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# Comparative Veterinary Anatomy

## Seven Domestic Species Compared

Comparative veterinary anatomy is the habit of learning one body plan instead of five.

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IN SHORT

**Comparative veterinary anatomy** is the habit of learning one body plan instead of five. Every species on your table is a variation on the same vertebrate design: the same limb segments, the same seven cervical vertebrae, the same six embryonic aortic arches, the same muscles carrying the same nerves. This guide opens with a **seven-species reference block** — dog, cat, horse, ox, sheep, goat and pig set against dental formulae, stomach type and capacity, digits and vertebral formulae — then builds the plan behind those numbers from labelled plates: **homology versus analogy**, the **pentadactyl limb** and where the missing digits went, **vertebral formulae** compared, five skeletons, four body cavities and the aortic arches in the same view. It closes on the clinical payoff: which cross-species assumptions are safe, and which land you in trouble. Free illustrated PDF included.

KEY POINTS

1. **Homology is about ancestry, not function.** Two structures are homologous when they trace back to the same structure in a common ancestor — which is why a bird's wing and a mole's forelimb are the same limb doing different work.
2. **Ox, sheep and goat are not one row.** They share a dental formula and an identical foot — but the ox gives 8% of its stomach to the omasum and 7% to the abomasum, where the small ruminants invert that to 4% and 13%; the sheep has four sacral vertebrae to the goat's five; and the small ruminant's spinal cord can run on through almost the whole sacrum.
3. **Every tetrapod limb has three segments** — stylopodium, zeugopodium, autopodium. Almost all of the species variation is packed into the third one.
4. **Five digits was never the starting point.** The earliest tetrapods had seven and eight; five is an early settlement, and the domestic species have been subtracting ever since.
5. **Seven cervical vertebrae** is one of the most conserved numbers in mammalian anatomy. Thoracic, lumbar and sacral counts are not — the horse has 18 thoracic to the dog's 13.
6. **Nerve supply is the strongest evidence of muscle homology.** A muscle keeps its nerve even when its attachments migrate; shared function proves nothing.
7. **The bird is the outlier that proves the rule** — fused vertebrae, no diaphragm, a right aortic arch, a cloaca — and every one of those is the shared plan edited, not replaced.
8. **Arch IV becomes the aorta.** Mammals keep the left, birds the right. A mammal that keeps the right instead has a vascular ring.

9. **The cord is shorter than its canal, by a different amount in every species** — ending at L6–L7 in the dog, L7–sacrum in the cat and S1–S2 in the ox. Vertebral counts are useless without it.

**About the images**

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Most veterinary students learn anatomy five times. Dog anatomy, then horse anatomy, then ruminant, then avian, then whatever exotic species turns up in final year — five vocabularies, five sets of landmarks, five things to forget. **Comparative veterinary anatomy** is the alternative: learn the plan once, then learn what each species did to it.

That is not a study trick. It is how the anatomy actually is. The bones in a horse's leg are the bones in your arm, in the same order, supplied by the same nerves. A bird's aorta and a dog's aorta are the same embryonic vessel with different sides retained. Once you can see the plan, an unfamiliar species stops being a blank sheet and becomes a set of edits to something you already know — and the places where a species has edited the plan hardest are, almost without exception, the places where it gets sick.

This guide is in two halves. It opens with the lookup — **domestic animal anatomy compared** in four reference tables covering seven species, values only, for when you need a dental formula or a vertebral formula and need it now. Everything after that explains where those numbers come from, working from the general to the particular: the shared plan and the vocabulary for talking about it, then the limb, the vertebral column, the skull, the muscles, the body cavities and the great vessels — each one shown across species in the same view. It is the hub for our individual species guides, all of which are linked at the end.

## 01 Domestic animal anatomy compared: the seven-species reference

This section is the lookup half of the article. Seven domestic mammals — **dog, cat, horse, ox, sheep, goat and pig** — set against the attributes you actually need a number for: the dental formula, the stomach, the foot and the vertebral column. Values only. Everything below it, from the shared body plan onwards, explains *why* the numbers come out that way.

The bird is deliberately not a row here. It appears throughout the rest of the article as the article's exemplar of the plan modified — fused vertebrae, no diaphragm, a right aortic arch — but it is not a domestic mammal, and putting it in a mammalian reference grid would force half the cells to read "not applicable." Seven means seven mammals.

### Teeth and mouth

Dental formulae are written per half-mouth, upper row over lower, in the order **incisor – canine – premolar – molar**. Multiply by two for the whole mouth. The single most useful line in this table is the fourth column: **ruminants have no upper incisors and no upper canines at all**, opposing instead a dental pad.

| SPECIES | PERMANENT DENTAL FORMULA | TOTAL | UPPER INCISORS | WHAT THE MOUTH IS FOR |
|---|---|---|---|---|
| **Dog** | 3–1–4–2 / 3–1–4–3 | **42** | Present | Seizing and shearing. The carnassial pair does the cutting |
| **Cat** | 3–1–3–1 / 3–1–2–1 | **30** | Present | The most reduced dentition of the seven — an obligate carnivore needs fewer teeth, not more |
| **Horse** | 3–1–3(4)–3 / 3–1–3–3 | **36–42** | Present | Cropping with the incisors, grinding with the cheek teeth. The bracketed 4 is the **wolf tooth**, variably present; canines are typically small or absent in mares |
| **Ox** | 0–0–3–3 / 3–1–3–3 | **32** | **None — a dental pad** | Tearing grass against a pad, then grinding |
| **Sheep** | 0–0–3–3 / 3–1–3–3 | **32** | **None — a dental pad** | As the ox. Dyce gives one formula for all three ruminants |
| **Goat** | 0–0–3–3 / 3–1–3–3 | **32** | **None — a dental pad** | As the ox |

| SPECIES | PERMANENT DENTAL FORMULA | TOTAL | UPPER INCISORS | WHAT THE MOUTH IS FOR |
|---|---|---|---|---|
| **Pig** | 3–1–4–3 / 3–1–4–3 | **44** | Present | The true omnivore. **The most complete dentition of any domestic animal** — the only one of the seven keeping the full complement in both jaws |

**The lower canine that is really an incisor**

In the ox, sheep and goat the lower canine sits alongside the incisors and behaves as one of them — Dyce notes that it is customary to call it the fourth or corner incisor. That gives **eight** teeth in a continuous crescent along the lower jaw, which is what you will count in the live animal, against the six the formula appears to promise.

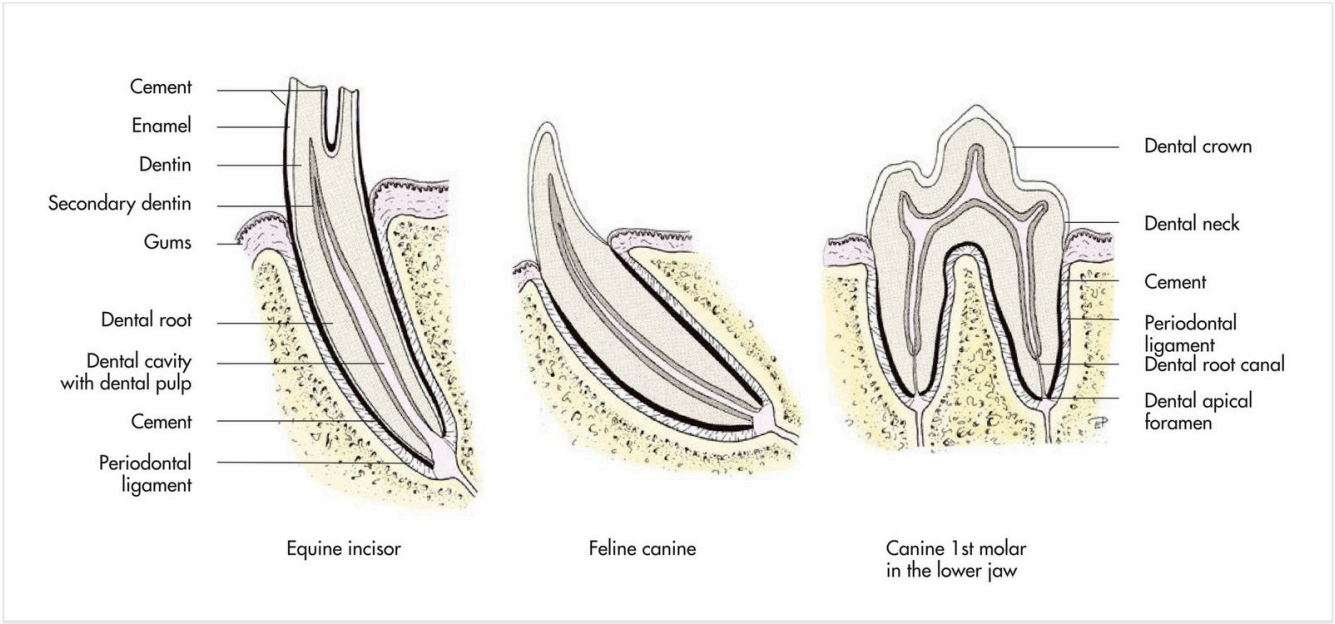



**Fig 1 — Why grazers and carnivores need different teeth.** Three teeth in section. On the left an **equine incisor**: a **hypsodont** tooth, its crown running far below the gum line so that it can keep erupting as grinding wears it away. In the centre a **feline canine** and on the right a **canine first molar**, both **brachyodont** — a short crown, a proper neck and a finished root. Labels run through **enamel**, **dentin**, **secondary dentin**, **cement**, the **dental cavity with pulp**, the **periodontal ligament** and the **apical foramen**. This is the reason a horse's cheek teeth need floating and a dog's do not.Image — König HE, Liebich H-G. *Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas*, 7th ed. Thieme — Fig. 8.19, hypsodont and brachyodont teeth. Reproduced for educational reference.

Image — König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas , 7th ed. Thieme — Fig. 8.19, hypsodont and brachyodont teeth. Reproduced for educational reference.

### Stomach and gut

Two decisions separate these seven animals: **how many chambers** the stomach has, and **where the microbes live**. Get those two right and the rest of the digestive anatomy follows.

| SPECIES | STOMACH | CAPACITY | LARGE INTESTINE | WHERE FERMENTATION HAPPENS |
|---|---|---|---|---|
| **Dog** | Simple | **0.5–6.0 L** by breed, averaging 2.5 L | Cecum short and spiralled, with **no direct connection to the ileum** | Negligible |
| **Cat** | Simple, more sharply flexed on itself than the dog's | Not stated as a figure; gross distension is less common than in dogs | Cecum small and comma-shaped | Negligible |

| SPECIES | STOMACH | CAPACITY | LARGE INTESTINE | WHERE FERMENTATION HAPPENS |
|---|---|---|---|---|
| **Horse** | Simple, and strikingly small for the animal | **5–15 L** | Cecum **over 30 L** in large horses; the large colon runs in four limbs and three flexures, including the **pelvic flexure** | **Hindgut** — cecum and large colon |
| **Ox** | Four chambers | **~60 L** — rumen 80%, reticulum 5%, **omasum 8%**, abomasum 7% | Spiral colon | **Foregut** — rumen and reticulum |
| **Sheep** | Four chambers | Rumen 75%, reticulum 8%, **omasum 4%**, **abomasum 13%** | Spiral colon | **Foregut** |
| **Goat** | Four chambers | As sheep — Dyce gives one set of proportions for small ruminants | Spiral colon | **Foregut** |
| **Pig** | Simple, plus a **conical diverticulum** off the fundus — a feature unique to the pig among domestic species | Not stated as a figure | Spiral colon | Appreciable hindgut fermentation |

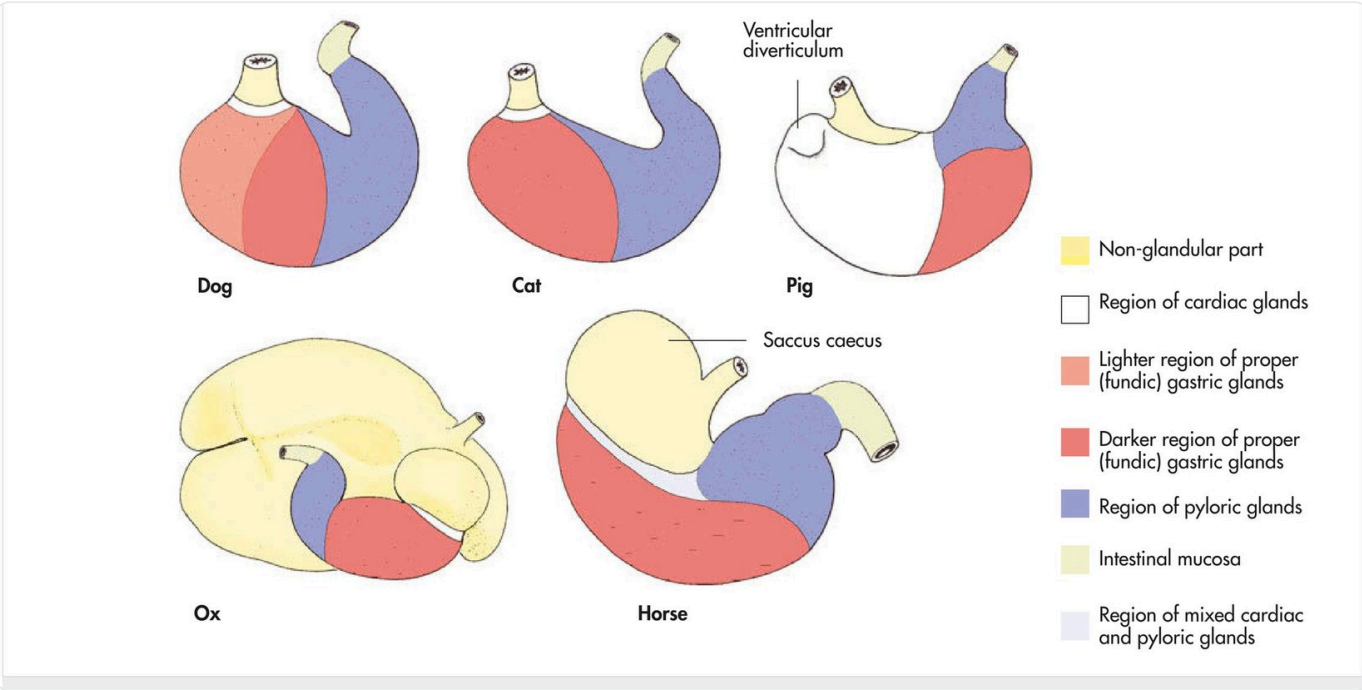



**Fig 2 — The stomach lining, five species, one colour key.** Dog, cat, pig, ox and horse, each shaded by the kind of mucosa lining it: **non-glandular**, **cardiac gland region**, **proper (fundic) gastric glands** in two shades, **pyloric glands** and **intestinal mucosa**. Read the ox: almost the whole organ is pale non-glandular lining, and only the abomasum is red glandular stomach — the picture of foregut fermentation. The pig's **ventricular diverticulum** is labelled top right, and the horse's blind non-glandular **saccus caecus** sits above a glandular floor.Image — König HE, Liebich H-G. *Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas*, 7th ed. Thieme — Fig. 8.49, distribution of the gastric mucosa in the domestic mammals. Reproduced for educational reference.

