **opposes** it — no receptors involved. The two senses share nothing but the Greek.

34 **Distinguish isometric from isotonic contraction.**

> ANSWER **Isometric**: tension rises with **no change in the muscle's length** — what a postural muscle does all day, and what happens in the moment before a limb moves. **Isotonic**: the tension is high enough that the muscle **shortens**, and movement results. Real movements alternate between them constantly.

35 **Why does an anaesthetised animal go floppy?**

ANSWER Because muscle tonus is not the muscle's own doing. Even at rest every muscle carries a small standing tension maintained by a **constant reflex stimulus arriving from the muscle spindles**. Anaesthesia interrupts that reflex and produces a **hypotonus**. The limpness is the absence of a reflex, not the absence of muscle.

36 **What are obligatorily linked joints, and what causes them?**

ANSWER Joints that are **always moved together** when one muscle contracts — caused by that muscle crossing both of them (a biarticular or polyarticular muscle). Joints that move together only in particular circumstances are **facultatively** linked. It is why you cannot always isolate a movement, and why fixators are needed as often as they are.

37 **The single most useful fact in this article. How do you predict which ramus supplies a trunk muscle?**

ANSWER By which side of the **vertebral transverse processes** it lies on. Each myomere splits into a dorsal **epimere** and a ventral **hypomere**; the epimere's muscles are supplied by the **dorsal ramus** and the hypomere's by the **ventral ramus**, and the **transverse processes mark the boundary**. Dorsal to them: epaxial, dorsal ramus. Ventral to them: hypaxial, ventral ramus — and because the limbs are a ventral extension of the hypomere, limb muscles sit on the ventral-ramus side, which is why limb plexuses are built from ventral rami. Sisson's caveat goes with it: **some** of those ventral muscles may develop from local somatic mesoderm rather than from the hypomere itself.

38 **Why are the muscles of mastication trigeminal and the muscles of facial expression facial?**

ANSWER Because they came from **different branchial arches**, and each arch keeps the cranial nerve it developed with. **Arch 1** gives the jaw closers, the mylohyoideus, the rostral belly of the digastricus and the tensors — nerve: the **mandibular branch of the trigeminal**. **Arch 2** gives the stylohyoideus, the caudal belly of the digastricus, the stapedius and the **mimetic muscles including the cutaneous muscles** — nerve: the **facial**. It also explains the digastricus having two different nerves: one belly came from each arch.

39 **What is a motor unit, and what does its size determine?**

ANSWER A motor nerve cell, its axon and **all the muscle fibres that axon supplies**. Its size determines precision: muscles with **many motor units for a given number of fibres are capable of more precise action**, while large muscles have fewer units each controlling many fibres. Fine control is wired in small parcels; brute pull in large ones.

40 **What happens to a muscle whose nerve is cut, and what is the deadline?**

ANSWER It atrophies — and the window is not indefinite. **Unless the nerve regenerates without great delay, the muscle fibres are replaced by connective tissue.** An actively used muscle is richly supplied with blood vessels; an atrophied one is pale.

41 **Name the eight features a muscle can be named after.**

ANSWER **Shape** (deltoideus), **direction of the fibres** (obliquus), **size** (longus, profundus), **position** (supraspinatus), **action** (extensor), **attachment** (sternocephalicus), **number of heads or bellies** (triceps, digastricus) and **consistency or make-up** (semimembranosus). Almost every muscle uses one or two of them, in Latin with the appropriate case endings.

42 **Decode *M. extensor carpi radialis* and *M. sternocephalicus* without looking either up.**

ANSWER *Extensor carpi radialis* = the **action** (extensor), the **joint it acts on** (the carpus), and **where it lies** (the radial side). *Sternocephalicus* = its two **attachments** in order — sternum to head. The name is the muscle's job description.

43 **How are muscles arranged in the Nomina Anatomica Veterinaria, and what else is listed with them?**

ANSWER **By region** — not alphabetically and not by function — and the **synovial structures associated with muscles and tendons** are included alongside them. If you cannot find a muscle in the index, look under where it is.

