VETERINARY · ILLUSTRATED GUIDE

VETERINARY ARTHROLOGY NOTES

Veterinary Arthrology Notes: Classify Any Joint, Name Its Movement (PDF)

Arthrology — also called syndesmology — is the anatomy of the joints, and it covers every junction between two skeletal elements, including the ones that do not move.

Contents

The 11 sections of this guide, in order.

IN SHORT

Arthrology — also called syndesmology — is the anatomy of the joints, and it covers every junction between two skeletal elements, including the ones that do not move. These veterinary arthrology notes are the general plan rather than a tour of named joints: the single question the whole classification turns on, the joints that have no cavity at all, the two classification axes and the one term the textbooks genuinely disagree about, everything a synovial joint is built from, why articular cartilage is the part that does not recover, the seven joint shapes with a named example of each, the movement vocabulary in full, the four separate things that stop a joint moving, and where the domestic species part company.

KEY POINTS

1. **The whole classification turns on one question.** König puts it in a sentence worth learning: the degree of mobility between two bones “depends entirely on the form of the gap between them”. Either there is a cavity or there is not.
2. **A joint does not have to move.** Skull sutures, tooth sockets and the horse's fused radius and ulna are all joints. Arthrology is the study of junctions, not of moving parts.
3. **Joints are sorted along two axes, and they do not quite line up.** By tissue: fibrous, cartilaginous, synovial. By mobility: synarthrosis, amphiarthrosis, diarthrosis. *Amphiarthrosis* is the term to define before you use it.
4. **Every synovial joint has exactly three things** — a capsule, a cavity containing synovia, and hyaline articular cartilage. Menisci, discs, labra, fat pads and intracapsular ligaments are additions that some joints have and others do not.
5. **The capsule's outer layer explains two clinical facts at once.** Its blood supply is limited, so it heals slowly; it is richly supplied with sensory fibres, so a stretched or injured capsule hurts. The cartilage has no nerve supply at all.
6. **Articular cartilage is avascular, alymphatic and aneural.** It is fed **for the most part by diffusion** — the synovia and the marrow vessels are both secondary routes — its metabolism is anaerobic, and it is lubricated and nourished by water being squeezed out of it and drawn back in as the joint is loaded.
7. **A degree of incongruence is required.** Perfectly matching surfaces would squeeze out the wedge of synovia between them — which is exactly what happens at the limit of the range, and is one of the four things that stop a joint moving.
8. **Shape is a permission, not a prediction.** The shoulder is spheroidal, but in domestic species it is used almost entirely for flexion and extension. Dyce warns that real joints “correspond very imperfectly to the theoretical models”.

About the images

Three figures are reproduced for educational reference: two from König and Liebich's *Veterinary Anatomy of Domestic Animals*, 7th ed. (Figs. 1.30 and 1.33) and one from Dyce, Sack and Wensing's *Textbook of Veterinary Anatomy*, 5th ed. (Fig. 1.25). 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 arthrology is, and what it is not

Arthrology is the part of anatomy that deals with the joints — every place where two skeletal elements meet. The formal name is *arthrologia*, from the Greek *arthron*, a joint; the same branch is also called **syndesmology**, from *syndesmos*, a binding, and you will meet that name in Sisson & Grossman and in most of the older literature. They are two names for one subject, and neither is more correct than the other.

The definition is broader than it first sounds, because a joint does not have to move. The sutures of the skull are joints. So is the socket a tooth sits in, and so is the fused union between the horse's radius and ulna, which cannot move at all and has turned to bone. Arthrology is not the study of moving parts; it is the study of **junctions**, and of what each junction is made of.

THE BRANCH

Arthrology is the normal joint

Also called syndesmology. One branch, with edges.

THIS PAGE OWNS	AND HANDS ON
How joints are classified	Joint disease and arthritis
What a synovial joint holds	Arthroscopy and surgery
The seven shapes	The stifle, carpus, hock
Flexion and abduction	Bone and the skeleton
Where the species differ	How a muscle contracts

Fig 1 — One branch, and where its edges are. Arthrology is the anatomy of the **normal** joint. Its edges matter more here than on most branches, because the neighbouring subject is not a different region of the body but a different kind of knowledge: joint disease, arthroscopy and joint surgery are clinical subjects with clinical books. What this page owns is the plan every joint follows.

Diagram — Vet-eBooks.com, drawn for this guide. Data from Veterinary Anatomy: The Regional Gross Anatomy of Domestic Animals, pp. 15–19, and König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas, 7th ed. Thieme, §1.4, pp. 37–41.

This page teaches the branch as our veterinary anatomy notes sets it out: the classification, the structure of a synovial joint, the shapes joint surfaces take, the movement vocabulary, what limits a movement, and where the domestic species differ. It does not teach joint disease. Arthritis, arthroscopy, joint injection and joint surgery are clinical subjects with clinical books, and the anatomy here is the normal anatomy those books assume you already have. The only place a clinical fact appears below is where a piece of *structure* explains a sign — why a distended joint hurts, why a capsular injury is slow to heal — and in each case the structure is the point.

Two other fences are worth stating at the start, because they are what stops this page becoming a textbook. Individual named joints — the stifle, the carpus, the hock, the fetlock — belong to the pages that teach those regions and those species. And the muscles that produce a movement belong to myology: this page names the movement a joint *permits*, not the muscle that *produces* it.

02 Everything follows from the gap

König and Liebich open their arthrology chapter with a sentence that organises the entire branch, and it is worth learning in the form they wrote it:

"The degree of mobility between two bones or cartilage structures depends entirely on the form of the gap between them."

That is the whole classification in one line. Two bones meeting can be arranged in only two fundamentally different ways. Either there is **no gap** — the tissue runs continuously from one bone into the other, and the two are bridged rather than separated — or there **is** one, a real space, filled with fluid, with the two bone ends free to move against each other across it.

The first arrangement is a **synarthrosis**: a continuous structure connecting two adjacent bones. The second is a **diarthrosis**: a joint containing a gap, that gap being a joint cavity filled with synovia. Every other name in this article is a subdivision of one or the other.

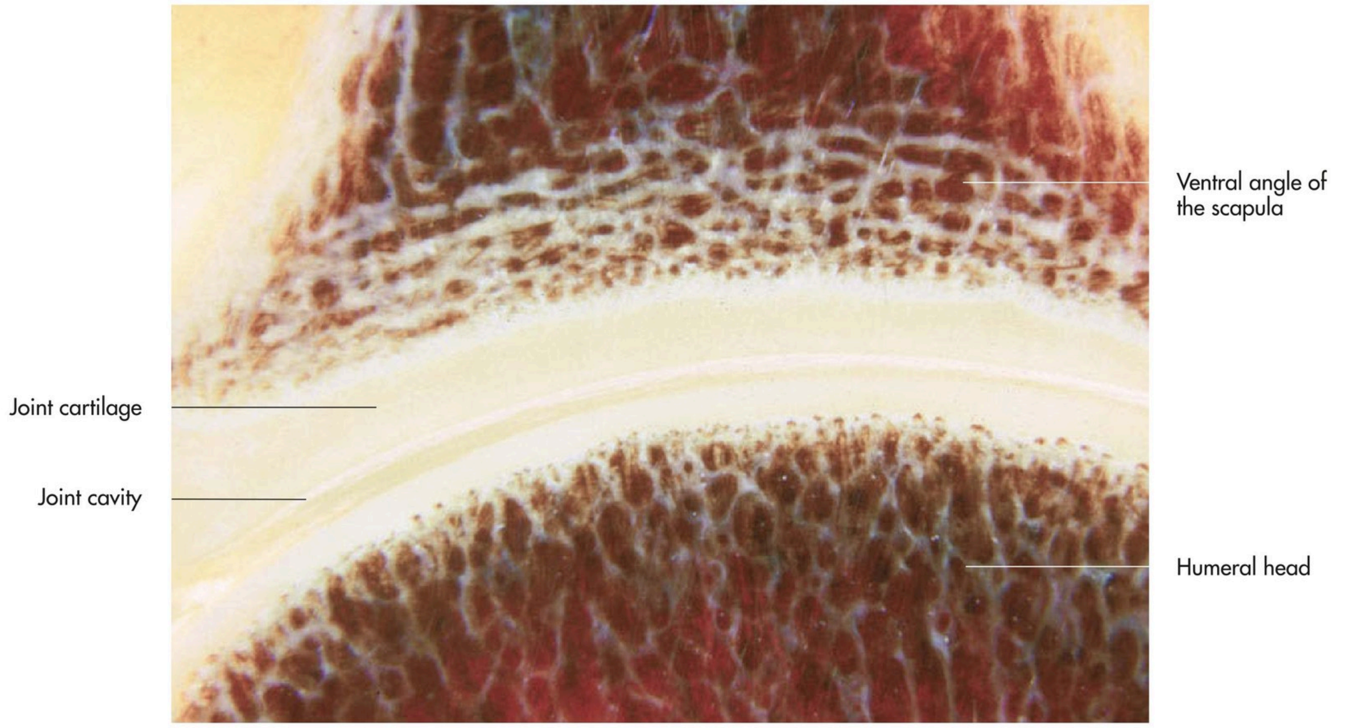

Fig 2 — A joint gap, in a real specimen. A plastinated longitudinal section of a dog's shoulder. The **ventral angle of the scapula** is above and the **humeral head** below; the two pale bands are the **joint cartilage** covering each bone end, and the narrow dark line between them is the **joint cavity** itself. This is what the whole classification below turns on — whether that line is there or not. Note also how thin the cartilage is against the depth of red marrow behind it.