Image — König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas , 7th ed. Thieme — Fig. 8.49, distribution of the gastric mucosa in the domestic mammals. Reproduced for educational reference.

### Limb and foot

Here the three ruminants are genuinely identical, and that is the finding rather than an omission. Ox, sheep and goat share a foot down to the digit number, the weight-bearing pair and the horn covering. They part company in the stomach above and in the vertebral column below.

| SPECIES | DIGITS PRESENT | WEIGHT-BEARING | STANCE | FOOT COVERING |
|---|---|---|---|---|
| **Dog** | 5 front, 4 behind | II–V | Digitigrade | Claws, not retractile |

| SPECIES | DIGITS PRESENT | WEIGHT-BEARING | STANCE | FOOT COVERING |
|---|---|---|---|---|
| **Cat** | 5 front, 4 behind | II–V | Digitigrade | Claws, **retractile** — the distal phalanx slides alongside the middle phalanx |
| **Horse** | **1** | III alone | Unguligrade | One hoof |
| **Ox** | 2 functional, 2 vestigial | III and IV | Unguligrade | Cloven — two claws |
| **Sheep** | 2 functional, 2 vestigial | III and IV | Unguligrade | Cloven — two claws |
| **Goat** | 2 functional, 2 vestigial | III and IV | Unguligrade | Cloven — two claws |
| **Pig** | **4** | III and IV; II and V reach the ground on soft going | Unguligrade | Four separate hooves, two large and two small, unfused |

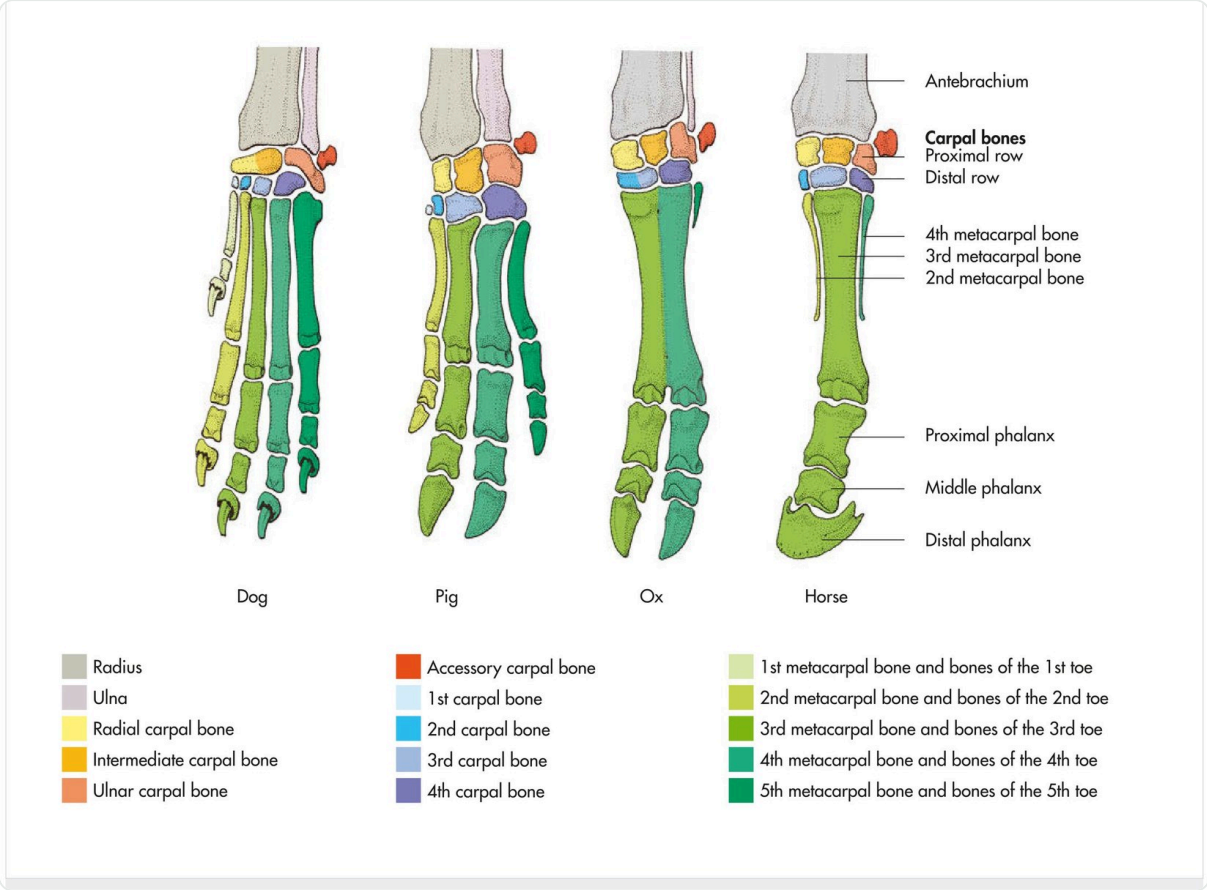



**Fig 3 — Four hands, one colour key, the whole digit-reduction story.** Dog, pig, ox and horse, with every bone coloured by **which digit it belongs to** rather than by what it is. Follow one colour across the plate and the reduction becomes impossible to misread: the dog keeps five, the pig four, the ox two, the horse one. The mid-green third metacarpal is the horse's **cannon bone**, with the second and fourth surviving as the slim **splint bones** flanking it; in the ox the same mid-green and teal pair are fused into the single cannon that only looks like one bone.Image — König HE, Liebich H-G. *Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas*, 7th ed. Thieme — Fig. 4.17, skeleton of the manus in the domestic mammals. Reproduced for educational reference.

Image — König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas , 7th ed. Thieme — Fig. 4.17, skeleton of the manus in the domestic mammals. Reproduced for educational reference.

### Vertebral column and spinal cord

A vertebral formula on its own is a trap. The cord is shorter than the canal that holds it, by a different amount in every species, so the count tells you where the *bones* are and nothing about where the *cord* stops.

| SPECIES | VERTEBRAL FORMULA | THE CORD ENDS AT | WHY IT MATTERS |
|---|---|---|---|
| **Dog** | C7 T13 L7 S3 Cd20–23 | **L6–L7** | The lumbosacral space is behind the cord, which is what makes it the safe window |
| **Cat** | C7 T13 L7 S3 Cd18–20 | **L6 to S3**, variably — commonly L7 to the sacrum | The cat's cord can still reach the lumbosacral space. A needle placed on canine landmarks is closer to cord than you intend |
| **Horse** | C7 T18 L6 S5 Cd15–21 | **S2** | The most caudal termination of the seven. Five extra thoracic vertebrae and one fewer lumbar than the dog |
| **Ox** | C7 T13 L6 **S5** Cd18–20 | **S1 in adult cattle** | Considerably further caudal in young calves — age changes the answer |
| **Sheep** | C7 T13 L6(7) **S4** Cd16–18 | **May occupy almost the whole sacrum** | The small ruminant is not a small cow. This is the single most important row in the table |
| **Goat** | C7 T13 L6(7) **S5** Cd16–18 | As sheep | Sheep and goat differ in sacral count — four against five |
| **Pig** | C7 T14–15 L6–7 S4 Cd20–23 | **L5–L6** | The most cranial termination of the seven. Thoracolumbar totals vary from 19 to 23 |

**Cord segments are not vertebrae**

There are **eight** cervical spinal cord segments and their nerve pairs inside **seven** cervical vertebrae — in the dog and in the ruminant alike. The mismatch starts at one in the neck and widens as you travel caudally. Reading a vertebral formula as if it also gave you nerve or segment levels is the error that puts a needle in the wrong space.

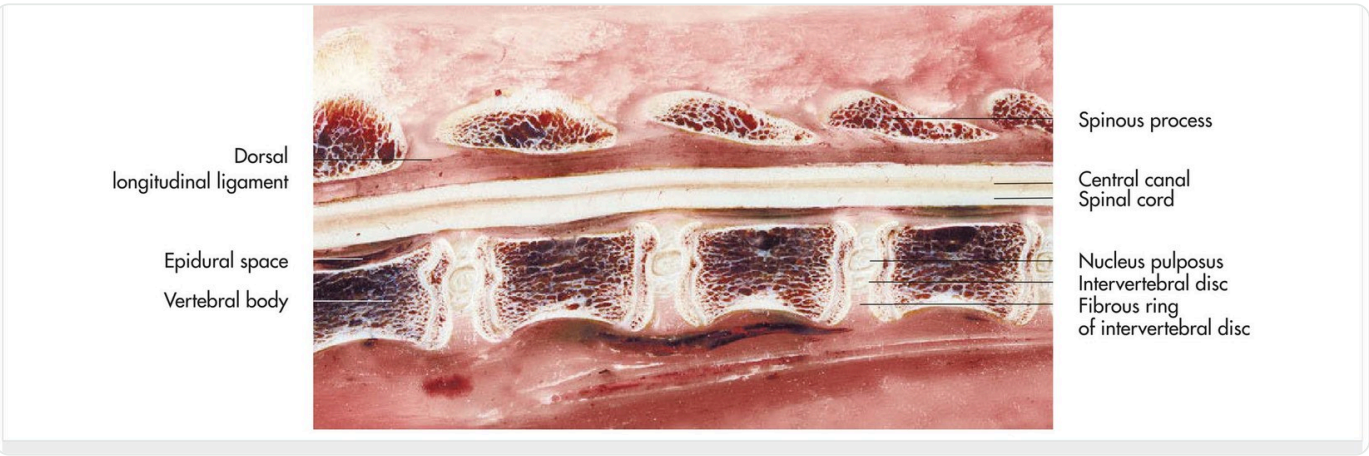



**Fig 4 — The cord inside its canal, in real tissue.** A median section through a dog's vertebral column. The pale band running the width of the plate is the **spinal cord**, with its **central canal** as a fine line inside it, and the dark gap beneath it is the **epidural space** — the space a needle is aimed into. Below that sit the **vertebral bodies** separated by **intervertebral discs**, each with a pale **nucleus pulposus** ringed by its **fibrous ring**. The section is taken mid-column, so it shows the relationship rather than the point of termination given in the table above.Image — König HE, Liebich H-G. *Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas*, 7th ed. Thieme — Fig. 15.3, vertebral column with the spinal cord of a dog. Reproduced for educational reference.

Image — König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas , 7th ed. Thieme — Fig. 15.3, vertebral column with the spinal cord of a dog. Reproduced for educational reference.

### The pig, the species most often left out

Of the seven, the pig is the one that goes missing from comparative teaching, and it is the one with the most complete dentition, four digits on the ground, a stomach feature no other domestic species has, and the most cranial spinal cord termination in the group. It earns its own plate.

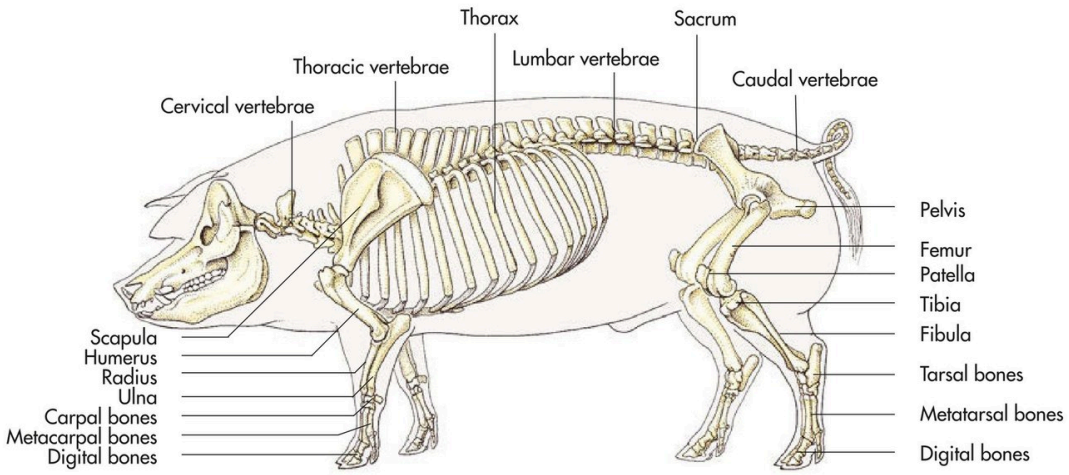



**Fig 5 — The porcine skeleton, lateral view.** The pig against its own body outline, labelled through the **cervical**, **thoracic**, **lumbar** and **caudal vertebrae**, the **sacrum** and **thorax**, then the limbs — **scapula**, **humerus**, **radius** and **ulna**, **carpal**, **metacarpal** and **digital bones** in front; **pelvis**, **femur**, **patella**, **tibia**, **fibula**, **tarsal**, **metatarsal** and **digital bones** behind. Count the ribs: the thoracic column is longer than any other domestic mammal's except the horse's.Image — König HE, Liebich H-G. *Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas*, 7th ed. Thieme — Fig. 1.27, skeleton of the pig. Reproduced for educational reference.