44 **Why are the supinators and pronators absent in ungulates?**

ANSWER Because the power to **rotate the forearm** has been lost, so the muscles that produced the rotation had nothing left to do. They are absent, or survive doing a different job as extensors or flexors of the carpus and digits. It is why those two words barely appear in equine anatomy.

45 **The horse's suspensory ligament is called the middle interosseous *muscle*. Why, and what does it do?**

> ANSWER Because that is what it is, developmentally — but König notes it **hardly contains muscle tissue at all** and functions as a tendon. Specifically as a spring: it is stretched as the limb loads, **stores the energy as elastic strain energy**, and returns it in the second half of the step. Under extreme load it stretches until the fetlock touches the ground with each stride. A muscle that traded its motor for a spring.

46 **Why has a quadruped no clavicle?**

> ANSWER Because **the position of the thoracic limb makes one unnecessary** — the limb is slung from the trunk in muscle rather than braced against it by a strut. The muscle portions that attach to the clavicle in primates are simply represented in the neighbouring muscles instead.

47 **Give two ways a muscle can be lost or repurposed as a species changes.**

> ANSWER **Replaced by connective tissue:** as the number of digits falls from the polydactyl towards the monodactyl state, the muscles that moved the missing digits **disappear or survive as ligaments** — the interossei of horse, ox and dog are one group at three stages. **Or left doing another job:** the ungulate supinators and pronators. In grazing animals the postural job of holding the head down is given to **elastic ligaments** instead of to muscle that would have to keep contracting.

13 Veterinary Myology — frequently asked questions

What is myology in veterinary anatomy?

Myology (*myologia*) is the branch of anatomy that deals with the muscles — their structure, their shapes, their attachments, what they do and how they are supplied. König describes the skeletal musculature as **the active part of the locomotor system**: the bones and joints are levers and hinges that do nothing until something pulls on them. It is the general half of the subject — the principles that hold across the domestic species — while the named muscles of a particular animal belong to that animal's own page.

What are the three types of muscle in animals?

Smooth muscle: non-striated and involuntary, in the walls of hollow organs and blood vessels, in certain glands, the spleen, the eyeball and the hair follicles, contracting weakly but in a sustained and usually rhythmic way. **Cardiac** muscle: striated and involuntary, in the heart wall only, with the ends of some fibres contacting the sides of others. **Skeletal** muscle: striated and voluntary, built of multinucleated fibres, and accounting for about half the weight of a carcass. Note that König counts these as **two** classes rather than three — smooth and striated, with striated splitting into skeletal and cardiac.

What is the difference between the origin and the insertion of a muscle?

The rule you are taught first is functional: the attachment that **stays more still** during the movement is the origin, and the one that moves is the insertion. In a limb there is a shortcut — proximal is the origin, distal the insertion. But König adds the qualification that matters: **origin and insertion are assigned by convention**. It is a naming rule, not a measurement. The proof is the biceps femoris, which flexes the stifle when the foot is off the ground and **extends** it when the foot is planted — the muscle did not change, only which end was free to move.

What is a pennate muscle, and why does it matter?

A muscle whose fibres meet the tendon **at an angle** rather than running along it — unipennate from one side of the tendon, bipennate from both, multipennate onto several tendon sheets at once. It matters because it is a trade. Angling the fibres packs far more of them into the same bulk, so the muscle is **strong in relation to its size**; but each fibre is shorter, so the muscle travels less, and only the **cosine** of the fibre angle pulls along the tendon, so some of the strength is spent sideways. It is also why the force a muscle can produce is predicted by its **physiologic** cross-section — the plane cutting every fibre transversely — and not by a simple slice through the belly.

What is the difference between a bursa and a tendon sheath?

Both are synovial sacs that stop a tendon being damaged by what it rubs against, and the difference is geometry. A **synovial bursa** is a flattened closed sac lying *between* the tendon and the structure beneath it. A **synovial tendon sheath** is the same sac **wrapped right around the tendon to make a tube**: it has a parietal layer on the outside, a visceral layer against the tendon, and a double fold joining the two called the **mesotendon**, which carries the tendon's blood supply.

How are muscles named in veterinary anatomy?