Image — König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas, 7th ed. Thieme — Fig. 1.30, joint gap formed by the ends of the scapula and humerus in the dog, longitudinal section, plastination. Reproduced for educational reference.

Figure 2 is worth more than a glance, because it is a real specimen rather than a diagram. It is a longitudinal section through a dog's shoulder, prepared by plastination, and it shows the thing the sentence above is about. The two pale bands are the articular cartilage on the scapula and on the humeral head. Between them is a narrow dark line, and that line is the entire reason the shoulder is a different kind of joint from the sutures in the skull above it. Notice how thin the cartilage is: a layer perhaps a millimetre or two deep, sitting on a great depth of red marrow, and carrying the whole load of the limb.

Once you have that image, the rest of the classification is bookkeeping. The sections that follow work outwards from it: first the joints with no gap, then the argument about what to call them, then everything that is built around a gap when there is one.

03 The joints that have no gap

Where there is no joint cavity, the two bones are joined by tissue that runs continuously between them — and the tissue is what gives the joint its name. There are three possibilities and they form a natural sequence: **fibrous** tissue, **cartilage**, or **bone**.

One structural point applies to all of them, and it is easy to miss because it is a negative: there is no capsule, and the fibrous layer of the periosteum **runs continuously over the joint** from one bone onto the next. In a synovial joint the periosteum stops at the edge of the articular cartilage. In a fibrous joint it does not stop at all.

Fibrous unions

The fibrous unions — *juncturae fibrosae* — are joined by collagenous connective tissue, and they subdivide into three.

A **syndesmosis** holds two bones apart at some distance and joins them across the gap with connective tissue — white fibrous tissue, elastic tissue, or a mixture of the two. Two domestic examples, from two different textbooks. The **intermetacarpal joint**, between the metacarpal bones themselves. And the **dew claws of the ox**, attached to the metapodium — the cannon region, the metacarpus in the forelimb and the metatarsus in the hind — by exactly this kind of union.

A **suture** is the special case that exists only between the bones of the skull, where a thin layer of fibrous tissue separates two plates. Sutures come in named varieties according to how the opposing edges are cut — *sutura serrata*, where the margins interlock like the teeth of a saw, as at the interfrontal suture; *sutura squamosa*, where the two edges are bevelled and overlap, as where the temporal meets the parietal; *sutura plana* or *harmonia*, where two plain surfaces simply abut, as at the internasal suture; and *sutura foliata*, where the edge of one bone fits into a fissure in the edge of the bone opposite. If you have looked at our guide to the canine skull and dental anatomy you have seen all four on one specimen.

A **gomphosis** is a peg driven into a socket and held there by fibrous tissue: a tooth in its alveolus, held by the **periodontal membrane**. It is the only joint in the body in which one of the two elements is not a bone.

Cartilaginous unions

Where the bridging tissue is cartilage, the kind of cartilage decides the name. A **synchondrosis** is bridged by **hyaline** cartilage, and it is characteristically **temporary**: the cartilage turns to bone before the animal reaches maturity. The epiphyseal plates are the example every student already knows under a different name, and the junction between the basioccipital and basisphenoid bones is another.

Two qualifications, because the sources hedge here and a revision page should not flatten them. The first is timing: **most** synchondroses are fused by the time bone growth ceases — *most*, not all. The second is scope: König's own example of a synchondrosis is neither of the two above but the union **between the base of the skull and the hyoid bone**, which is not a growth plate and does not follow a growth plate's timetable. A synchondrosis usually has an expiry date; the category is wider than the growth plates.

A **symphysis** is bridged by **fibrocartilage**, and it is usually found on a median plane: the pelvic symphysis, the mandibular symphysis. Fibrocartilage is tougher and slightly yielding, which is why a symphysis behaves differently from a synchondrosis even though both are cartilaginous.

> **A word to use carefully**
>
> The older texts call cartilaginous joints **immovable**, and then, a sentence later, allow them "a kind of flexibility". Both statements are in the same book. The accurate word for a symphysis is **slightly movable**: the pelvic symphysis of a bitch near parturition is not doing nothing. Where a source says *immovable*, treat it as shorthand for *no joint cavity* rather than as a measurement.

Bony union

A **synostosis** is the end state: the connecting tissue has been replaced by bone, and the two elements are now one. Every ossified suture in an adult skull is a synostosis, and so is the fused **radius and ulna of the horse** — a fact with a consequence worth carrying, since it is why the equine forelimb has no functional supination or pronation and why those two words barely appear in equine anatomy.

JOINT	WHAT JOINS THE BONES	A VETERINARY EXAMPLE	PERMANENT?
Syndesmosis *junctura fibrosa*	Collagenous connective tissue, the two bones held apart at a distance	The **dew claws of the ox**, attached to the metapodium	Yes
Suture *sutura*	A thin layer of fibrous tissue between two bones of the skull	The interfrontal, temporal–parietal and internasal sutures	No — sutures ossify with maturity
Gomphosis *gomphosis*	A peg-in-socket union made by the periodontal membrane	Every **tooth in its alveolus**	Yes, while the tooth is in place

JOINT	WHAT JOINS THE BONES	A VETERINARY EXAMPLE	PERMANENT?
Synchondrosis hyaline cartilage	Hyaline cartilage bridging the two bones	The **epiphyseal plates**; the basioccipital–basisphenoid junction; König's own example is the skull base to the hyoid	**Usually not** most fuse as growth ceases — most, not all
Symphysis fibrocartilage	Fibrocartilage, usually on a median plane	The **pelvic symphysis**; the mandibular symphysis	Usually, though many ossify with age
Synostosis bone	Bone — the union has ossified completely	The fused **radius and ulna of the horse**	Yes, and irreversibly

04 Three names, two systems, and a disagreement worth knowing about

Joints are sorted along two different axes, and most of the confusion students have with this subject comes from meeting the two axes without being told they are two.

The first axis asks **what tissue joins the bones**: fibrous, cartilaginous, or synovial. The second asks **how far the joint travels**: a synarthrosis does not move, a diarthrosis moves freely, and between them sits *amphiarthrosis*, a joint that moves a little.

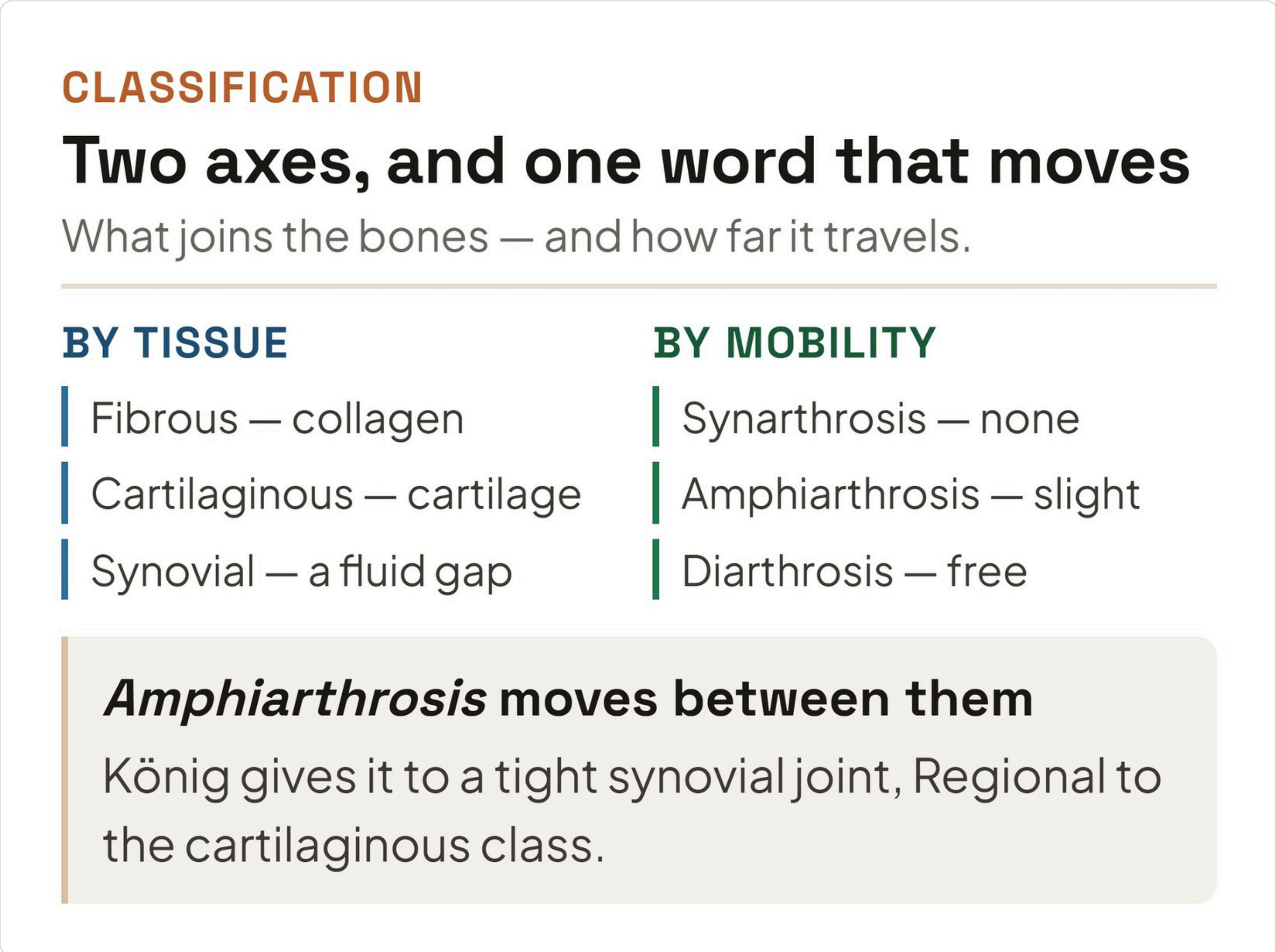

Fig 3 — Two axes, and the word that will not sit still. Joints are sorted twice over: by **what tissue joins the bones**, and by **how far the joint travels**. Most of the two axes line up — fibrous joints are immobile, synovial joints are free. *Amphiarthrosis* is the exception, and it is worth knowing before an examiner uses it: König gives the word to a tight **synovial** joint such as the sacroiliac, while the classical scheme gives it to the **cartilaginous** class.