Image — König HE, Liebich H-G. Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas , 7th ed. Thieme — Fig. 1.27, skeleton of the pig. Reproduced for educational reference.

**Where the three ruminants agree, and where they do not**

Ox, sheep and goat share a dental formula and an identical foot, and saying so is more useful than inventing differences. But they are not interchangeable. The ox devotes **8%** of its stomach volume to the omasum and **7%** to the abomasum; in the small ruminants that inverts to **4%** and **13%**. The sheep has **four** sacral vertebrae to the goat's and the ox's five. And where the bovine cord stops around the first sacral vertebra, the small ruminant's may run on through almost the whole sacrum. A textbook row reading "ox, sheep, goat" hides all four of those.

## 02 The shared vertebrate body plan

The idea that vertebrates share an underlying pattern is older than evolutionary theory. In the middle of the nineteenth century **Richard Owen** argued that the whole vertebrate skeleton could be derived from one repeated unit — an idealised vertebra with a fixed cast of elements, stacked, and then modified segment by segment. He called that abstraction the **vertebrate archetype**.

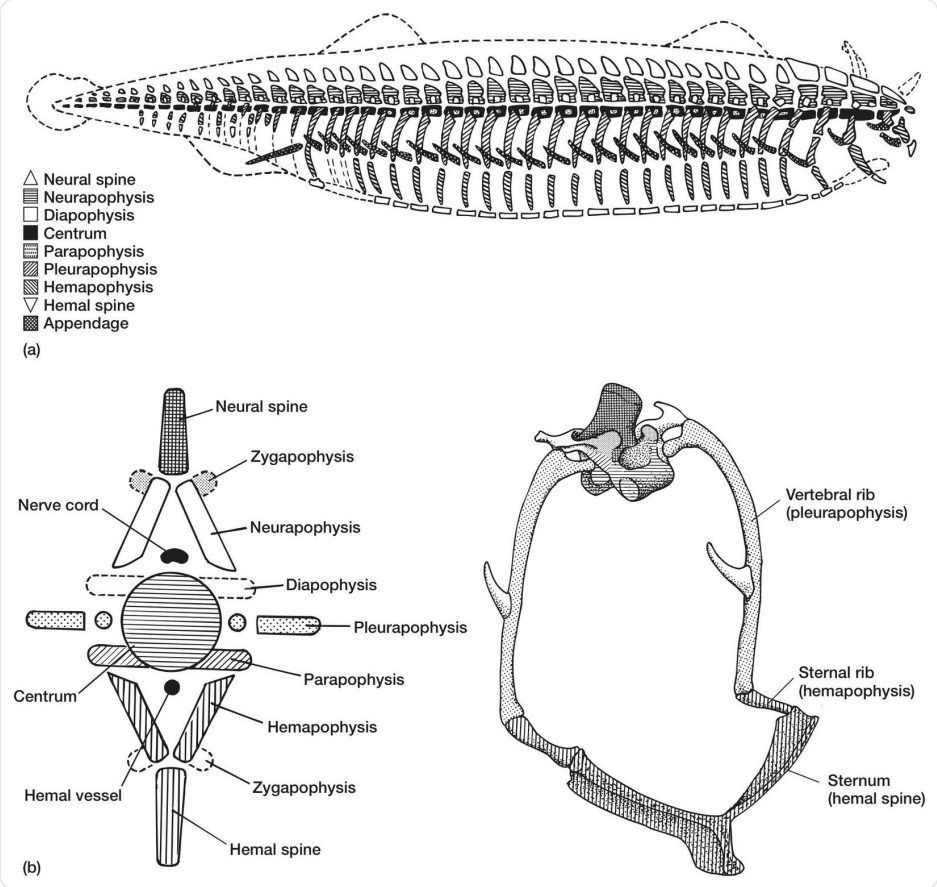



**Fig 6 — Owen's vertebrate archetype. (a)** The whole animal read as a chain of repeated units. Each element type is shaded to match the key: **neural spine**, **neurapophysis**, **diapophysis**, **centrum**, **parapophysis**, **pleurapophysis**, **hemapophysis**, **hemal spine** and **appendage**. Owen held that this pattern, carried forward into the head, even produced the elements of the skull. **(b)** The ideal vertebra on the left — **nerve cord** above the **centrum**, **hemal vessel** below, **zygapophyses** front and back — and beside it an actual section from a bird's skeleton showing how the plan is realised: the **vertebral rib** is the pleurapophysis, the **sternal rib** the hemapophysis, and the **sternum** the hemal spine.

Image — Kardong KV. Vertebrates: Comparative Anatomy, Function, Evolution , 6th ed. McGraw-Hill — Fig 1.11, vertebrate archetype, after R. Owen. Reproduced for educational reference.

Owen was wrong about why the pattern exists — he saw a divine template where Darwin would soon see common descent — but he was right that it exists, and the archetype remains the most efficient way to introduce comparative anatomy. Two things in that figure are worth holding onto.

First, **the body is segmental.** Vertebrae repeat, ribs repeat, muscle blocks repeat, spinal nerves repeat, and they repeat *in register* with each other. That is why a spinal cord lesion can be localised to a segment at all, and why the dermatomes of the trunk run as a series of bands.

Second, **elements are conserved even when they are unrecognisable.** The rib you count on a radiograph and the keeled sternum of a chicken are, on this scheme, built from the same classes of element in different positions. This is the single most useful habit in comparative anatomy: when a structure looks unfamiliar, ask what it is made of rather than what it looks like.

> **Segmentation.** A body built of repeating sections. In vertebrates the repeats are *metameres* — and vertebrae, ribs, myotomes and spinal nerves are all laid down on the same segmental grid, which is why they stay in register with one another for life.

## 03 Homology, analogy and homoplasy

Before comparing anything, you need three words that are constantly confused. Parts in different animals can resemble each other for three quite different reasons — **ancestry**, **function** or mere **appearance** — and comparative anatomy gives each of those a separate name.

| TERM | SIMILAR IN… | WORKED EXAMPLE |
|---|---|---|
| **Homology** | **Ancestry.** The parts trace back to the same structure in a common ancestor | A bird's wing and a mole's forelimb. Same bones, same order, same nerves — utterly different jobs |
| **Analogy** | **Function.** The parts do the same job, whatever their ancestry | A bird's wing and an insect's wing. Both fly; they share no wing-bearing ancestor |
| **Homoplasy** | **Appearance.** The parts simply look alike | The streamlined body of a tuna and of a dolphin. One is a fish, one a mammal |
| **Serial homology** | **Repetition within one animal.** Successively repeated parts of the same body | The chain of vertebrae down a single backbone; the pharyngeal arches of one embryo |

The formal definition of the first is worth learning verbatim: features in two or more species are **homologous when they can be traced back in time to the same feature in a common ancestor**. Nothing about function enters into it. A bird's wing and a mole's forelimb are homologous forelimbs; one flies and one digs.

These categories are **not mutually exclusive**, which is where most confusion comes from. Two structures can be homologous *and* analogous at once — a dog's forelimb and a cat's forelimb share both ancestry and function. The interesting cases are the ones where the categories come apart.

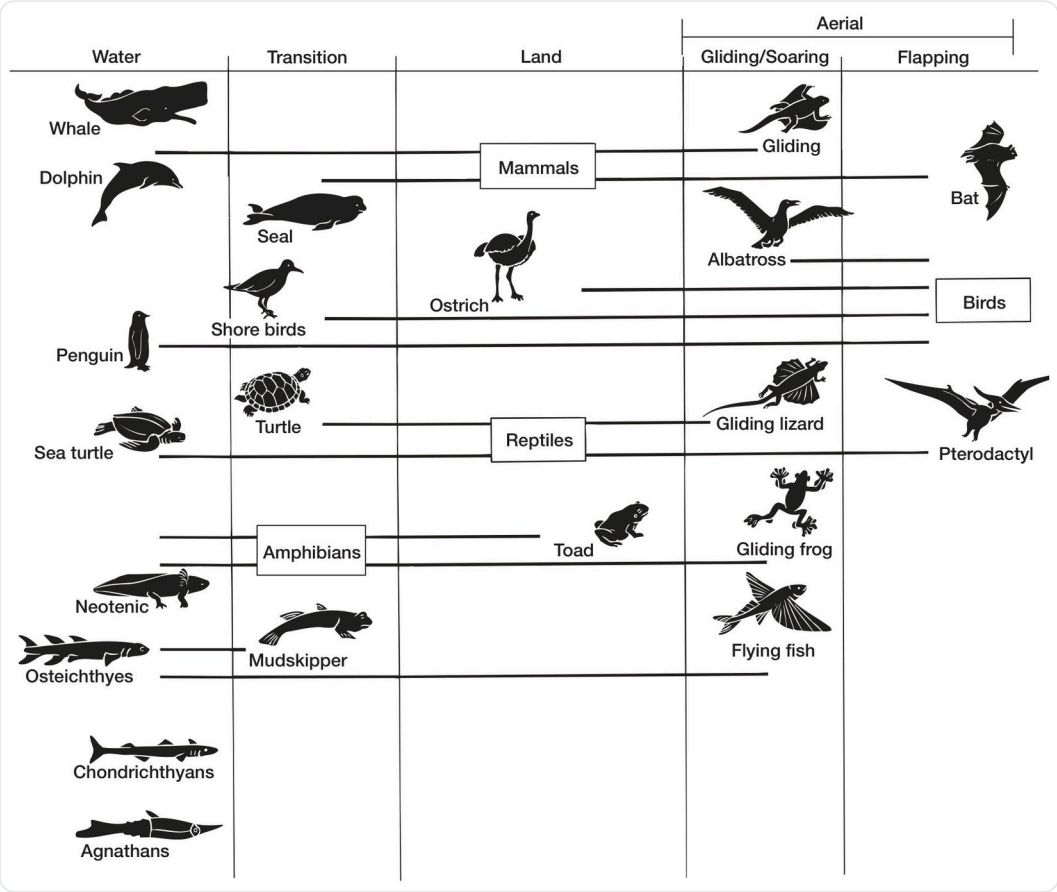



**Fig 7 — Convergence of design: why function is a poor guide to ancestry.** Groups of animals plotted against the habitat they occupy — **water**, **transition**, **land** and **aerial** (gliding or soaring, and flapping) — rather than against their ancestry. Read down a column and you find **mammals**, **birds**, **reptiles**, **amphibians** and **fishes** arriving at the same solution independently: **whale**, **dolphin** and **seal** alongside **penguin** and **sea turtle** in the water; **bat**, **albatross** and **pterodactyl** in the air; **gliding lizard**, **gliding frog** and **flying fish** in between; and the **ostrich** and **mudskipper** going the other way. Similar demands produce similar parts — but a tuna and a dolphin remain a fish and a mammal.

Image — Kardong KV. Vertebrates: Comparative Anatomy, Function, Evolution , 6th ed. McGraw-Hill — Fig 1.13, convergence of design. Reproduced for educational reference.

The clinical version of this lesson is blunt: **you cannot infer anatomy from function.** Two species that do the same thing may do it with different structures, and two species with the same structure may use it differently. The only reliable guide to what a structure *is* — and therefore to what it is attached to, supplied by and at risk from — is its ancestry.

**Serial homology.** A special case: similarity between *successively repeated parts within the same organism*. The chain of vertebrae in one backbone, and the pharyngeal arches of one embryo, are serially homologous — which is exactly what Owen's archetype was trying to capture.

## 04 The pentadactyl limb: one blueprint, many jobs

The tetrapod limb is the classic demonstration of homology, and it is worth doing properly because every lame animal you ever examine is built on it. Strip away the species detail and the same three segments appear in the same order, fore and hind.

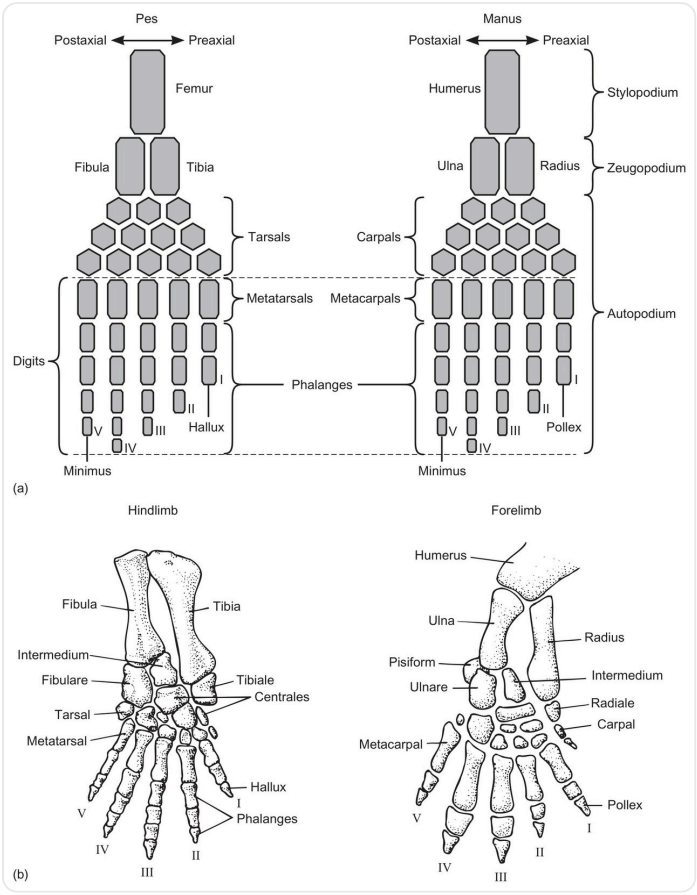



**Fig 8 — The basic organisation of the fore- and hindlimb. (a)** The schematic. Reading down the manus: **humerus** = the **stylopodium**; **ulna** and **radius** = the **zeugopodium**; then **carpals**, **metacarpals** and **phalanges** = the **autopodium**. The pes matches it bone for bone — **femur**, then **fibula** and **tibia**, then **tarsals**, **metatarsals** and phalanges. Digits run **I** to **V** from the **preaxial** to the **postaxial** side, digit I being the **pollex** in the hand and the **hallux** in the foot, digit V the **minimus**. **(b)** The same plan in a real primitive tetrapod, with the individual carpal and tarsal bones named — **radiale**, **intermedium**, **ulnare**, **centrale**, **pisiform**; **tibiale**, **fibulare**, **tarsal**.