Systematically, and from only **eight** features, in Latin with the appropriate case endings: **shape**, **fibre direction**, **size**, **position**, **action**, **attachment**, **number of heads or bellies**, and **consistency**. So *M. sternocephalicus* is simply its two attachments in order — sternum to head. Almost every muscle uses one or two of the eight, which is why the names decode on sight.

Sources

1. Sisson S, Grossman JD. *The Anatomy of the Domestic Animals*, Volume I, 5th ed. W.B. Saunders. The primary source, and almost all of it from one chapter: **chapter 4, General Myology**, by L. E. St. Clair, printed pp. 39–46. The three muscle types and the connective-tissue sheaths (p. 39); fibre growth, denervation atrophy and the 1975 position on regeneration (p. 40); the fibre arrangements, the motor unit and the one-third-to-one-half shortening (p. 41); origin and insertion, the biceps femoris reversal, the functional roles and the leverage trade (p. 42); bursae, tendon sheaths, the mesotendon, sesamoid bones, fascia and the aponeurosis (p. 43); the eight naming rules and the ungulate supinators (p. 44); the epimere/hypomere and dorsal/ventral ramus rule and the interossei series (p. 45); and the branchial arches with their cranial nerves (p. 46). Figure 3 is Fig. 4–2.
2. König HE, Liebich H-G. *Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas*, 7th ed. Thieme. §1.4.2 "Muscular system", pp. 43–47: the branch as the active part of the locomotor system and the two-class scheme (p. 43); satellite cells, the motor end-plate, the autonomic supply to intramuscular vessels and the epitendineum (p. 44); Sharpey fibres, the physiological cross-section, the forms of muscle and the horse's middle interosseous muscle (p. 46); and origin and insertion as a convention, *punctum fixum* and *punctum mobile*, muscle tonus and anaesthetic hypotonus, isometric and isotonic contraction, and the uni-, bi- and polyarticular classification (p. 47). The accessory structures continue on pp. 50–51, which is where the *retinacula tendinum* are described as ring-like thickenings of fascia over the extensor and flexor surfaces of a joint. Figure 5 is Fig. 1.39.
3. Dyce KM, Sack WO, Wensing CJG. *Textbook of Veterinary Anatomy*, 5th ed. Saunders/Elsevier. "The Organization of Skeletal Muscles" and "Variations in Muscle Architecture", pp. 57–58: skeletal muscle as about half a carcass, cell dimensions and the three sheaths merging into the tendon (p. 57); the two principles of architecture, the cosine loss, the anatomic-versus-physiologic cross-section, why limb muscles are pennate on long tendons, the raphe, aponeuroses and the fibre-type hedge (p. 58). ⚠️ One sentence on p. 58 does double duty here: it is where the **slow-twitch** and **fast-twitch** names come from, and it is also the sentence that reverses the colours, saying fast-twitch fibres predominate in dark muscle. The article takes the two names from it and the colour mapping from Sisson and König, and says so where it does. Figure 2 is Fig. 1.26.
4. *Veterinary Anatomy: The Regional Gross Anatomy of Domestic Animals.* Consulted for the classical treatment of the muscular system and for its handling of the attachment vocabulary, as a cross-check on Sisson's general chapter.
5. Constantinescu GM. *Illustrated Veterinary Anatomical Nomenclature*, 4th rev. ed. Thieme. The naming authority for the branch. The Latin used on this page — *myologia*, *m. fusiformis*, *m. unipennatus*, *m. bipennatus*, *m. multipennatus*, *m. biventer*, *punctum fixum* — is checked against it, as is the region-by-region arrangement described in the naming section.
6. Dellmann H-D, Eurell J. *Dellmann's Textbook of Veterinary Histology*, 6th ed. Blackwell, and *Color Atlas of Veterinary Histology*, 3rd ed. Consulted on the microscopic structure of muscle tissue and of the endomysium, perimysium and epimysium, which the gross textbooks treat in a paragraph.
7. Evans HE, de Lahunta A. *Miller and Evans' Anatomy of the Dog*, 5th ed. Saunders/Elsevier. A **dog** text, used here for one claim only and stated as it states it: *the patella is the largest sesamoid bone in the body* (p. 347). None of the cross-species books above makes that comparison, so this page does not present it as one.

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