Diagram — Vet-eBooks.com, drawn for this guide. Schematic, not to scale. Data from König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas, 7th ed. Thieme, pp. 37 and 40, and Veterinary Anatomy: The Regional Gross Anatomy of Domestic Animals, p. 15 — which map the term amphiarthrosis differently, as the diagram records.

For most joints the two axes agree so well that you can use them interchangeably. A suture is fibrous and it does not move. A stifle is synovial and moves freely. The trouble is entirely with the word in the middle.

König and Liebich use *synarthrosis* to mean any continuous union at all — so the fibrous joints, the cartilaginous joints and the bony ones are all synarthroses together — and then place *amphiarthrosis* inside the **synovial** group, as the name for a synovial joint whose movement is very tightly restricted. Their example is the sacroiliac joint, which has a real cavity and barely moves.

The classical scheme used by the regional textbooks does something else entirely. It maps the three tissue classes straight onto the three mobility names, one to one: fibrous joints *are* synarthroses, cartilaginous joints *are* amphiarthroses, and synovial joints *are* diarthroses. On that scheme the sacroiliac joint is a diarthrosis like any other and *amphiarthrosis* means "pelvic symphysis".

> **The one term to define before you use it**
>
> If an examiner asks you to classify a joint, say which scheme you are using. **König and Liebich** treat *synarthrosis* as any continuous union — fibrous, cartilaginous or bony — and reserve *amphiarthrosis* for a **tight synovial joint** such as the sacroiliac. The classical scheme, which the regional textbooks use, maps the three tissue classes straight onto the three mobility names: fibrous = synarthrosis, cartilaginous = amphiarthrosis, synovial = diarthrosis. Neither is wrong. Naming the scheme is what turns a half-mark into a full one.

There is a third scheme as well, older still, which classifies by surface shape using four Latin names. One piece of vocabulary comes with it: in that scheme the synovial joints as a whole are the **arthrodial** or **diarthrodial** joints, and it is the adjective the regional textbooks use throughout. The four names are *arthrodia* for a gliding joint such as the carpometacarpal or tarsometatarsal articulations, *enarthrosis* for a ball-and-socket joint such as the hip, *ginglymus* for a hinge such as the elbow, and *trochoid* for a pivot such as the atlantoaxial joint. Those four names are still in use, and the modern seven-shape scheme in the next section but one is a descendant of them.

None of this is a defect in the subject. Classification schemes are tools, and three of them survive because each answers a different question: what is it made of, how far does it move, what shape is it. The practical rule is the one in the box above — name the scheme, then classify the joint.

05 What a synovial joint is built from

Every synovial joint in every domestic species shares exactly three features. It has a **joint capsule**. It has a **joint cavity** inside that capsule — the regional textbooks call the same space the **articular cavity**, and an examiner may use either — containing synovia. And it has **hyaline articular cartilage** covering the bone ends that face each other across the cavity. Anything else — a meniscus, a disc, a fat pad, a sesamoid bone, a ligament inside the capsule — is an addition that some joints have and others do not.

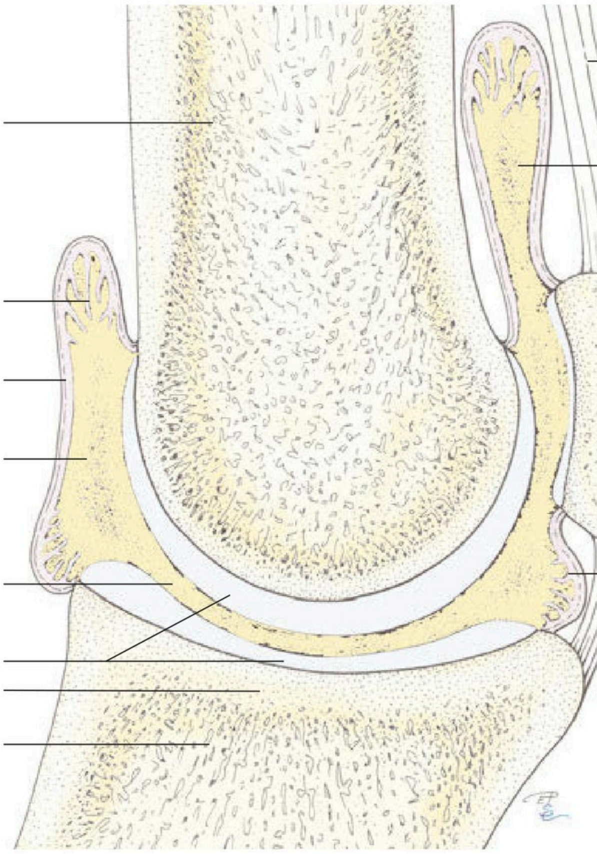

Fig 4 — Every component of a synovial joint, named at once. Thirteen labels on one section, and two of them are the parts most study pages leave out. The **subchondral bone plate** is the layer of bone immediately beneath the cartilage that takes the axial load; the **joint capsule diverticulum** is an outpouching of the capsule that carries the joint cavity beyond the articular surfaces themselves. Note that the **synovial villi** are labelled twice, in two different recesses, and that the **sesamoid bone** lies inside the same capsule as the joint proper.

Image — König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas, 7th ed. Thieme — Fig. 1.33, a joint including the sesamoid bones and the suspensory apparatus (schematic). Reproduced for educational reference.

Figure 4 puts thirteen labels on one section, which is more than most study pages name at all, and two of them are the parts usually left out. Work through it before reading on: it is the map for the rest of this section.

The capsule, and its two layers

The capsule is a sleeve, and it is built in two layers with quite different jobs. The outer layer is the ***stratum fibrosum***: dense irregular connective tissue, continuous at either end with the periosteum of the bone it attaches to, so that capsule and periosteum are really one fibrous envelope with a gap in the middle. The inner layer is the ***stratum synoviale***, the synovial membrane, and it lines everything inside the capsule *except* the articular cartilage.

LAYER	WHAT IT IS MADE OF	WHAT IT DOES	WHAT IT EXPLAINS
Stratum fibrosum the outer, fibrous layer	Dense irregular connective tissue, continuous with the periosteum of both bones	Holds the joint together and limits the range mechanically	**Two clinical facts at once.** Its blood supply is limited, so injuries to it heal slowly; and it is richly supplied with sensory nerve fibres, which is why a damaged or stretched capsule hurts
Stratum synoviale the inner, synovial layer	An inner *intima synovialis* of synoviocytes over a *stratum subsynoviale* that may be loose, fibrous or fatty	Produces and manages the synovia; throws out **synovial villi** and folds that increase its surface	Why the fluid is renewed at all, and why debris is cleared. The two cell types divide the work: **type-A synoviocytes are phagocytic**, **type-B synoviocytes secrete proteins**

The fibrous layer explains two clinical facts at the same time, which is the kind of economy that makes anatomy worth learning properly. Its blood supply is limited, so injuries to it heal slowly. And it is **richly supplied with sensory nerve fibres** — which is why an injured capsule hurts, and why a joint that fills with fluid hurts even when nothing has been torn.

> **Why a swollen joint hurts**
>
> The pain of a distended joint is not coming from the cartilage. Articular cartilage has no nerve supply at all. It is the **stratum fibrosum** of the capsule that is richly supplied with sensory fibres, so an increase in the volume of fluid inside the joint stretches the capsule wall and stimulates the receptors in it. The same anatomy explains why capsular injuries are slow: the fibrous layer's blood supply is limited.

The synovial layer is more interesting than its name suggests. It is not a smooth lining: it throws its surface into **synovial villi** and **synovial folds**, filament-like projections that increase the area available for exchange and let the membrane follow the changing shape of the cavity as the joint moves. Structurally it divides again, into an inner *intima synovialis* of **synoviocytes** and an outer *stratum subsynoviale* that may be loose connective tissue, fibrous tissue or fat depending on where in the joint you look. The synoviocytes come in more than one kind. There are **two**, and they divide the work: **type A synoviocytes are responsible for phagocytosis** — the joint cleans itself — while **type B synoviocytes produce and secrete proteins**.