Image — Kardong KV. Vertebrates: Comparative Anatomy, Function, Evolution , 6th ed. McGraw-Hill — Fig 9.23, basic organization of the fore- and hindlimbs, after Smith and Jarvik. Reproduced for educational reference.

| SEGMENT | FORELIMB BONES | HINDLIMB BONES | WHAT IT BECOMES IN THE DOMESTIC SPECIES |
|---|---|---|---|
| **Stylopodium** the upper segment | Humerus | Femur | Recognisably the same bone in every mammal and in the bird. Length and muscle attachment change; identity does not |
| **Zeugopodium** the middle segment | Radius + ulna | Tibia + fibula | The paired bones tend to **fuse or reduce** in runners: the bovine ulna fuses to the radius, the equine fibula is a splinter, the avian tibiotarsus is a compound bone |
| **Autopodium** the hand or foot | Carpals, metacarpals, phalanges | Tarsals, metatarsals, phalanges | Where nearly all the species difference lives — bones fuse, digits are lost, and the animal ends up standing on fingertips |

Now the part that surprises people. "Pentadactyl" suggests that five is the ancestral number and that everything since has been loss. It is not. **The earliest tetrapods had more than five digits**, and the fossils are unambiguous about it.

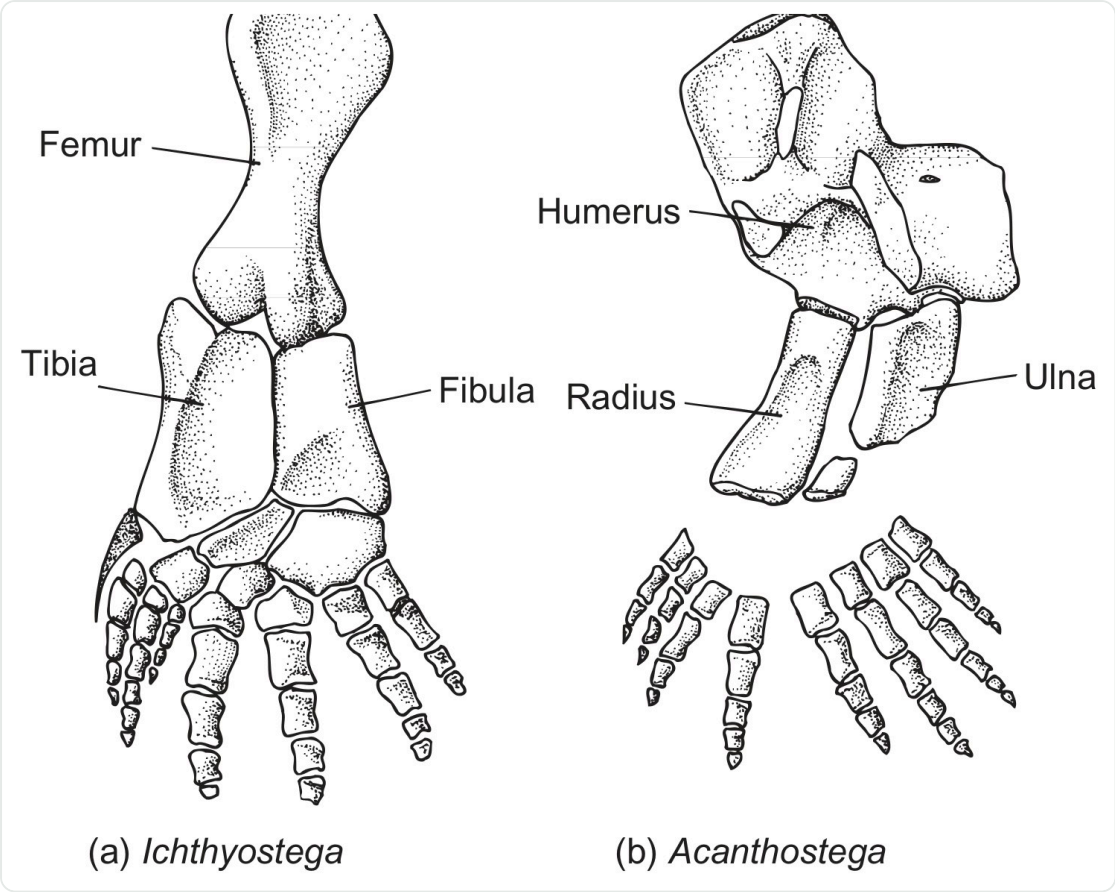



**Fig 9 — The earliest tetrapods were polydactylous.** Dorsal views. **(a)** The hindlimb of *Ichthyostega* — **femur**, then **tibia** and **fibula**, then a tarsus carrying **seven** digits. **(b)** The forelimb of *Acanthostega*, an ichthyostegalian — **humerus**, **radius** and **ulna**, then **eight** digits. The three-segment plan is already fully in place; only the digit count is unsettled. Five is not the vertebrate starting point but an early compromise that later groups then reduced further.

Image — Kardong KV. Vertebrates: Comparative Anatomy, Function, Evolution , 6th ed. McGraw-Hill — Fig 9.24, polydactylous limbs of the earliest tetrapods, after Coates and Clark. Reproduced for educational reference.

Once five is established, the variation is astonishing — and all of it happens in the **autopodium**. The stylopodium stays a single long bone in a bat, a mole, a whale and a horse. The hand is where evolution does its work.

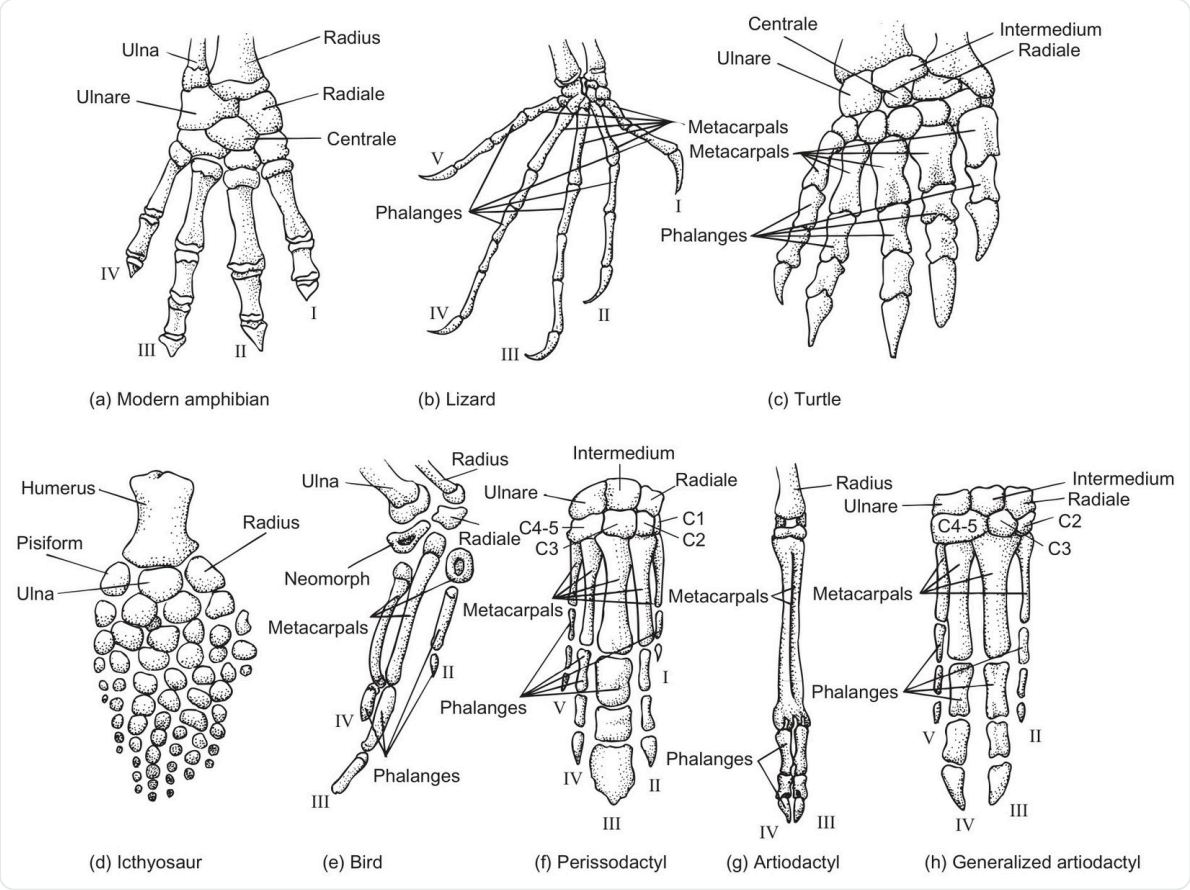



**Fig 10 — Variations of the tetrapod manus across eight groups.** The same hand, eight times. **(a)** a modern amphibian (*Necturus*), **(b)** lizard, **(c)** turtle (*Pseudemys*), **(d)** ichthyosaur, **(e)** bird, **(f)** a hypothetical primitive **perissodactyl**, **(g) artiodactyl** and **(h)** a generalised artiodactyl. Follow one label through the series — **radius** and **ulna**, then **radiale**, **ulnare**, **intermedium** and **centrale**, then **metacarpals** and **phalanges**. The ichthyosaur multiplies its phalanges into a paddle; the bird fuses its carpus; the perissodactyl narrows towards a single central digit while the artiodactyl narrows towards a pair. Same elements, radically different arithmetic.

Image — Kardong KV. Vertebrates: Comparative Anatomy, Function, Evolution , 6th ed. McGraw-Hill — Fig 9.25, variations of the tetrapod manus, after Smith. Reproduced for educational reference.

Panels **(f)** and **(g)** are the two that matter most in practice. They are not the horse and the ox themselves — (f) is a *hypothetical primitive* perissodactyl, and both are less reduced than the modern animals — but they are the patterns the horse and the ox come from. Both lineages faced the same problem, moving a heavy body fast over open ground, and both answered it by reducing the hand. The difference is *where they put the axis of the limb*, and it has a name.

> **Mesaxonic vs paraxonic.** In a **mesaxonic** limb the axis of symmetry runs *down the middle of digit III*, so reduction converges on one central digit — the **perissodactyl** pattern, ending in the horse. In a **paraxonic** limb the axis runs *between digits III and IV*, so reduction converges on a symmetrical pair — the **artiodactyl** pattern, ending in the cloven hoof of the ox, sheep, goat and pig.

Those two words carry more weight than almost anything else in this article, because nearly every difference between a horse's foot and a cow's follows from them: one digit versus two, one hoof versus a cloven pair, a single distal sesamoid versus a pair, a cannon bone that is one metacarpal versus a cannon that is two fused together.

## 05 Where the missing digits went

This is the table that turns comparative anatomy from a curiosity into something you use on clinics. When you look at a limb radiograph, you are looking at a subtraction from five.

| SPECIES | DIGITS PRESENT | WHICH ONES SURVIVE | THE GIVE-AWAY ON THE SKELETON |
|---|---|---|---|
| **Dog & cat** | 5 in front, 4 behind | Weight-bearing digits **II–V**; digit I is the small, non-weight-bearing **dewclaw** | Digit I is commonly absent in the pelvic limb altogether — hence 5 in front, 4 behind |
| **Horse** | 1 | Digit **III** only | Metacarpal III is the cannon bone; metacarpals **II and IV** survive as the medial and lateral **splint bones** |
| **Ox** | 2 functional (+2 vestigial) | Digits **III and IV** take the load; II and V hang behind as the **dewclaws** | One apparent cannon bone is really the **fused third and fourth metacarpal** — you can see the fusion line and the paired distal ends |
| **Sheep** | 2 functional (+2 vestigial) | Digits **III and IV** take the load; II and V hang behind as the **dewclaws** | The same fused cannon as the ox, on a smaller frame. Foot structure is identical across the three ruminants — it is the stomach and the sacrum that separate them |
| **Goat** | 2 functional (+2 vestigial) | Digits **III and IV** take the load; II and V hang behind as the **dewclaws** | As sheep. A goat's foot is not distinguishable from a sheep's on digit count or weight-bearing pair |
| **Pig** | 4 | III and IV bear weight; II and V reach the ground on soft footing | Two large and two small digits, unfused — the artiodactyl pattern without the cannon |
| **Bird (wing)** | 3 | Named in avian anatomy as the **alular**, **major** and **minor** digits rather than by number | The major digit carries the primaries; the carpus and metacarpus are fused into a single **carpometacarpus** |

Two points repay attention. The first is that **reduction is not the same as disappearance**. The horse's digits II and IV are still there as the splint bones, and they still cause disease — a "splint" is periostitis at the interosseous ligament binding those vestiges to the cannon. The ox's digits II and V are still there as dewclaws. Vestigial structures keep their blood supply and their capacity to become inflamed.

The second is that **fusion and loss are different processes**. The horse *lost* digits; the ox *fused* two metacarpals while keeping both digits. A radiograph that shows one bone where you expected two may be showing either, and the distinction determines whether you are looking at normal anatomy or at pathology.

> **Clinical note**Because the ox walks on two digits, it can be lame in one of them and sound in the other — and it will transfer load onto the healthy claw. Digit-level lameness examination makes sense in cattle in a way it cannot in the horse, which has only one digit per limb to be lame in.

## 06 Stance: plantigrade, digitigrade and unguligrade

The other axis on which the same limb is modified is not *how many digits* but **how much of the foot touches the ground**. It is the quickest way to place a species at a glance, and it explains why the bones you palpate sit where they do.

A **plantigrade** animal walks on the whole sole, carpus and tarsus included — bears, rodents, rabbits and ourselves. It is stable, good for climbing and manipulation, and slow. A **digitigrade** animal walks on the digits with the carpus and tarsus carried well clear of the ground, which is the dog and the cat: the raised "backward knee" that owners point at on a dog's hindlimb is the *hock*, the tarsus, and it is high because the animal stands on its toes. An **unguligrade** animal walks on the very tips of the digits, encased in hoof — horses, cattle, sheep and pigs. Each step along that series lengthens the limb, lightens its lower end and lengthens the stride, and each one trades away dexterity to do it.

**The exam trap**The apparent "elbow" high on a horse's forelimb is the elbow, but the joint most people point to as the knee is the **carpus** — the wrist. Everything below it corresponds to your palm and one finger. Fix the stance categories and this stops being confusing.

The gut is classified along an equally useful axis. **Monogastric** species have a single simple stomach — the dog and cat as carnivores, the pig and the human as omnivores. **Foregut fermenters**, the ruminants, put the microbial vat in front of the true stomach. **Hindgut fermenters** such as the horse and rabbit put it behind, in the caecum and colon. All three are herbivore-or-carnivore solutions to the same problem — no vertebrate makes its own cellulase — and which one a species uses predicts its dentition, its abdominal topography and the emergencies it presents with.

## 07 Vertebral formulae compared

The vertebral column is where the shared plan and the species differences are easiest to state numerically. Anatomists write the count as a **vertebral column formula** — cervical, thoracic, lumbar, sacral and caudal in order.

| SPECIES | VERTEBRAL COLUMN FORMULA | WHAT THE NUMBERS ARE TELLING YOU |
|---|---|---|
| **Dog** | **C7 T13 L7 S3 Cd20–23** | The mammalian baseline. Seven cervical vertebrae — the same seven as in a giraffe or a whale |
| **Cat** | **C7 T13 L7 S3 Cd18–20** | Identical to the dog down to the sacrum — only the tail differs. Cd18–20 is the usual figure; the plate below prints **Cd5–23**, a span wide enough to cover tailless breeds such as the **Manx** |
| **Horse** | **C7 T18 L6 S5 Cd15–21** | Five extra thoracic vertebrae and one fewer lumbar: a longer, stiffer thorax built to carry a barrel of gut at speed |
| **Ox** | **C7 T13 L6 S5 Cd18–20** | Thirteen thoracic as in the dog, but **five fused sacral segments** instead of three — the same as the horse. A large body loading the pelvis through its hindlimbs needs that bracing, fast or slow |
| **Sheep** | **C7 T13 L6(7) S4 Cd16–18** | Thirteen thoracic as in the ox — but **four** fused sacral segments, not five. The lumbar count varies between six and seven |
| **Goat** | **C7 T13 L6(7) S5 Cd16–18** | Identical to the sheep except in the sacrum, where the goat keeps the ox's five. The one number that separates the two small ruminants |
| **Pig** | **C7 T14–15 L6–7 S4 Cd20–23** | The most variable column of the seven: thoracolumbar totals run from 19 to 23, and an increase is the more common direction — possibly a consequence of selective breeding for a longer loin |
| **Bird** | **C8–25 T7 L/S1 Cd4–9 P1** | The cervical count varies hugely between species; **L/S1** counts the lumbar and sacral vertebrae as **one** unit — the fused **synsacrum** — and **P1** is the **pygostyle**. A map of the fusions, not a tally |

The famous conserved number is the **seven cervical vertebrae**. It holds in the dog, the cat, the horse, the ox, in a giraffe and in a whale — neck length is achieved by changing the size of the seven, not the number. It is a striking constraint, but it is not absolute: among mammals, **sloths carry six to nine** and **sirenians (manatees and dugongs) six**, and in armadillos and jumping mammals such as kangaroo rats the seven may themselves **fuse**. None of those is a domestic species, which is why "seven" is safe in practice — but "*typically* seven" is the accurate claim. Beyond the neck, conservation breaks down quickly, and the thoracolumbar counts follow lifestyle: the horse's eighteen thoracic vertebrae make a long, stiff, deep thorax, and its six lumbar vertebrae make a short back.

Mammals fuse vertebrae too — the **sacrum** is nothing but fused vertebrae, three in the dog and five in the horse and ox. What makes the bird different is not that it fuses but **how much, and in how many places**.

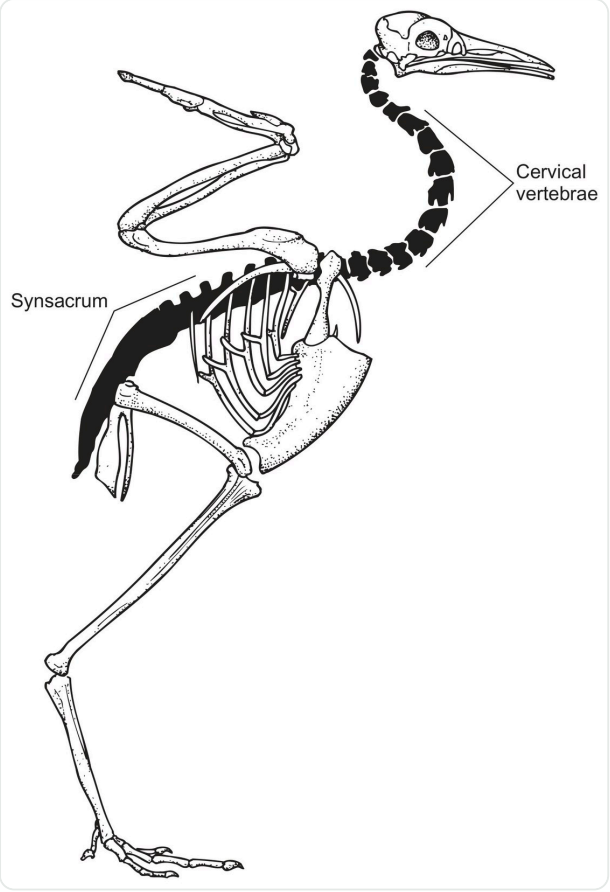



**Fig 11 — The avian vertebral column: mobile at the front, fused behind.** The whole bird in one view, with the two ends of the column contrasted. The **cervical vertebrae** are numerous and **heterocoelous** — their saddle-shaped articular surfaces allow the extraordinary neck mobility a bird needs to reach every part of its body with its beak, since it cannot use its forelimbs. Behind them, shaded, the **synsacrum**: an extensive region of **vertebral fusion** welding the lumbar and sacral vertebrae to the pelvis into a single rigid girder. Mobility where feeding and grooming demand it; rigidity where flight loads demand it.

Image — Kardong KV. Vertebrates: Comparative Anatomy, Function, Evolution , 6th ed. McGraw-Hill — Fig 8.41, bird vertebral column. Reproduced for educational reference.

In the bird the column is fused in **three separate places**: the **notarium** in the thorax, the **synsacrum** in the lumbosacral region, and the **pygostyle** at the tail. That is why the avian formula in the table looks so strange — **C8–25 T7 L/S1 Cd4–9 P1**. The cervical count is written as a range because it genuinely varies that much between species; **L/S1** counts the whole lumbosacral region as a *single* unit because that is what the synsacrum is; and **P1** is the pygostyle. The formula is less a count than a map of what has been welded together. Free intervertebral spaces are so few and so narrow that the **atlanto-occipital space is effectively the only site** for cerebrospinal fluid collection in a bird.

> **Study tip**Learn the dog formula cold (**C7 T13 L7 S3**) and then learn each other species as a *difference* from it. Horse: five more thoracic, one fewer lumbar, five sacral. Ox: same thoracic as the dog, one fewer lumbar, five sacral. That is three facts instead of twelve.

### What the column contains: the cord ends in a different place in every species

Counting vertebrae is only half of it. The **spinal cord is shorter than the canal it lies in**, and it stops at a different level in each species — which is the reason a needle placed by memory rather than by species is dangerous. The cord tapers to the **conus medullaris**, behind which the lumbar, sacral and caudal roots run on alone as the **cauda equina**.

| SPECIES | THE CORD (CONUS MEDULLARIS) ENDS AT… | WHY IT MATTERS |
|---|---|---|
| **Dog** | Between the **L6 and L7** vertebrae — more cranial in large breeds, more caudal in small ones | The lumbosacral space lies behind the cord itself, which is what makes it usable. Breed size shifts the target |
| **Cat** | Between the **L7 vertebra and the sacrum** | Further caudal than the dog, so a needle placed at a "canine" depth and site is closer to cord than you intend |
| **Horse** | **S2** | The most caudal termination of the seven, which is why the equine lumbosacral space is a different proposition from the dog's |
| **Ox** | At the level of **S1–S2**, with the dura running on to the **4th caudal vertebra** | The subarachnoid space continues to about S3–S4 — the anatomical basis for caudal approaches in cattle |
| **Sheep** | May occupy **almost the whole sacrum** | The row that matters most in this table. A small ruminant is not a small cow: the cord runs on where the bovine cord has already finished |
| **Goat** | As sheep — potentially the length of the sacrum | Dyce treats the small ruminants together here, and separates them only on the sacral count |

| SPECIES | THE CORD (CONUS MEDULLARIS) ENDS AT… | WHY IT MATTERS |
|---|---|---|
| **Pig** | **L5–L6** | The most cranial termination of the seven — the opposite end of the range from the horse |
| **Bird** | As a small extension into the **pygostyle**, after the last spinal nerve has left | Combined with the vertebral fusions, this leaves the **atlanto-occipital space** as effectively the only CSF site |

Read that table beside the formulae above and the practical point lands: the ox has one fewer lumbar vertebra than the dog *and* a cord that ends further back again — in the *sacrum* rather than in the lumbar spine. Neither fact is usable without the other.

## 08 Five skeletons, one plan

Everything so far has been general. Here are five domestic species drawn in the same view, at the same orientation, by the same atlas — which is the single most useful comparative exercise there is, because it removes every difference except the anatomy.

Work through them looking for the same three things in each: **how long is the thorax**, **how much of the limb is off the ground**, and **where does the column stop being mobile**.

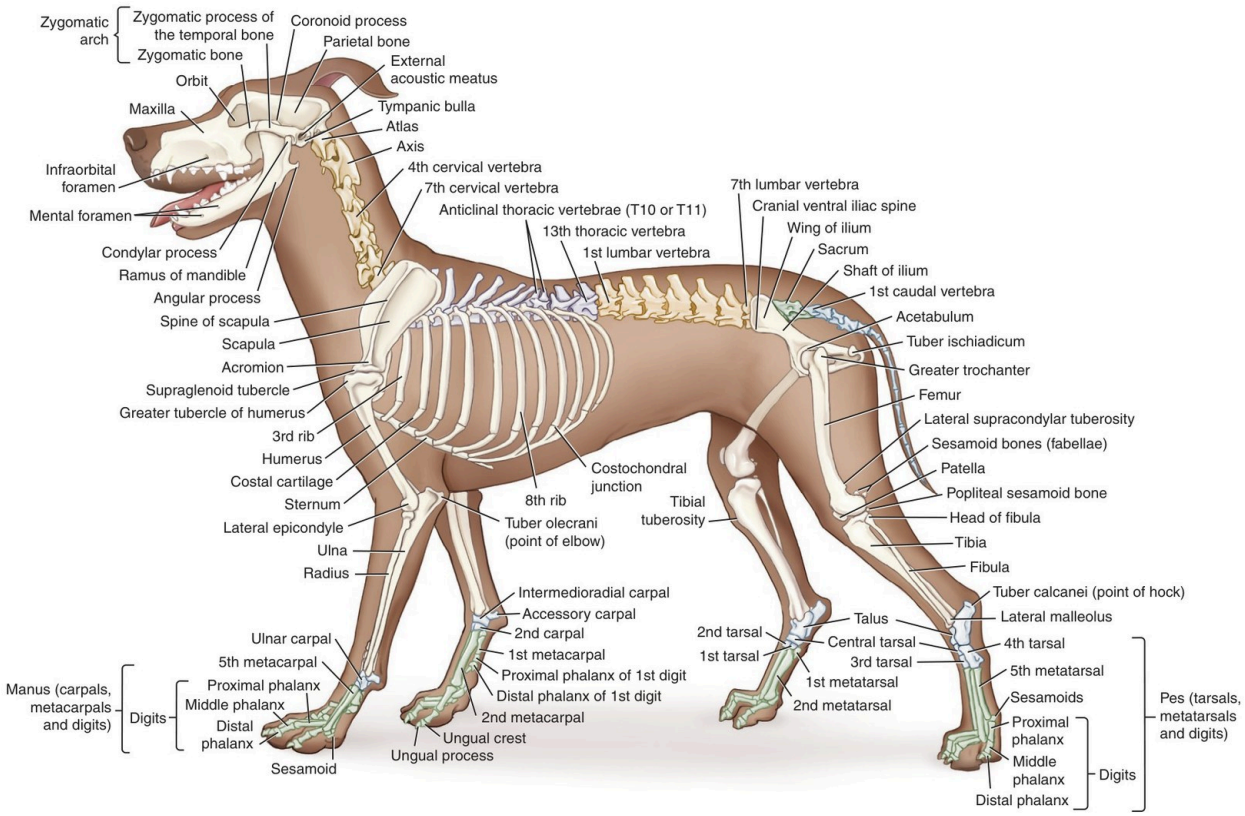



**FIGURE 3A-9** Lateral view of the canine skeleton. *Vertebral column formula*: $C_7T_{13}\ L_7\ S_3\ Cd_{20\text{-}23}$.

**Fig 12 — The canine skeleton, lateral view.** The baseline. Named landmarks run from the **maxilla** and **ramus of the mandible** through the **axis**, the **7th cervical**, **1st** and **7th lumbar** and **1st caudal vertebra**, then the limbs — **scapula** and its **spine**, **humerus** with the **greater tubercle**, **radius** and **ulna**, the individual carpals (**accessory**, **ulnar**, **intermedioradial**, **2nd**), the **5th metacarpal**, and behind, **femur**, **patella**, **talus** and the **tuber calcanei**. Vertebral column formula: **C7 T13 L7 S3 Cd20–23**.