> **One thing you will read that is not right**
>
> At least one widely used regional anatomy text states that the synovial membrane is “lined internally by **endothelial** cells”. It is not. Endothelium lines blood and lymphatic vessels; the synovial lining is made of **synoviocytes**, which are not even a continuous epithelium — they sit in an incomplete layer with gaps through which the subsynovial tissue reaches the cavity. That structural difference is the reason synovial fluid can be an ultrafiltrate of blood plasma in the first place.

The fluid

Start with what it looks like, because the chemistry means more once you can picture it: a **pale yellow, viscous fluid**, excreted by the synovial membrane, whose first job is simply to lubricate the joint and reduce friction between the articular surfaces.

Chemically it is an **ultrafiltrate of blood plasma** with a substantial quantity of polymerised **hyaluronan** added to it by the synovial cells. Its composition is otherwise similar to plasma, which is exactly what you would expect of a filtrate. That is the whole explanation of why joint fluid is viscous and why its viscosity is the first thing that changes when a joint is not well: the plasma part is filtered, and the slippery part is manufactured on site.

What some joints add

Beyond the three universal features, joints add structures according to what they have to do.

Ligaments strengthen the joint, and they are classified by where they sit relative to the capsule: **intracapsular**, inside it; **capsular**, thickenings of the capsule itself; and **extracapsular**, outside it altogether. The stifle carries the standard example of each kind on one specimen — the **cruciate ligaments** are the intracapsular pair and the **collateral ligaments** the extracapsular ones. Most ligaments are collagenous and barely stretch; a few, such as the nuchal ligament, contain substantial elastic tissue and behave quite differently.

The cruciates come with a correction worth having, because the word *intracapsular* invites the wrong picture. They run from bone to bone and *appear* to cross the joint cavity — but they are **actually excluded from the cavity by a covering of synovial membrane**. They are inside the capsule and outside the cavity, which is not the same thing. The structures that are **truly** intracapsular are a few discs and menisci.

And the fibrous layer's nerve supply is worth stating more precisely than "sensory". The fibrous layer and the ligaments carry **proprioceptive** endings that register the joint's **position and its rate of change of position**; **other** receptors register pain. A joint is therefore reporting where it is, continuously, as well as reporting when it is hurt.

Menisci and **articular discs** are fibrocartilaginous plates inside the cavity. A meniscus is crescent-shaped and incomplete, as in the femorotibial joint; a disc is complete and divides the cavity in two, as in the temporomandibular joint. Both exist for the same two reasons: to stabilise the joint, and to **compensate for articular surfaces that do not fit each other**.

That second reason is the standard one, and **it is disputed**. Dyce accepts that menisci and discs do produce congruence and then says that this "can hardly explain their presence, because congruence is achieved at other joints more simply". His alternative is better teaching: a disc or a meniscus **resolves a complicated movement into simpler components and assigns each to a different level** of the articulation. The temporomandibular joint is the worked example — the hinge movement that opens the mouth happens at the **lower** level, between the disc and the mandible, while the sliding movements that protrude, retract or shift the jaw sideways happen at the **upper** level, between the disc and the skull. One joint, two movements, kept apart by a plate of fibrocartilage.

Two further facts about menisci are worth having. They are usually anchored on one side to the fibrous layer of the capsule; and their ends, the **horns**, are heavily supplied with proprioceptive nerve endings, so a meniscus is a sense organ as well as a spacer. If a meniscus is removed after injury a replacement structure can grow from the fibrous layer of the capsule, but it is made of dense collagen rather than fibrocartilage and is not the same thing.

An **articular labrum** is a fibrocartilaginous rim around the edge of a concave surface — the acetabulum is the standard example. It deepens and extends the surface, increases the load-bearing area, and helps spread the synovial fluid; and because it is deformable it lets the socket adapt to a ball whose curvature does not quite match.

Intra-articular fat forms pads and cushions between the synovial and fibrous layers. These are sometimes described as swabs that spread the synovia about, but their main purpose is mechanical: they let the synovial membrane change shape to fit whichever part of the bone it happens to be lying against at that moment in the movement.

> **Why the plate includes a sesamoid bone**
>
> The joint in Figure 4 is drawn with its sesamoid bones and suspensory apparatus on purpose. A sesamoid is a bone developed inside a tendon where the tendon crosses a joint, and it lies within the same capsule, against the same cartilage, bathed in the same synovia. It is a reminder that the joint cavity is not always the simple slot the schematics suggest: the **diverticulum** labelled on the same figure is the cavity reaching out beyond the articular surfaces themselves.

One structure belongs here although it is not part of a joint at all. A **synovial sheath** is a two-layered sac wrapped around a tendon where the tendon runs over bone, and the two layers are continuous with each other along a fold called the **mesotendon**, which carries the tendon's blood supply. It is built on the same plan as a joint capsule and filled with the same fluid, which is why it is described alongside joints even though nothing articulates inside it.

06 The cartilage, and why it is the part that does not recover

Articular cartilage is hyaline cartilage, smooth and glossy, bluish-pink in the fresh state, and of thickness that varies from joint to joint and from place to place within the same joint. Its job, stated plainly: it **reduces the friction and the concussion** between the two opposing surfaces. That much is easy. The important facts are the negatives.

Articular cartilage is **avascular**. It contains no blood vessels. It is also **alymphatic**, and it has no nerve supply. Nothing arrives by the usual routes, and so nothing about how it is fed or how it repairs resembles the other tissues in the joint.

> **The one-sentence version**
>
> Articular cartilage has **no blood vessels, no lymphatics and no nerves**. It is fed **for the most part by diffusion**, and only to a lesser degree from the synovia above it or the marrow vessels beneath; its metabolism is anaerobic and slow. Everything a student needs to remember about cartilage repair follows from that one sentence.

What it lives on instead is diffusion, and König is precise about the routes in a way worth copying exactly. Nutrients reach the cartilage **for the most part bradytrophically, by diffusion** — *bradytrophic* meaning slow-feeding. **To a lesser degree**, they can also reach it from the synovia above or through the blood vessels of the bone marrow beneath. Note that both of those named routes are in the minor category; the principal one is diffusion itself. Its metabolism is **anaerobic**, which is unusual in a load-bearing tissue and follows directly from having no blood supply to carry oxygen.

The mechanism by which the synovia actually reaches the cells is worth knowing, because it explains something that sounds paradoxical: a joint is fed by being used. The cartilage matrix is rich in highly anionic glycosaminoglycans, which bind water. When the cartilage is compressed that water is squeezed out; when the compression is released it is drawn back in and rebinds. The result is a slow pumping cycle that both lubricates the surface — the term is **weeping lubrication** — and circulates nutrients in and waste products out. An immobilised joint does not pump.

Two independent sources describe that mechanism, from opposite ends. König records it as a property of the matrix: its **high proteoglycan content lends a high capacity for binding water molecules, which facilitates the intrachondral transport of metabolites**.

Cartilage is not uniform through its depth. Three zones are described — **superficial**, **middle** and **deep** — and beneath the deep zone the cartilage becomes calcified, with one or more **tidemarks** marking the boundary. Below that lies the **subchondral bone plate**, labelled on Figure 4, which cushions the axial forces reaching the joint and supports the metabolic supply to the deeper layers of cartilage from below.

One curiosity that regularly confuses students on a fresh specimen: some articular surfaces carry **synovial fossae**, small rough non-articular pits set into the otherwise smooth cartilage. They are normal. They are not lesions, and they are not where cartilage has worn through.

07 Seven shapes, and what each one permits

Two systems are used to classify synovial joints, and unlike the argument in section 4 these two do not compete — they answer different questions and are used together.

The **numerical** system is quickly dealt with. A **simple** joint has one pair of articular surfaces: two bones, one level of movement. The shoulder is the standard example. A **composite** joint has more than two opposing surfaces, with movement occurring at more than one level inside a shared capsule. The carpus is the standard example, and the distinction matters clinically because a composite joint can be damaged at one level while the others are intact.

The **geometrical** system is the one worth learning properly, and the current version has seven categories.

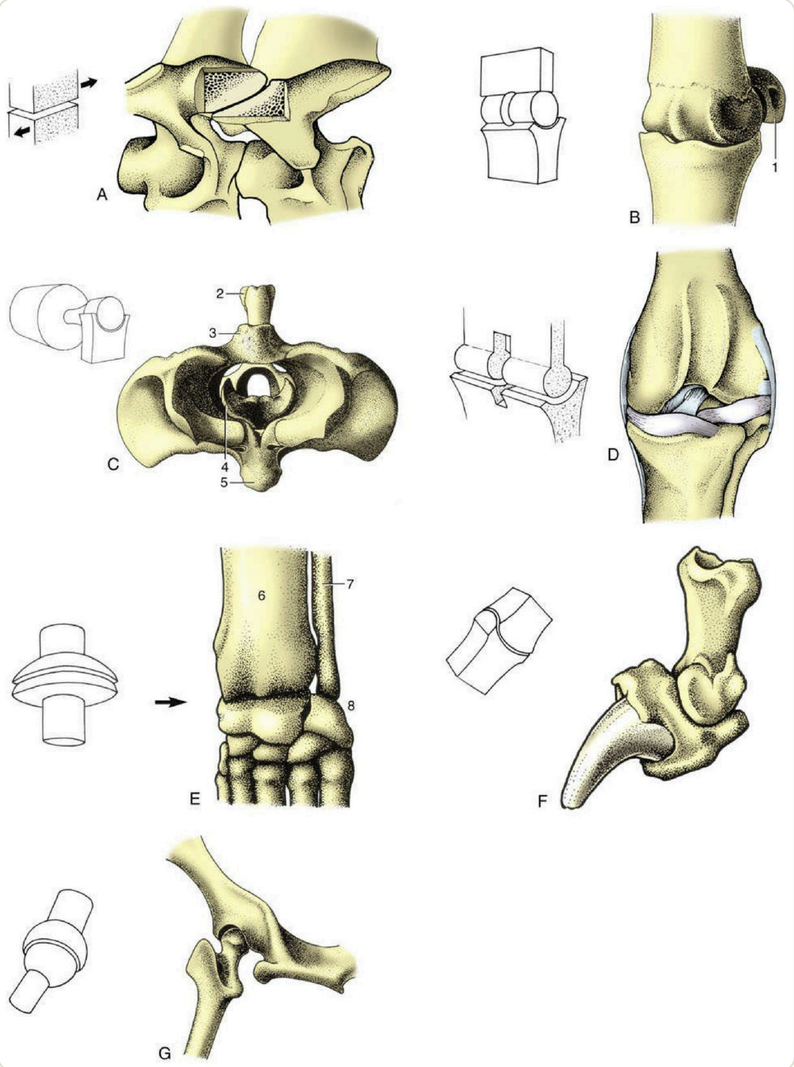

Fig 5 — The seven shapes, each beside the bone that has it. The reason to spend time on this plate is the pairing: every panel puts the abstract solid next to the actual specimen, so the shape name stops being a word to memorise. **A** plane — the articular processes of equine cervical vertebrae. **B** hinge — the equine fetlock (metacarpophalangeal). **C** pivot — the **bovine** atlantoaxial joint, cranial view. **D** condylar — the canine femorotibial joint (stifle). **E** ellipsoidal — the canine carpus. **F** saddle — the canine distal interphalangeal joint. **G** spheroidal — the canine hip, caudodorsal view. The numbered key: **1** proximal sesamoid bone, **2** spine of the axis, **3** dorsal arch of the atlas, **4** dens of the axis, **5** ventral arch of the atlas, **6** radius, **7** ulna, **8** proximal row of carpal bones.

Image — Dyce KM, Sack WO, Wensing CJG. Textbook of Veterinary Anatomy, 5th ed. Saunders/Elsevier — Fig. 1.25, the seven types of synovial joints, with examples. Reproduced for educational reference.

Figure 5 is the best single image in this article, and the reason is the pairing. Each of the seven panels puts the abstract geometric solid immediately beside the real bones of a real example, from three different species. Look at panel F for a minute if you have never understood why a saddle joint is called that.

SHAPE	LATIN	AXES OF MOVEMENT	A NAMED EXAMPLE
Plane	*articulatio plana*	Gliding only, in theory none Dyce: true translation probably never occurs	Between the **articular processes of the vertebrae**
Hinge	*ginglymus*	**Uniaxial** — one plane, pendular	The **elbow**; the equine fetlock
Pivot	*articulatio trochoidea*	**Uniaxial** — about the long axis of the peg	The **atlantoaxial** joint; the proximal radioulnar joint
Condylar	*articulatio condylaris*	Primarily uniaxial, with some rotation and slide	The **femorotibial** joint; the two mandibular articulations together
Ellipsoidal	*articulatio ellipsoidea*	**Biaxial**, with a little rotation possible	The canine **carpus**; the atlanto-occipital joint
Saddle	*articulatio sellaris*	**Biaxial**, with rotation permitted or imposed by the surfaces	The canine **distal interphalangeal** joint
Spheroidal ball-and-socket	*articulatio sphaeroidea*	**Multiaxial** — the greatest range of any joint	The **hip**; the shoulder, in shape if not in behaviour

A few of the seven need a sentence more than the table can carry.

The **plane joint** is a definition made on an assumption that is not true. It is defined as a joint in which movement is pure translation — one flat surface sliding over another with no spin. Dyce is explicit that true translation **probably never occurs**, since it would need perfectly flat surfaces, and articular surfaces are always curved. The category exists because a group of joints with very small, nearly flat surfaces behaves close enough to that model to be worth naming.

The **pivot joint** comes in two arrangements that are easy to confuse and easy to distinguish once stated. Sometimes the peg rotates inside a fixed ring, as at the proximal radioulnar joint. Sometimes the ring rotates around a fixed peg, as at the atlantoaxial joint, where the atlas and the head turn about the dens of the axis. The joint type is the same; which element moves is not.

The **condylar joint** is formed by two knuckle-shaped condyles engaging matching concave surfaces. The two may be close together, as in the femorotibial joint, or widely separated with independent capsules, as with the two articulations of the mandible — and in both cases the whole arrangement counts as **one** condylar joint, which is why the temporomandibular joint cannot be assessed on one side alone.

The **spheroidal joint** carries a caution that matters in veterinary practice more than in human anatomy. In shape it permits the greatest range of movement of any joint. But while the hip uses that range, **the shoulder of domestic species largely restricts its movement to flexion and extension**. The human shoulder conforms far more closely to the theoretical ball-and-socket than the dog's does. A spheroidal shape is a permission, not a prediction.

König adds two useful refinements to this list. The first is a classification **by axis** that runs in parallel with the shapes: **uniaxial** joints (hinge and pivot), **biaxial** joints (saddle and ellipsoidal) and **multiaxial** joints (spheroidal). The second is the **cotyloid** joint, *articulatio cotylica* — a spheroidal joint in which the socket covers *more than half* the sphere. The example is the avian hip, and our guide to how bird bodies differ is the place to see what else follows from a bird's skeleton being built for flight.

When the surfaces do not fit

Not all articular surfaces correspond to each other, and the ones that do not have a name: **incongruent joints**. The femorotibial and temporomandibular joints are the two standard examples, and in both the mismatch is corrected by inserting fibrocartilage — the menisci in the stifle, the articular disc in the temporomandibular joint — so that the surfaces are made congruent by something other than their own shape.

Here is the subtlety, and it is the sort of thing that separates a memorised answer from an understood one: **a degree of incongruence is required**. A wedge of synovia has to be maintained between the two surfaces, and perfectly matched surfaces would squeeze it out. As a joint approaches the limit of its range the radius of curvature of the convex surface increases towards its margin until it matches the concave surface it is running on; the two become congruent in what is called the **close-packed position**, the lubricant wedge is lost, and the movement is checked by the surfaces being pressed together. Incongruence is not a defect. It is what keeps the joint lubricated everywhere except at its own limit.

> **The caution the whole classification needs**
>
> Dyce puts it plainly: anatomical joints "correspond very imperfectly to the theoretical models", and the departure can be large enough to make the right category **a matter of controversy**. The seven shapes are a vocabulary for describing a joint, not a set of boxes every joint fits into. If a joint seems to sit between two of them, that is often because it does.

08 The movement vocabulary

This is the section our own library did not have. Across every anatomy article on this site the word *flexion* appears three times and *abduction* has never appeared at all, and the same hole is visible in the university lecture notes that rank for this subject. It is also the vocabulary an examiner will use without explaining it.

Start with the framework. However complicated a movement looks it resolves into **three basic classes**: **gliding**, **angular** and **rotary**. Most real movements combine two or three of them, and much of what looks like a single action at a limb is the sum of modest movements at several neighbouring joints.

MOVEMENT

Three classes, four angles

In the digits these read against the limb axis.

Gliding flat surfaces slide, as in the carpus

Flexion the angle between segments closes

Extension the angle opens, the limb straightens

Abduction swings away from the median plane

Adduction and back towards it

Rotation the bone spins on its own axis

Circumduction the foot draws a circle

Fig 6 — The whole vocabulary on one screen. Three classes of movement and the four angular terms inside one of them. The distinction that decides most exam answers is the **plane**: flexion and extension are pendular movements in a **sagittal** plane, abduction and adduction pendular movements in a **transverse** one, and rotation a spin about an axis perpendicular to the articular surface. The one refinement to remember is that in the **digits**, abduction and adduction are read against the axis of the limb rather than the median plane.

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. 52–54, and Veterinary Anatomy: The Regional Gross Anatomy of Domestic Animals, pp. 18–19.

Gliding

Gliding is one surface sliding on another, and it occurs where the surfaces are nearly flat — between the bones of the carpal and tarsal rows above all. In its pure theoretical form, **translation**, one flat surface slides over another with both bodies keeping their original orientation. As noted above, that pure form probably never happens, because articular surfaces are always curved.

Angular movements

Angular movements are the ones with names students are examined on, and there are four. They divide neatly by plane.

Flexion reduces the angle between the two segments of the limb — the segments come together. **Extension** is the opposite: the angle opens and the two segments come more nearly into line. Both are pendular movements in a **sagittal** plane.

Abduction carries a part *away* from the median plane, and **adduction** carries it back *towards* the median plane. Both are pendular movements in a **transverse** plane — and if *median*, *sagittal* and *transverse* are not yet second nature, our guide to the anatomical planes in animals is the prerequisite for this whole section. If the two words will not stay apart in your memory, the Latin does it: *ab-* is away from, *ad-* is towards.

> **Get the planes right and the terms follow**
>
> Flexion and extension are pendular movements in a **sagittal** plane; abduction and adduction are pendular movements in a **transverse** plane; rotation is a spin about an axis **perpendicular** to the articular surface. Every one of these terms is defined against a plane, which is why the movement vocabulary is impossible to keep straight until the planes are — and if they are not yet, our guide to the anatomical planes in animals is the place to fix that before going further.