Image — Orsini JA, Grenager NS, de Lahunta A (eds). Comparative Veterinary Anatomy: A Clinical Approach . Academic Press/Elsevier — Fig 3A-9, lateral view of the canine skeleton. Reproduced for educational reference.

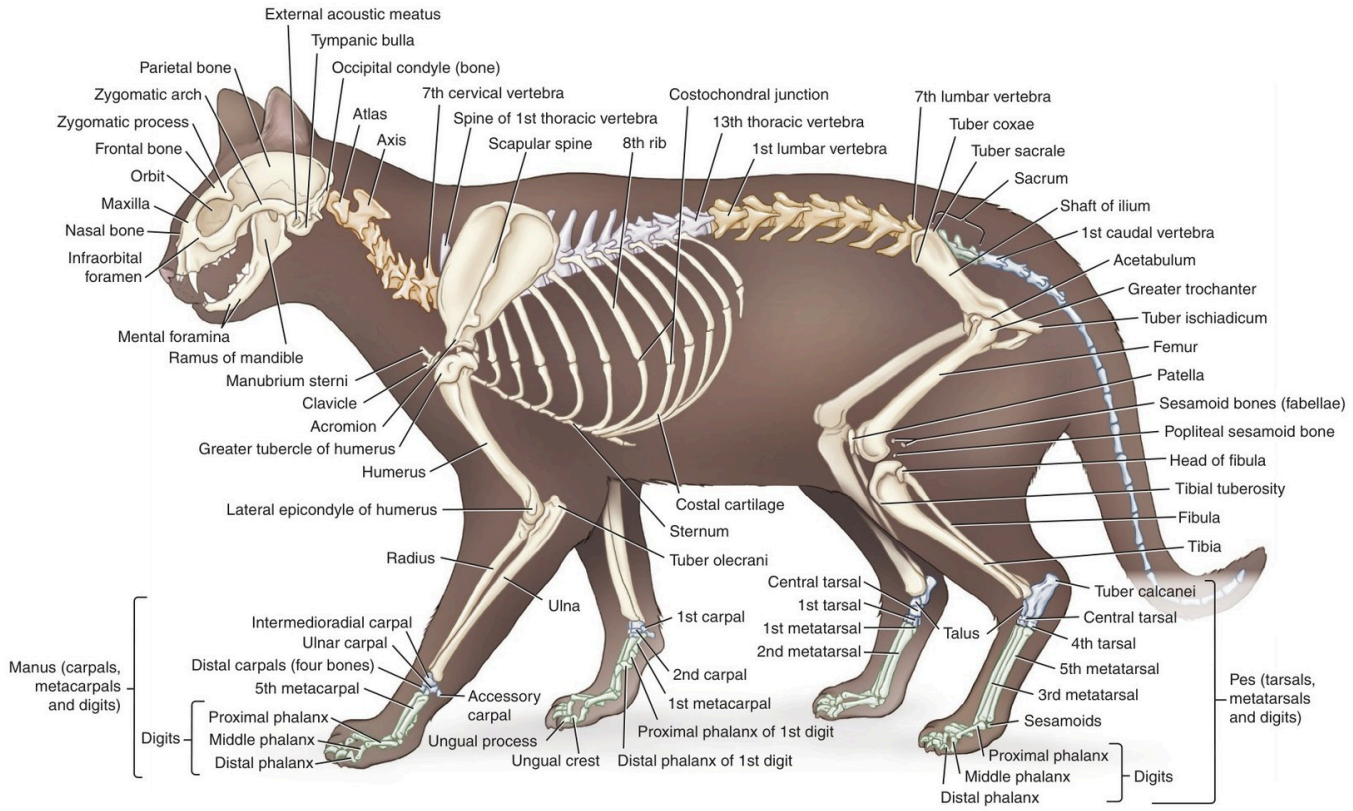



**FIG. 3B-9** Lateral view of the feline skeleton. *Vertebral column formula*: $C_7T_{13}L_7S_3Cd_{5\text{-}23}$.

**Fig 13 — The feline skeleton, lateral view.** Almost the same animal as the dog, and deliberately drawn the same way so that it is obvious. The same **7th cervical**, **1st** and **7th lumbar** and **1st caudal** vertebrae; the same **scapular spine**, **humerus**, **radius** and **ulna**; the same carpal set, here including the **intermedioradial carpal** and the **distal carpals (four bones)**. Feline extras worth noting: the **occipital condyle**, the **popliteal sesamoid** and the **fabellae** behind the stifle. The formula is identical to the dog's as far as the sacrum.

Image — Orsini JA, Grenager NS, de Lahunta A (eds). Comparative Veterinary Anatomy: A Clinical Approach . Academic Press/Elsevier — Fig 3B-9, lateral view of the feline skeleton. Reproduced for educational reference.

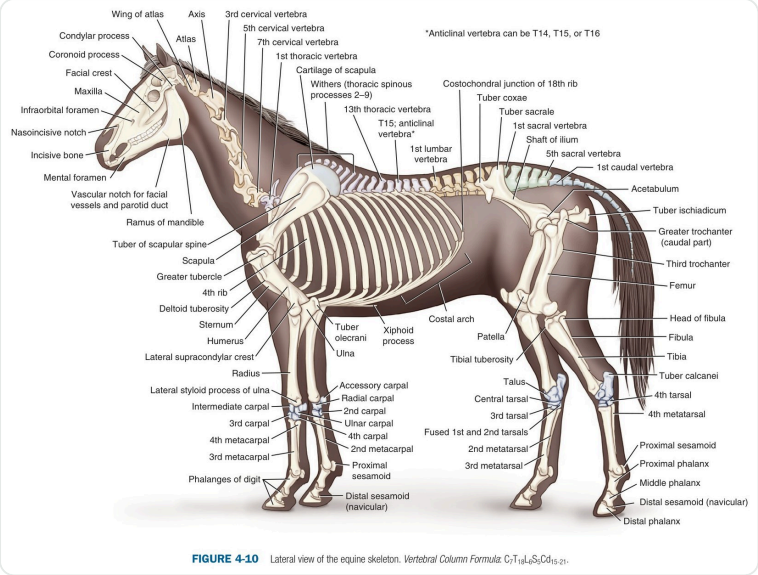



**FIGURE 4-10** Lateral view of the equine skeleton. *Vertebral Column Formula:* $C_7T_{18}L_6S_5Cd_{15-21}$.

**Fig 14 — The equine skeleton, lateral view.** Now the plan has been stretched. The **withers** are named explicitly as the **spinous processes of thoracic vertebrae 2–9**; the **atlas**, **axis**, **3rd**, **5th** and **7th cervical**, **1st lumbar**, **1st** and **5th sacral** and **1st caudal** vertebrae are all labelled, along with the **4th rib** and the **costal arch**. Note the **cartilage of the scapula** extending the bone dorsally, the prominent **deltoid tuberosity**, and the limb ending in a **single digit**. Vertebral column formula: **C7 T18 L6 S5 Cd15–21**.

Image — Orsini JA, Grenager NS, de Lahunta A (eds). Comparative Veterinary Anatomy: A Clinical Approach . Academic Press/Elsevier — Fig 4–10, lateral view of the equine skeleton. Reproduced for educational reference.

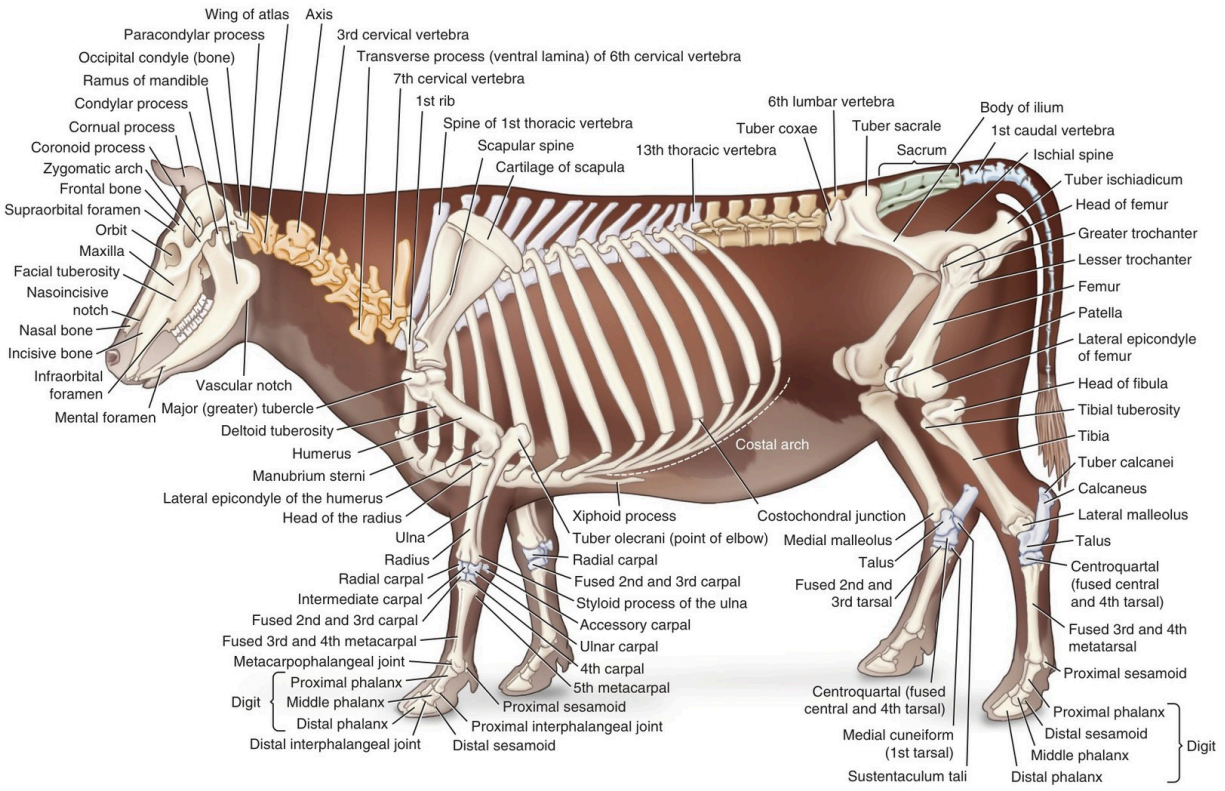



**FIG. 5-9** Lateral view of the bovine skeleton. *Vertebral column formula*: $C_7T_{13}\ L_6\ S_5\ Cd_{18\text{-}20}$.

**Fig 15 — The bovine skeleton, lateral view.** The artiodactyl answer to the same problem. Labels include the **wing of the atlas**, the **3rd** and **7th cervical**, the **6th lumbar** and **1st caudal** vertebrae, the **manubrium sterni** and **xiphoid process**, and the **cartilage of the scapula**. In the limb, read the carpus carefully: **radial**, **ulnar** and **accessory carpals**, the **fused 2nd and 3rd carpal**, the **4th carpal** — and then the give-away, the **fused 3rd and 4th metacarpal** with a separate small **5th metacarpal**. Behind, the **fused 3rd and 4th metatarsal**. Formula: **C7 T13 L6 S5 Cd18–20**.

Image — Orsini JA, Grenager NS, de Lahunta A (eds). Comparative Veterinary Anatomy: A Clinical Approach . Academic Press/Elsevier — Fig 5–9, lateral view of the bovine skeleton. Reproduced for educational reference.

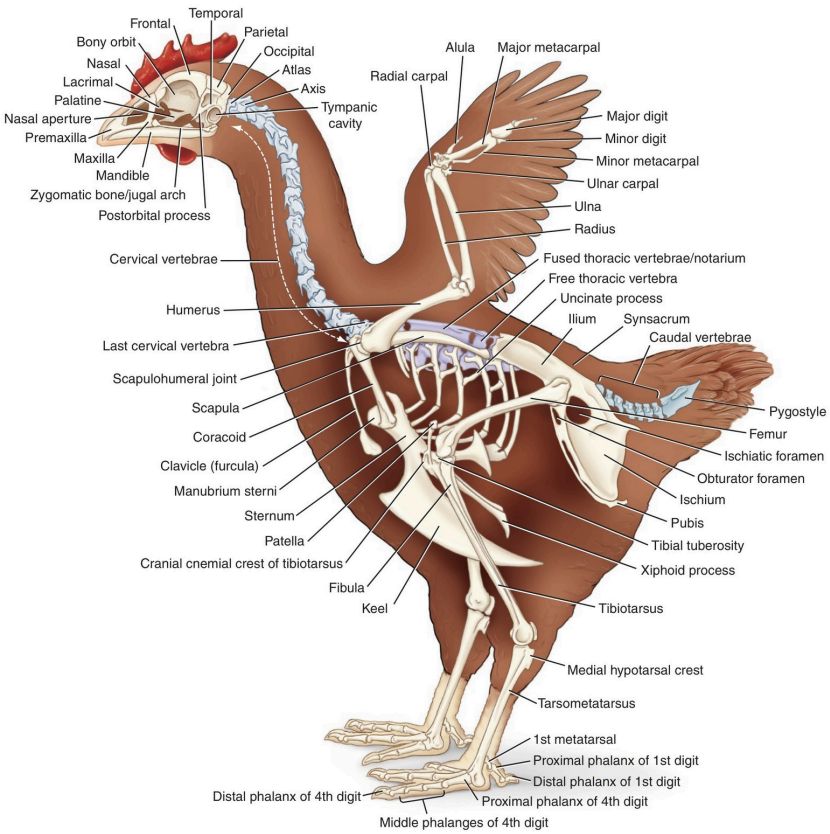



**FIG. 6-7** Lateral view of the avian skeleton. Vertebral column formula: $C_{8\text{-}25}T_7L/S_1Cd_{4\text{-}9}P_1$.

**Fig 16 — The avian skeleton.** The same plan, edited hardest. The skull bones are still named individually — **premaxilla**, **nasal**, **frontal**, **parietal**, **temporal**, **occipital**, **mandible** — and the **atlas** and **axis** are where you expect them. Then the departures: the **fused thoracic vertebrae (notarium)** beside a **free thoracic vertebra**, the **synsacrum**, and the **caudal vertebrae** ending in the **pygostyle**. In the girdles, the **coracoid**, the **clavicle (furcula** — the wishbone**)** and the deep **keel** of the breastbone. In the pelvic limb, **femur**, **patella**, **fibula** and the compound **tarsometatarsus**, with the **1st metatarsal** and the proximal phalanges of the **1st** and **4th digits**.