There is one refinement that is easy to miss and specifically veterinary. **When these terms are applied to the digits, they are read against the axis of the limb rather than against the median plane**, and they describe the digits spreading apart and converging. In a cloven-hoofed animal that is a real and visible movement, not a technicality.

Rotation, and the terms built on it

Rotation is a spin of the moving bone about an axis **perpendicular** to its articular surface. Rotation can always go either way, so its direction has to be specified: by convention an **internal** (inward) rotation of a limb carries the cranial surface medially, and an **external** (outward) rotation carries that surface laterally.

Set against rotation is the **swing**: a turn about an axis **parallel** to the articular surface, a pendular or rolling movement which is really a slide between two curved surfaces. Most swings are accompanied by a certain amount of rotation, although it usually goes undetected. Flexion and extension are swings.

Circumduction is not a fifth kind of movement but a combination: flexion and extension combined with adduction and abduction, so that the end of the limb describes a circle or an ellipse while the proximal end stays more or less put.

Overextension, and why the standing horse is not in neutral

One term deserves its own paragraph because it is where the vocabulary meets a species. Most joints move from a neutral position in one direction only. But some range from one flexed position, through full extension at 180 degrees, into a *second* flexed position at the other limit — and the fetlock of the horse is the standard example. Where that happens the two terminal positions are distinguished: **overextension** (also called dorsal flexion) and, at the other end, palmar flexion.

The consequence is worth sitting with. **The fetlock of a horse standing at rest is in overextension**, not in neutral; the flexed position is the one the joint takes when the foot is picked up. If you have read our guide to the horse's hoof and distal limb this is the joint immediately above everything described there, and its resting posture is the reason the suspensory apparatus is loaded in a standing animal at all.

09 What stops a joint moving

What a joint can do is its **range of movement** — you will also see it written as *range of motion*, and the two mean the same thing. Ask a student what limits it and the answer is usually “the ligaments”. That is one of four factors, and the source that sets them out most clearly is also careful to say it may not be the most important one.

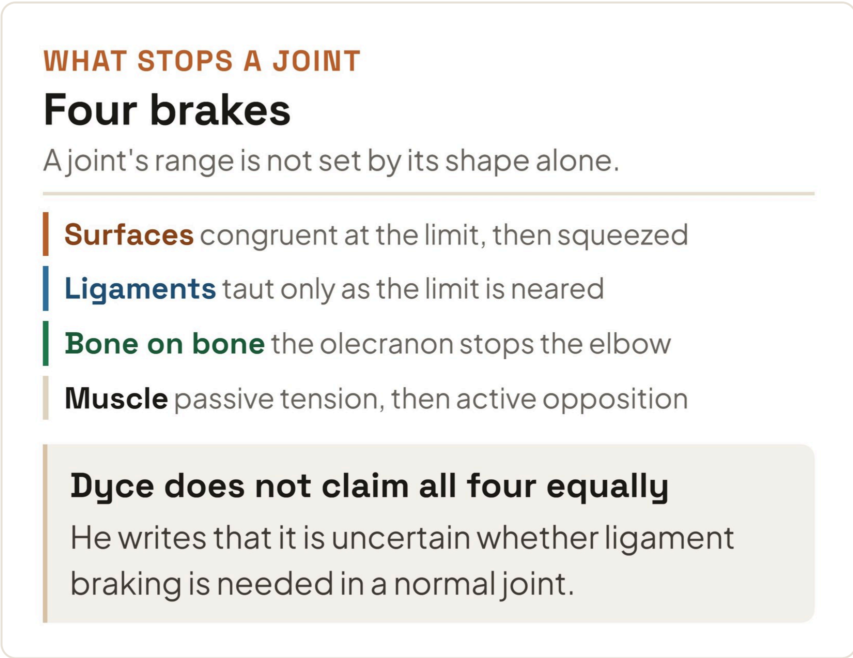

Fig 7 — Four brakes, not one. A joint's range of movement is not set by the shape of its surfaces alone. Dyce sets out four limits, and is careful not to weight them equally: he writes that it is **uncertain whether ligament braking is required in normal circumstances**, and that the contraction of the muscles opposing a movement may be the most important factor of the four. The hedge is his, and it is kept here.

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, p. 54.

1. The shape of the articular surfaces. This is the mechanism described at the end of section 7. As the joint approaches its limit the two surfaces become congruent, the wedge of synovia between them is squeezed out, and further movement is checked by the surfaces being pressed together. It is the only one of the four that is built into the bones themselves.

2. Tension in the extracapsular ligaments. Ligaments can certainly arrest a movement. But they do not all behave alike: some are moderately taut throughout the normal range, while others are generally slack and only become taut when the movement threatens to go past its normal limit. And here Dyce writes something a revision page should not smooth over — that it is **"uncertain whether this method of braking is required in normal circumstances"**. Ligaments may be the emergency brake rather than the service brake.

3. Contact between extra-articular structures. Sometimes a movement stops because something is in the way. The **olecranon** is the clean example: it physically prevents forceful overextension of the elbow. In a heavily muscled animal the apposition of soft tissue does the same job at other joints.

4. Tension in the surrounding muscles. Muscles and other soft structures near a joint can first decelerate and then arrest a movement passively — the inability of a muscle to stretch beyond a certain length is called **passive insufficiency**. And beyond that, the *contraction* of the muscles that oppose a given movement may be the most important factor of the four. That is an active brake, not a structural one, and it is the reason our guide to the dog's muscle origins and insertions and our guide to how a muscle contracts belong beside this page rather than inside it.

The practical version, for a joint you are examining: if the range is reduced, the cause is not automatically in the joint. It may be in the ligaments, in a bony obstruction, or in the muscles that cross it — and only one of those four is visible on a radiograph.

10 Where the species differ

Almost everything above applies to every domestic mammal. This section is the part that does not, and it is what a comparative anatomy examiner asks about. Our comparative anatomy guide, species compared sets out the broader pattern; what follows is the joint-specific version.

SPECIES	THE JOINT	WHAT IS DISTINCTIVE
Horse	The **elbow**	A **spring or snap joint** (*articulatio* with a suspension function). The collateral ligaments attach eccentrically and **proximal** to the joint axis, so they are under greatest tension in the neutral position; flexion or extension *relaxes* them, and the joint springs out of neutral rather than back into it

SPECIES	THE JOINT	WHAT IS DISTINCTIVE
Horse	The **stifle**	A **spiral joint** (*articulatio spiralis*). The collateral ligaments attach eccentrically and **distal** to the axis, so they are shortest in neutral and tension *increases* as the joint moves, slowly braking it. The mirror image of the elbow
Horse	The **hock**	A **cochlear joint** (*articulatio cochlearis*) — a hinge whose ridges and grooves run obliquely, so flexion carries the limb slightly outwards
Horse	The **fetlock**	The standard example of a joint whose range runs through full extension into a second flexed position. The standing horse's fetlock is in **overextension**, not in neutral
Horse	The **radius and ulna**	Fused — a **synostosis**. There is no functional supination or pronation in the equine forelimb, which is why those two terms barely appear in equine anatomy
Ox	The **dew claws**	Attached to the metapodium by a **syndesmosis** — the clearest domestic-animal example of a fibrous joint that is neither a suture nor a tooth socket
Cloven-hoofed species	The **digits**	Abduction and adduction are real, visible movements here, and they are read against the **axis of the limb**: the digits spread and converge
Birds	The **hip**	A **cotyloid joint** (*articulatio cotylica*) — a spheroidal joint whose socket covers **more than half** of the ball, which the mammalian hip does not
Dog	The **shoulder**	Spheroidal in shape, but domestic species largely restrict it to flexion and extension. The human shoulder conforms far more closely to the theoretical model than the dog's does

Two of those entries are worth expanding, because they are a matched pair and they are the most elegant thing in this branch.

König describes two joints in the horse whose behaviour is decided not by the shape of the articular surfaces but by **where the collateral ligaments attach relative to the joint axis**. Both attach eccentrically — off to one side of the axis rather than on it — and the difference between them is whether the attachment is proximal or distal to that axis.

In the **spring or snap joint**, the horse's elbow, the ligaments attach eccentrically and **proximal** to the joint axis. In the neutral position they are under the greatest tension they will experience; as the joint flexes or extends, that tension *decreases*. The joint therefore springs *out* of neutral into a position other than the neutral one, which is a mechanically odd thing for a joint to do and part of how the standing horse's forelimb holds itself up.

In the **spiral joint**, the horse's stifle, the same ligaments attach eccentrically and **distal** to the axis. Now they are *shortest* in the neutral position, and tension *increases* during extension or flexion — so the ligaments slowly brake the movement instead of encouraging it. Two joints in the same animal, the same anatomical trick, opposite consequences, decided by a few centimetres of attachment site.

König lists two further functional names from the same animal. The **cochlear joint**, *articulatio cochlearis*, is the hock of the horse: a hinge whose matching ridges and grooves run obliquely rather than straight, so that flexion carries the limb slightly out of the sagittal plane. And the **sledge or gliding joint**, *articulatio delabens*, is the femoropatellar joint, where the patella slides on the trochlea of the femur rather than pivoting on it. Our guide to the horse's bones, muscles and landmarks covers the skeleton these sit in.

11 Reading a joint name

Joint terminology looks worse than it is, because the names are built from a small number of pieces that recur. Learn the pieces and most of the vocabulary becomes readable rather than memorable — which is the difference between recognising a term in an exam and having to have seen it before.

WORD PIECE	WHAT IT MEANS	SO THE NAME TELLS YOU
arthr-	joint (Greek *arthron*)	*Arthrology* is the study of joints; an *arthrosis* is a joint
syndesm-	ligament, binding (Greek *syndesmos*)	*Syndesmology* is the same branch under its other name; a *syndesmosis* is a joint made of binding tissue
syn-	together, with	*Syn*arthrosis — the bones are joined together, with no gap
di-	through, apart	*Di*arthrosis — the bones are held apart by a cavity

WORD PIECE	WHAT IT MEANS	SO THE NAME TELLS YOU
amphi-	on both sides, in between	*Amphi*arthrosis — a joint between the two, which is why the books disagree about where to put it
-osis	a condition or state, not a disease here	Synost*osis* is the state of being joined by bone
ginglym-	hinge (Greek *ginglymos*)	A *ginglymus* moves in one plane, like a door
troch-	wheel, to run or spin	A *trochoid* joint spins; so does the *trochanter* region it sounds like, but that is a bone landmark, not a joint
sell-	saddle (Latin *sella*)	A *sellar* joint has saddle-shaped surfaces
sphaer-	sphere	A *spheroidal* joint is a ball in a socket
synov-	from *syn-* + *ovum*, egg — the fluid was named for its resemblance to egg white	*Synovia*, *synovial*, *synoviocyte* all belong to the fluid and the membrane that makes it
chondr-	cartilage	A syn*chondr*osis is joined by cartilage; *sub*chondral bone lies beneath it

Two habits make this pay off. First, when you meet a joint name, split it before you look it up: *syn-arthr-osis* is "the state of joints being together", and that is the definition. Second, watch for the pieces that describe **shape** — *ginglym-*, *troch-*, *sell-*, *sphaer-*, *cotyl-*, *ellips-* — because in this branch a shape name is also a movement prediction. A joint called a *ginglymus* moves in one plane; a joint called *sphaeroidea* moves in all of them.

The same word-piece method works across the whole of anatomy, and our guide to veterinary anatomy terminology takes it further than one branch can.

12 Test yourself

Thirty-five 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 arthrology, and what is its other name?**

ANSWER Arthrology (*arthrologia*) is the branch of anatomy dealing with the **joints or articulations** — every junction between two skeletal elements. Its other name is **syndesmology**, from the Greek *syndesmos*, a binding, and you will meet that name in Sisson & Grossman and in most older texts. They mean the same subject.

2 **A joint that cannot move at all — is it still a joint?**

ANSWER Yes. A joint is a junction between two skeletal elements, and mobility is not part of the definition. The sutures of the skull, the socket a tooth sits in and the fused radius and ulna of the horse are all joints. This is the point students most often lose marks on: arthrology is the study of **junctions**, not of moving parts.

3 **State the single principle the whole joint classification rests on.**

ANSWER König and Liebich state it directly: the degree of mobility between two bones or cartilage structures **"depends entirely on the form of the gap between them"**. Either the tissue runs continuously from one bone to the other, or there is a real cavity between them. Everything else is a subdivision of that.

4 **Define synarthrosis and diarthrosis.**

ANSWER A **synarthrosis** is a continuous structure connecting two adjacent bones — no cavity. A **diarthrosis** is a joint containing a gap, that gap being a **joint cavity filled with synovia**. Note that König uses *synarthrosis* for any continuous union, fibrous, cartilaginous or bony alike.

5 **Name the three fibrous joints and give a veterinary example of each.**

> ANSWER **Syndesmosis** — two bones held apart and joined by collagenous tissue across the gap; the **dew claws of the ox**, attached to the metapodium. **Suture** — a thin fibrous layer between two skull bones; the interfrontal or internasal suture. **Gomphosis** — a peg in a socket held by the **periodontal membrane**; every tooth in its alveolus.

6 **Name the four suture types by the shape of the opposing edges.**

> ANSWER *Sutura serrata*, where the margins interlock like saw teeth (interfrontal); *sutura squamosa*, where the edges are bevelled and overlap (temporal on parietal); *sutura plana* or *harmonia*, where two plain surfaces abut (internasal); and *sutura foliata*, where the interlocking is deeper and leaf-like.

7 **What is the difference between a synchondrosis and a symphysis, and which one expires?**

> ANSWER The kind of cartilage. A **synchondrosis** is bridged by **hyaline** cartilage and is characteristically **temporary** — the cartilage turns to bone before maturity, though the sources say **most** rather than all. The epiphyseal plates and the basioccipital-basisphenoid junction are the examples, and König's own is the union between the skull base and the hyoid, which is not a growth plate at all. A **symphysis** is bridged by **fibrocartilage** and is usually on a median plane: the pelvic symphysis, the mandibular symphysis.

8 **What is a synostosis, and what does the horse's radius and ulna tell you about the forelimb?**

> ANSWER A **synostosis** is a synarthrosis in which **bone** now unites the two elements. In the horse the radius and ulna are fused into one, and the consequence is functional: there is no supination or pronation in the equine forelimb, which is why those two terms barely appear in equine anatomy at all.

9 **How does the periosteum behave differently at a fibrous joint and at a synovial joint?**

> ANSWER At a fibrous joint there is no capsule and the fibrous layer of the periosteum runs **continuously over the joint** from one bone onto the next. At a synovial joint the periosteum stops at the margin of the articular cartilage, and the joint capsule takes over — its outer layer being continuous with that same periosteum.

10 **The one that separates a memorised answer from an understood one: two textbooks classify the sacroiliac joint differently. Explain.**

> ANSWER They are using different schemes and both are internally consistent. **König** reserves *amphiarthrosis* for a **tight synovial joint**, and the sacroiliac — which has a real cavity and barely moves — is his example. The **classical scheme** used by the regional textbooks maps the tissue classes one-to-one onto the mobility names, so fibrous = synarthrosis, cartilaginous = **amphiarthrosis**, synovial = diarthrosis, and on that scheme the sacroiliac is a diarthrosis while *amphiarthrosis* means the pelvic symphysis. In an exam, **name the scheme first**.

11 **Name the classical four shape names and one joint for each.**

> ANSWER *Arthrodia* — a gliding joint, such as the carpometacarpal or tarsometatarsal articulations. *Enarthrosis* — ball-and-socket, the hip. *Ginglymus* — a hinge, the elbow. *Trochoid* — a pivot, the atlantoaxial joint.

12 **What three features does every synovial joint have, without exception?**

> ANSWER A **joint capsule**; a **joint cavity** inside it containing synovia; and **hyaline articular cartilage** on the bone ends facing each other across that cavity. Everything else — menisci, discs, a labrum, fat pads, intracapsular ligaments, sesamoid bones — is an addition some joints have and others do not.

13 **Name the two layers of the joint capsule and say what each explains.**

> ANSWER The outer **stratum fibrosum**, dense irregular connective tissue continuous with the periosteum of both bones: its blood supply is limited, so it heals slowly, and it is richly supplied with **sensory nerve fibres**, so it hurts when injured or stretched. The inner **stratum synoviale**: an *intima synovialis* of synoviocytes over a *stratum subsynoviale*, throwing out synovial villi and folds, and producing the synovia. **Type-A synoviocytes are phagocytic**.

14 **A joint fills with fluid and the animal is painful. Which structure is generating the pain, and why not the cartilage?**

> ANSWER The **stratum fibrosum of the capsule**. An increase in the volume of synovial fluid stretches the capsule wall and stimulates the sensory receptors in it. It cannot be the cartilage, because **articular cartilage has no nerve supply at all** — it is avascular, alymphatic and aneural.

15 **What is synovial fluid, chemically?**

ANSWER An **ultrafiltrate of blood plasma** with a substantial quantity of polymerised **hyaluronan** added by the synovial cells. Its composition is otherwise similar to plasma, which is what you would expect of a filtrate. The plasma part is filtered; the viscous part is manufactured on site.

16 **How is articular cartilage fed, and in what order of importance?**

ANSWER **For the most part bradytrophically, by diffusion.** Only **to a lesser degree** do nutrients reach it from the synovia above or through the blood vessels of the bone marrow beneath — both of those are secondary routes, not the main one. Its metabolism is **anaerobic**, which follows from having no blood supply of its own.

17 **Explain weeping lubrication, and why an immobilised joint is a problem.**

ANSWER The cartilage matrix is rich in highly anionic glycosaminoglycans that bind water. Compression squeezes that water out onto the surface; releasing the compression draws it back in. That cycle both lubricates the surfaces and **circulates nutrients in and waste out** — which matters because the cartilage is avascular and alymphatic and has no other supply route. A joint that is not loaded and released does not pump.

18 **What is the subchondral bone plate, and what are synovial fossae?**

ANSWER The **subchondral bone plate** is the layer of bone immediately beneath the articular cartilage; it cushions axial forces and supports the metabolic supply to the deeper cartilage from below. **Synovial fossae** are small, rough, non-articular pits found normally on some articular surfaces — they are not lesions and not worn-through cartilage.

19 **Give the seven geometrical types of synovial joint with a named example of each.**

ANSWER **Plane** — between the articular processes of the vertebrae. **Hinge** (*ginglymus*) — the elbow, the equine fetlock. **Pivot** (*articulatio trochoidea*) — the atlantoaxial joint. **Condylar** — the femorotibial joint. **Ellipsoidal** — the canine carpus. **Saddle** (*articulatio sellaris*) — the canine distal interphalangeal joint. **Spheroidal** or ball-and-socket — the hip.