Image — Orsini JA, Grenager NS, de Lahunta A (eds). Comparative Veterinary Anatomy: A Clinical Approach . Academic Press/Elsevier — Fig 6–7, the avian skeleton. Reproduced for educational reference.

Placed together, the five plates make the argument better than any amount of prose. The dog and cat are near-identical. The horse and ox have both raised the wrist and ankle clear of the ground and reduced the digits, but by different routes. The bird has fused what the mammals kept mobile and hollowed what the mammals kept solid — and yet the **maxilla, mandible, atlas, axis, scapula, humerus, femur and patella** are named in exactly the same words on all five.

## 09 Skulls: fenestration and feeding

Skulls are classified by something that sounds obscure and turns out to be useful: **how many holes there are behind the eye socket**. Those openings, the **temporal fenestrae**, exist because jaw muscles need somewhere to bulge as they contract, and their arrangement defines the great amniote lineages.

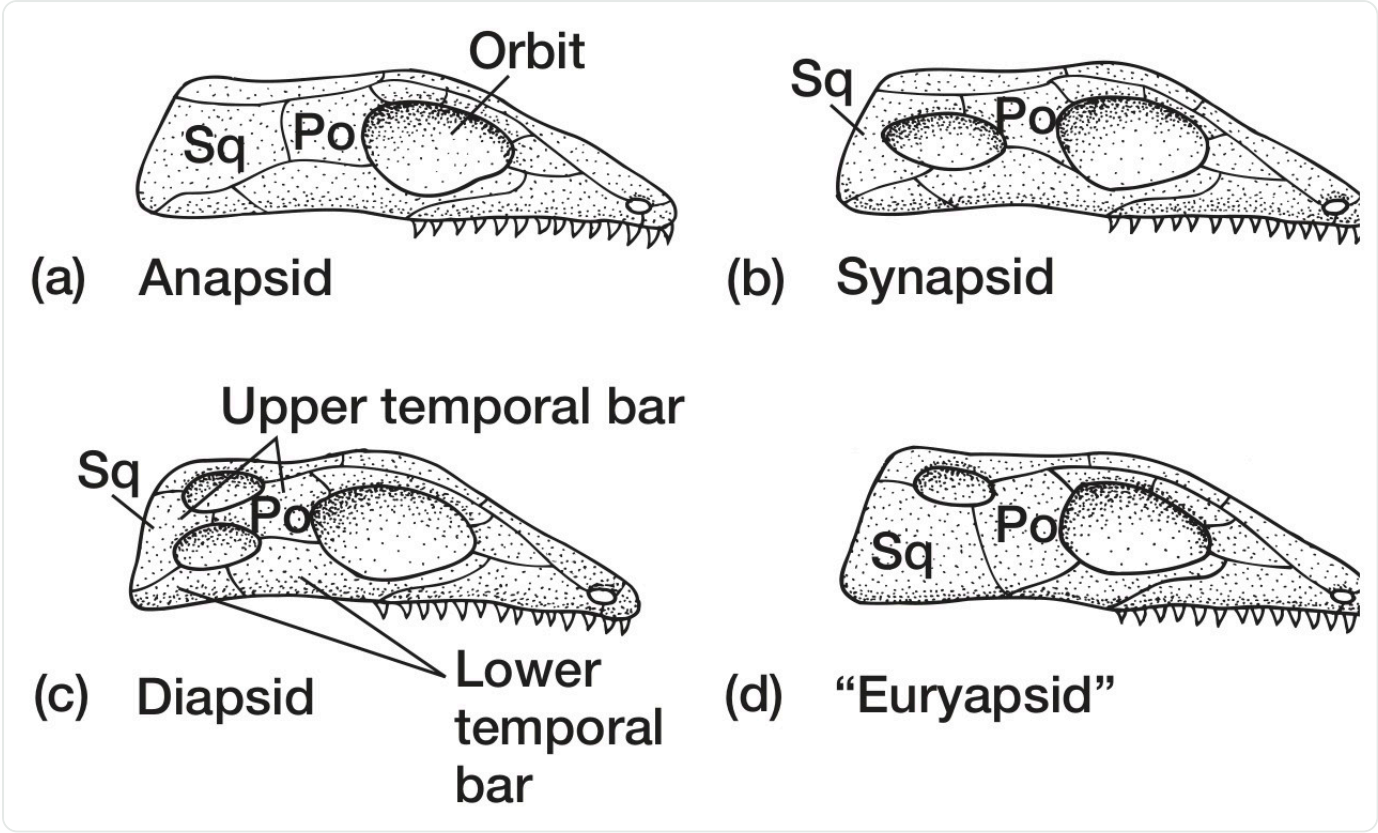



**Fig 17 — The four amniote skull types.** Each skull is drawn in lateral view with the **orbit** in front and the **squamosal (Sq)** and **postorbital (Po)** bones marked, because it is those two bones that form the bars between the openings. **(a) Anapsid** — no temporal fenestra at all. **(b) Synapsid** — a single fenestra with a bar *above* it. **(c) Diapsid** — two fenestrae separated by the **upper temporal bar**, with the **lower temporal bar** beneath. **(d) "Euryapsid"** — a single fenestra with a bar *below* it, now interpreted not as a separate type but as a **diapsid skull that lost its lower temporal bar**.

Image — Kardong KV. Vertebrates: Comparative Anatomy, Function, Evolution , 6th ed. McGraw-Hill — Fig 3.28, amniote skull types. Reproduced for educational reference.

| SKULL TYPE | TEMPORAL OPENINGS | WHO HAS IT | HOW TO SPOT IT |
|---|---|---|---|
| **Anapsid** | None | The primitive amniote condition; the skull retained by modern **turtles** | Solid bone behind the orbit — no fenestra at all. Whether turtles are *primitively* anapsid, or diapsids that lost their fenestrae, is unresolved |
| **Synapsid** | One | Mammals and their ancestors — so every domestic mammal you will meet | A single opening, bounded **above** by a **postorbital–squamosal** bar. In mammals that bone is **lost**; the bar that survives is the one **below** — the **zygomatic arch** |
| **Diapsid** | Two | Reptiles and **birds** | Two openings separated by the **upper temporal bar** |
| **"Euryapsid"** | One, low | Some Mesozoic marine reptiles — plesiosaurs, ichthyosaurs | A single opening with a bar **below** it. Now read as a **modified diapsid** skull that lost its lower bar, not a separate type |

Here is why this is not trivia. Every domestic mammal is a **synapsid** — one temporal opening. Follow what happens to it: in mammals the opening *enlarges* enormously to house a bigger temporalis, the **postorbital bone is lost altogether**, and the bar that survives is the one **below** the fenestra. That surviving bar is the **zygomatic arch**, formed by the **zygomatic (jugal) bone** and the **zygomatic process of the temporal bone** — exactly as the canine skeleton plate above labels it. When you palpate the arch on a dog, evaluate a cat for masticatory muscle myositis, or reduce a zygomatic fracture, that is the bone you are working on. Meanwhile every bird is a **diapsid**, which is one of several places in this article where the chicken turns out to be closer to a crocodile than to a cow.

Losing the postorbital bone has a second consequence you can feel on any patient: it leaves a gap in the **orbital rim**. Dogs and cats, like other carnivores, have an **open (incomplete) orbit** — bone only part of the way round, with the **orbital ligament** completing the lateral rim as a band of fibrous tissue you can palpate between the frontal bone and the zygomatic arch. The larger herbivores went the other way: the horse and the ox have a **complete bony orbital rim**, closed by the zygomatic process of the frontal bone meeting the zygomatic. It is the

reason a blow that would fracture an orbital rim in a horse tears soft tissue in a dog, and the reason an equine eye sits in a bony socket that a dog's does not.

Within the synapsid pattern, the domestic species then vary the *proportions* rather than the plan — the long-nosed **dolichocephalic** skull of a greyhound, the intermediate **mesaticephalic** skull of a labrador and the flattened **brachycephalic** skull of a pug are three arrangements of an identical set of bones. Our canine skull and dental anatomy guide works through that variation and its consequences in detail.

## 10 Proving two muscles are the same

Bones are relatively easy to homologise: they are hard, they articulate in a fixed order, and they fossilise. Muscles are much harder. They attach in different places in different species, they change function, and they can split or fuse. So how do you decide that a muscle in a frog and a muscle in a horse are *the same muscle*?

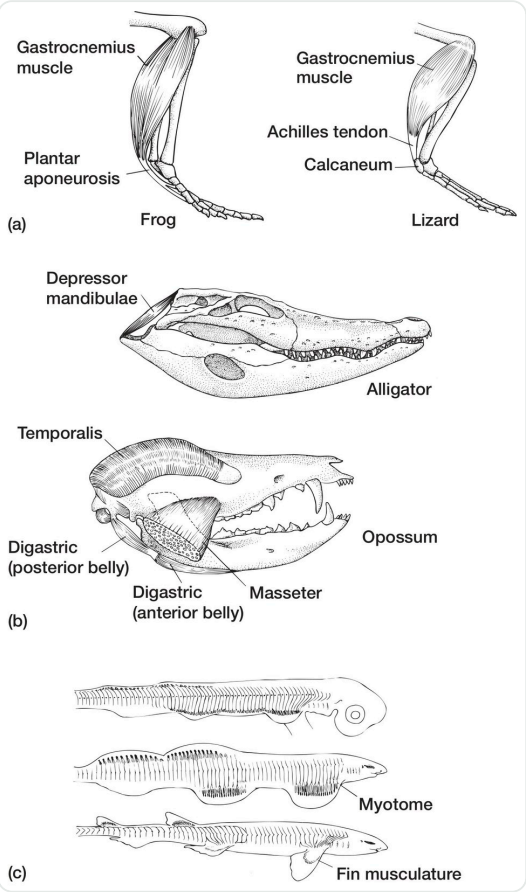



**Fig 18 — Three criteria for muscle homology — and how one of them fails. (a)** *Function.* The posterior shank muscles of a **frog** and a **lizard** both extend the foot, and both use a **gastrocnemius muscle**, an **Achilles tendon** and a **plantar aponeurosis** over the **calcaneum** — but the insertions are slightly different in each animal, so similar function only *suggests* homology. **(b)** *Nerve supply.* The **depressor mandibulae** of the **alligator** and the **digastric** of the **opossum** (here with **anterior** and **posterior bellies**, beside the **temporalis** and **masseter**) both open the jaw — yet their nerve supply differs, so the two are **not** homologous. **(c)** *Embryonic origin.* In a shark, the ventral tips of the **myotomes** grow downward and enter the fin to form the **fin musculature**; tetrapod limb muscles arise from myotomes in the same way.

Image — Kardong KV. Vertebrates: Comparative Anatomy, Function, Evolution , 6th ed. McGraw-Hill — Fig 10.19, criteria for muscle homology, (c) after Goodrich. Reproduced for educational reference.

| CRITERION | HOW STRONG IS IT? | WHY |
|---|---|---|
| **Similar function** | Weak | Two muscles can do the same job and be unrelated. The posterior shank muscles of a frog and a lizard both extend the foot, yet their insertions differ |
| **Position and attachments** | Moderate | Useful, but origins and insertions **migrate** over evolutionary time, so a shifted attachment does not disprove homology |
| **Nerve supply** | Strong | A muscle keeps its nerve. The reptilian **depressor mandibulae** and the mammalian **digastric** both open the jaw, but their nerve supply differs — so they are **not** homologous |
| **Embryonic origin** | Strong | A shared developmental pattern is powerful evidence. Limb muscles arise from **myotomes** in the same way that fin muscles do in a shark |

The rule that falls out of this is one of the most practically useful in the whole subject: **follow the nerve.** A muscle carries its innervation with it through evolution, so nerve supply survives changes of position, attachment and function. It is why the diaphragm — the partition between thorax and abdomen, a long way from the neck — is supplied by the **phrenic nerve** from *cervical* spinal segments: the muscle arises from cervical somites, migrates caudally during development, and takes its nerve with it.