20 **A pivot joint can be arranged two ways. What are they?**

ANSWER Either the **peg rotates inside a fixed ring**, as at the proximal radioulnar joint, or the **ring rotates about a fixed peg**, as at the atlantoaxial joint, where the atlas turns about the dens of the axis. Same joint type; different element moving.

21 **Why is some incongruence between articular surfaces necessary?**

ANSWER Because a **wedge of synovia** has to be maintained between the two surfaces, and perfectly matching surfaces would squeeze it out. As the joint nears the end of its range the radius of curvature of the convex surface increases towards its margin until it matches the concave surface; the two become congruent in the **close-packed position**, the lubricant wedge is lost, and the movement is checked by the surfaces being pressed together.

22 **Distinguish flexion, extension, abduction and adduction by plane.**

ANSWER **Flexion** (the angle between the two segments reduces) and **extension** (the angle opens and the segments come into line) are pendular movements in a **sagittal** plane. **Abduction** (a part moves away from the median plane) and **adduction** (it moves back towards it) are pendular movements in a **transverse** plane.

23 **What changes about abduction and adduction when they are applied to the digits?**

ANSWER The reference changes. In the digits they are read against **the axis of the limb**, not against the median plane, and they describe the digits **spreading and converging**. In a cloven-hoofed animal that is a real, visible movement.

24 **Define rotation precisely, and say how its direction is specified.**

ANSWER Rotation is a spin of the moving bone about an axis **perpendicular to its articular surface**. Because it can go either way the direction must always be stated: by convention an **internal** (inward) rotation of a limb carries the cranial surface **medially**, and an **external** rotation carries it **laterally**.

25 **What is circumduction, and is it a distinct kind of movement?**

ANSWER No — it is a **combination**. Flexion-extension combined with adduction-abduction lets the distal end of the limb describe a circle or an ellipse while the proximal end stays roughly put. There is no separate anatomical mechanism for it.

26 **Is the fetlock of a standing horse in flexion, extension or neither?**

ANSWER In **overextension** — also called dorsal flexion. The fetlock is the standard example of a joint whose range runs from one flexed position, through full extension at 180 degrees, into a second flexed position at the other limit. The standing posture is the overextended one; the flexed position is what the joint takes when the foot is picked up.

27 **List the four things that limit the movement of a joint, and say which one the source is least sure about.**

ANSWER **1.** The shape of the articular surfaces — they become congruent at the limit and are checked by being squeezed together. **2.** Tension in the extracapsular ligaments. **3.** Contact between extra-articular structures — the **olecranon** prevents forceful overextension of the elbow. **4.** Tension in the surrounding muscles, both passive (*passive insufficiency*) and active. Dyce writes that it is **uncertain whether ligament braking is required in normal circumstances**, and that the contraction of the opposing muscles may be the most important factor of the four.

28 **What are a spring joint and a spiral joint, and which horse joints are they?**

ANSWER Both are named for **where the collateral ligaments attach relative to the joint axis**, not for the shape of the surfaces. In the **spring or snap joint** — the **elbow** of the horse — the ligaments attach eccentrically and **proximal** to the axis, so tension is greatest in the neutral position and falls on movement: the joint springs out of neutral. In the **spiral joint** — the **stifle** of the horse — they attach eccentrically and **distal** to the axis, so they are shortest in neutral and tension increases with movement, braking it.

29 **What is a cotyloid joint and where would you find one?**

ANSWER A spheroidal joint in which the socket covers **more than half** of the sphere — *articulatio cotylica*. The example is the **avian hip**. The mammalian hip is spheroidal but not cotyloid.

30 **Split *synarthrosis*, *amphiarthrosis* and *ginglymus* into their word pieces and read them.**

ANSWER *Syn-arthr-osis* — the state of the joints being **together**, no gap. *Amphi-arthr-osis* — a joint **in between**, which is exactly why the books disagree about where to put it. *Ginglymus* is from Greek *ginglymos*, a **hinge**. In this branch a shape name is also a movement prediction.

31 **Why is a meniscus more than a spacer?**

ANSWER Two reasons beyond filling a gap. It exists to **compensate for articular surfaces that do not correspond**, in an incongruent joint such as the femorotibial. And its ends — the **horns** — are heavily supplied with **proprioceptive** nerve endings, so it reports on the joint as well as spacing it. If it is removed, a replacement can grow from the fibrous layer of the capsule, but of **dense collagen rather than fibrocartilage**.

32 **Why is calling the cruciate ligaments *intracapsular* a little misleading?**

ANSWER Because they are inside the **capsule** but not inside the **cavity**. They run from bone to bone and appear to cross the joint cavity, but they are **excluded from it by a covering of synovial membrane**. The structures that are *truly* intracapsular are a few discs and menisci. On one stifle you can see both classes: the **cruciates** are the intracapsular pair, the **collateral ligaments** the extracapsular ones.

33 **The textbooks give two different reasons why menisci and articular discs exist. What are they, and which does Dyce prefer?**

ANSWER The standard reason is that they **compensate for articular surfaces that do not fit each other**. Dyce accepts that they do, and then says it "can hardly explain their presence, because congruence is achieved at other joints more simply". His alternative is that a disc or meniscus **resolves a complicated movement into simpler components at different levels** of the joint — in the temporomandibular joint, the hinge movement that opens the mouth happens between the disc and the mandible, and the sliding movements between the disc and the skull.

34 **What is a synovial sheath, and why is it described alongside joints?**

ANSWER A two-layered sac wrapped around a tendon where it runs over bone, the two layers continuous with each other along a fold called the **mesotendon**, which carries the tendon's blood supply. It is built on the same plan as a joint capsule and filled with the same fluid — but nothing articulates inside it, so it is not a joint.

35 **The shoulder is a spheroidal joint. Does that tell you how the dog uses it?**

ANSWER No, and this is the caution to carry. Spheroidal shape permits the greatest range of any joint, but **the shoulder of domestic species largely restricts its movement to flexion and extension**; the human shoulder conforms much more closely to the theoretical model. Dyce generalises the warning: real joints "correspond very imperfectly to the theoretical models", and the departure can be big enough to make the right category a matter of controversy.

13 Veterinary Arthrology — frequently asked questions

What is arthrology in veterinary anatomy?

Arthrology (*arthrologia*) is the branch of systematic anatomy that deals with the joints, or articulations — every junction between two skeletal elements. It is also called **syndesmology**, and the two names mean the same subject. It covers how joints are classified, what a synovial joint is built from, the shapes joint surfaces take, the movements each shape permits and what limits them. It is the anatomy of the **normal** joint; joint disease, arthroscopy and joint surgery are clinical subjects that begin where it ends.

What are the three types of joints in animals?

By the tissue that joins the bones: **fibrous** joints, held by collagenous connective tissue and having no cavity — syndesmoses, sutures and gomphoses; **cartilaginous** joints, bridged by cartilage and also having no cavity — synchondroses (hyaline, and usually temporary) and symphyses (fibrocartilage); and **synovial** joints, which have a fluid-filled cavity between the bone ends. A fourth state exists at the end of the sequence: a **synostosis**, where the uniting tissue has itself turned to bone.

What is the difference between a synarthrosis, an amphiarthrosis and a diarthrosis?

These name joints by **how much they move** rather than by what they are made of. A **synarthrosis** is a continuous union with no cavity and effectively no movement; a **diarthrosis** has a joint cavity and moves freely. The word in the middle is where the textbooks part company, and it is worth knowing before an examiner uses it. **König and Liebich** reserve *amphiarthrosis* for a **tight synovial joint** such as the sacroiliac. The **classical scheme** maps the tissue classes straight onto these three names, making *amphiarthrosis* the label for the **cartilaginous** class — the pelvic symphysis. Neither is wrong; say which one you are using.

What are the seven types of synovial joint?

Plane (articular processes of the vertebrae), **hinge** or *ginglymus* (elbow, equine fetlock), **pivot** or *articulatio trochoidea* (atlantoaxial), **condylar** (femorotibial), **ellipsoidal** (canine carpus), **saddle** or *articulatio sellaris* (canine distal interphalangeal), and **spheroidal** or ball-and-socket (hip). Alongside this, joints are also counted: a **simple** joint has one pair of articular surfaces, a **composite** joint more than two, with movement at more than one level inside a shared capsule — the carpus being the standard example.

What is the difference between abduction and adduction?

Both are pendular movements in a **transverse** plane. **Abduction** carries a part *away* from the median plane; **adduction** carries it back *towards* the median plane. The Latin prefixes are the memory aid: *ab-* away from, *ad-* towards. One veterinary refinement matters: **applied to the digits, both are read against the axis of the limb rather than the median plane**, and describe the digits spreading and converging — which in a cloven-hoofed animal is a real movement.

Why does a swollen joint hurt if cartilage has no nerves?

Because the pain is not coming from the cartilage. Articular cartilage is avascular, alymphatic and has **no nerve supply at all**. The structure that is innervated is the **stratum fibrosum**, the outer fibrous layer of the joint capsule, which is richly supplied with sensory fibres. An increase in the volume of fluid within the joint stretches that capsule wall and stimulates the receptors in it. The same anatomy explains a second clinical observation — that capsular injuries are slow to heal, because the fibrous layer's blood supply is limited.

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