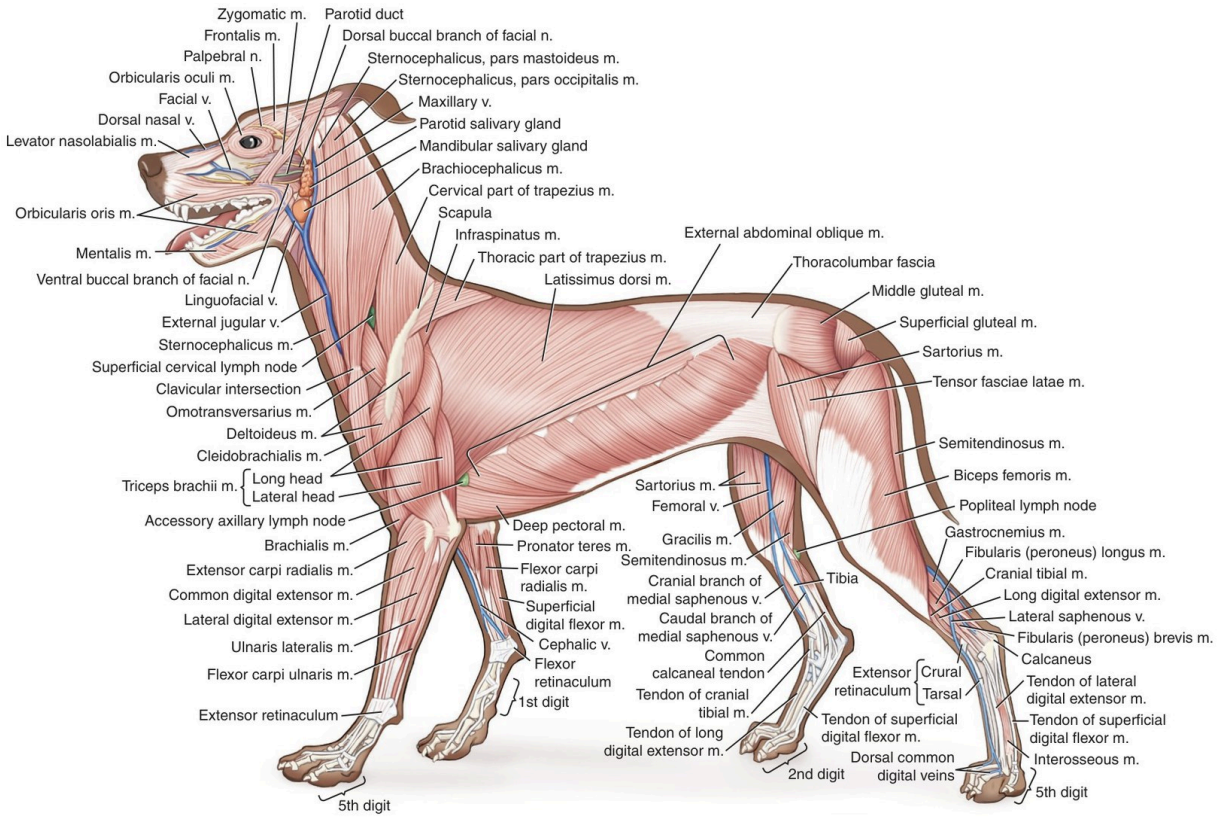



**FIGURE 3A-4** Superficial canine muscle layer.

**Fig 19 — The superficial muscle layer of the dog.** The homology argument cashed out in a real patient. The superficial sheet is dissected in lateral view, with the muscles you will meet in every small-animal approach named in place — the **brachiocephalicus**, **sternocephalicus**, **omotransversarius** and **cleidobrachialis** in the neck and shoulder, **trapezius**, **deltoideus**, **latissimus dorsi**, the **pectoral** group, **triceps brachii**, the **external abdominal oblique**, and behind, **gluteal**, **biceps femoris** and **sartorius**. Each of these has a named equivalent in the horse, the ox and, with more editing, the bird.

Image — Orsini JA, Grenager NS, de Lahunta A (eds). Comparative Veterinary Anatomy: A Clinical Approach . Academic Press/Elsevier — Fig 3A-4, superficial muscles of the dog, lateral aspect. Reproduced for educational reference.

Our dog muscle anatomy guide takes this layer apart origin by origin and insertion by insertion, and it is worth reading alongside this section: once you can name a muscle's nerve, you can usually predict where the same muscle sits in a species you have never dissected.

## 11 Body cavities and viscera: same rooms, different furniture

In the *mammals*, the trunk is divided by the diaphragm into a **thoracic** and an **abdominal** cavity, with the same organs in the same relative positions — heart and lungs in front, liver against the diaphragm, kidneys retroperitoneal, bladder in the pelvis. What differs between them, dramatically, is the size of the fermentation vat and where it has been put. The bird does not follow this plan at all: it has **no diaphragm**, so no thorax and abdomen in the mammalian sense but a single **coelom**, and it has **no urinary bladder** — the ureters open directly into the cloaca. Keep that in view as you read the fourth plate against the first three.

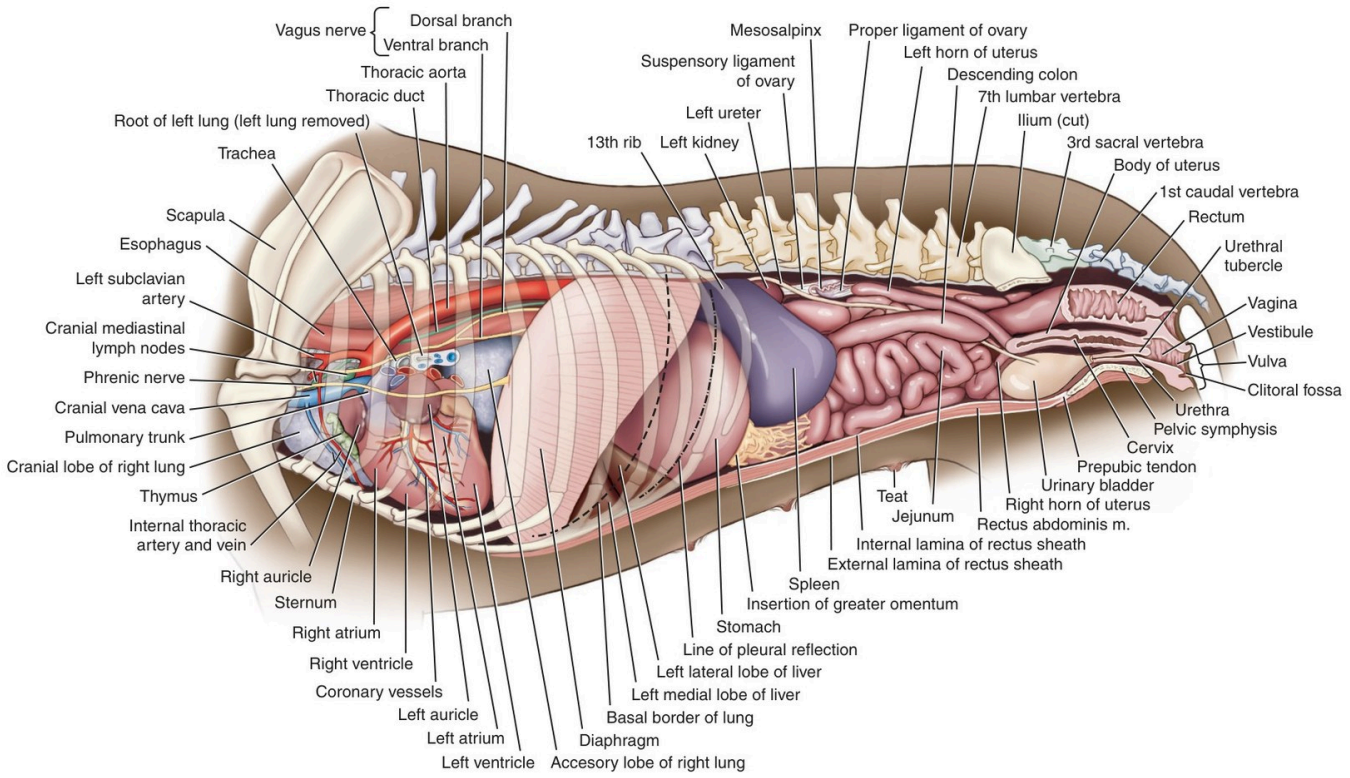



**FIGURE 3A-6** Left view of the canine thoracic and abdominal cavities and pelvis (female).

**Fig 20 — The canine thoracic and abdominal cavities, left view.** The carnivore baseline, with the left lung removed to expose the mediastinum. In the thorax: **trachea**, **esophagus**, **aorta**, **heart** with its **atria** and **ventricles**, the **lung lobes**, and the **phrenic** and **vagus** nerves running the length of it. Behind the **diaphragm**: the **liver**, **stomach**, **spleen**, the coils of **jejunum**, the **descending colon**, **left kidney** and **urinary bladder**. Note how little of the abdomen any single organ claims.

Image — Orsini JA, Grenager NS, de Lahunta A (eds). Comparative Veterinary Anatomy: A Clinical Approach . Academic Press/Elsevier — Fig 3A-6, left view of the canine thoracic and abdominal cavities. Reproduced for educational reference.

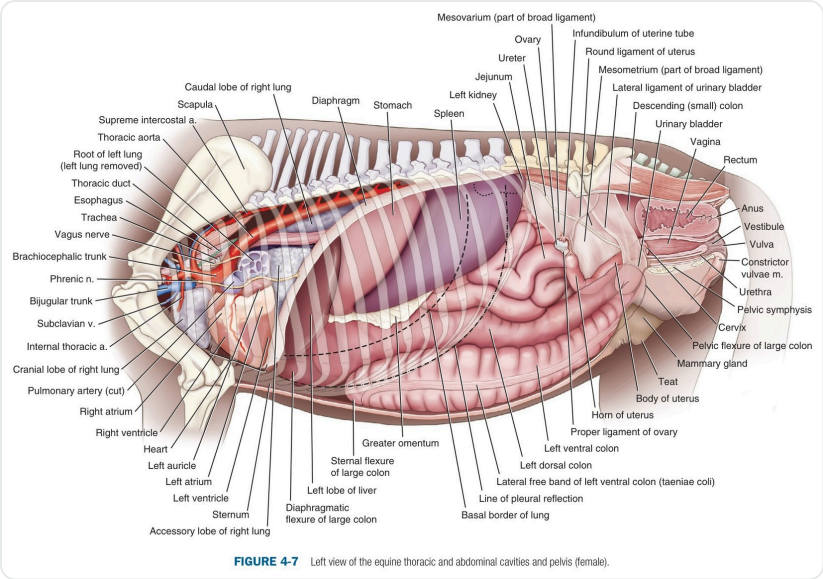



**FIGURE 4-7** Left view of the equine thoracic and abdominal cavities and pelvis (female).

**Fig 21 — The equine cavities, left view — the hindgut fermenter.** The same view in the horse, and the abdomen is now dominated by one structure: the **large colon**. Its named parts are all here — the **left ventral** and **left dorsal colon**, the **sternal flexure**, the **diaphragmatic flexure**, the **pelvic flexure**, and the **lateral free band of the left ventral colon (taeniae coli)** — with the **descending (small) colon**, **stomach**, **spleen**, **jejunum** and **left kidney** fitted around it. The **greater omentum** and the **line of pleural reflection** are marked, as are the reproductive structures of the mare.

Image — Orsini JA, Grenager NS, de Lahunta A (eds). Comparative Veterinary Anatomy: A Clinical Approach . Academic Press/Elsevier — Fig 4–7, left view of the equine thoracic and abdominal cavities and pelvis (female). Reproduced for educational reference.

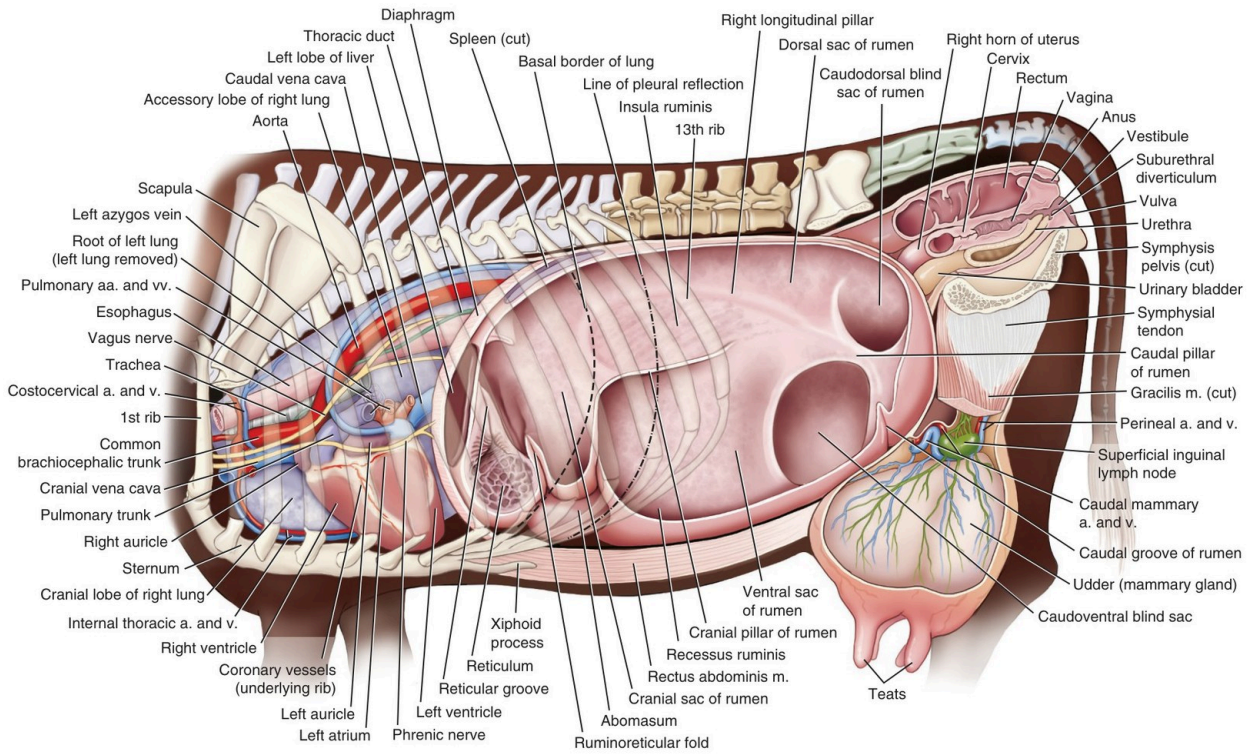



**FIG. 5-6** Left view of the bovine thoracic and abdominal cavities and pelvis (female).

**Fig 22 — The bovine cavities, left view — the foregut fermenter.** The ruminant solution, and it fills the left abdomen completely. The **rumen** is labelled through its architecture: **dorsal** and **ventral sacs**, **caudodorsal** and **caudoventral blind sacs**, the **right longitudinal**, **cranial**, **caudal** and **dorsal pillars**, the **insula ruminis** and the **recessus ruminis**. In front of it the **reticulum** with its **reticular groove** and the **ruminoreticular fold**; behind, the **abomasum** — the true stomach, and the only one of the four with a mammalian glandular lining. Note the **13th rib** and the **line of pleural reflection** for the flank landmarks.

Image — Orsini JA, Grenager NS, de Lahunta A (eds). Comparative Veterinary Anatomy: A Clinical Approach . Academic Press/Elsevier — Fig 5–6, left view of the bovine thoracic and abdominal cavities and pelvis (female). Reproduced for educational reference.

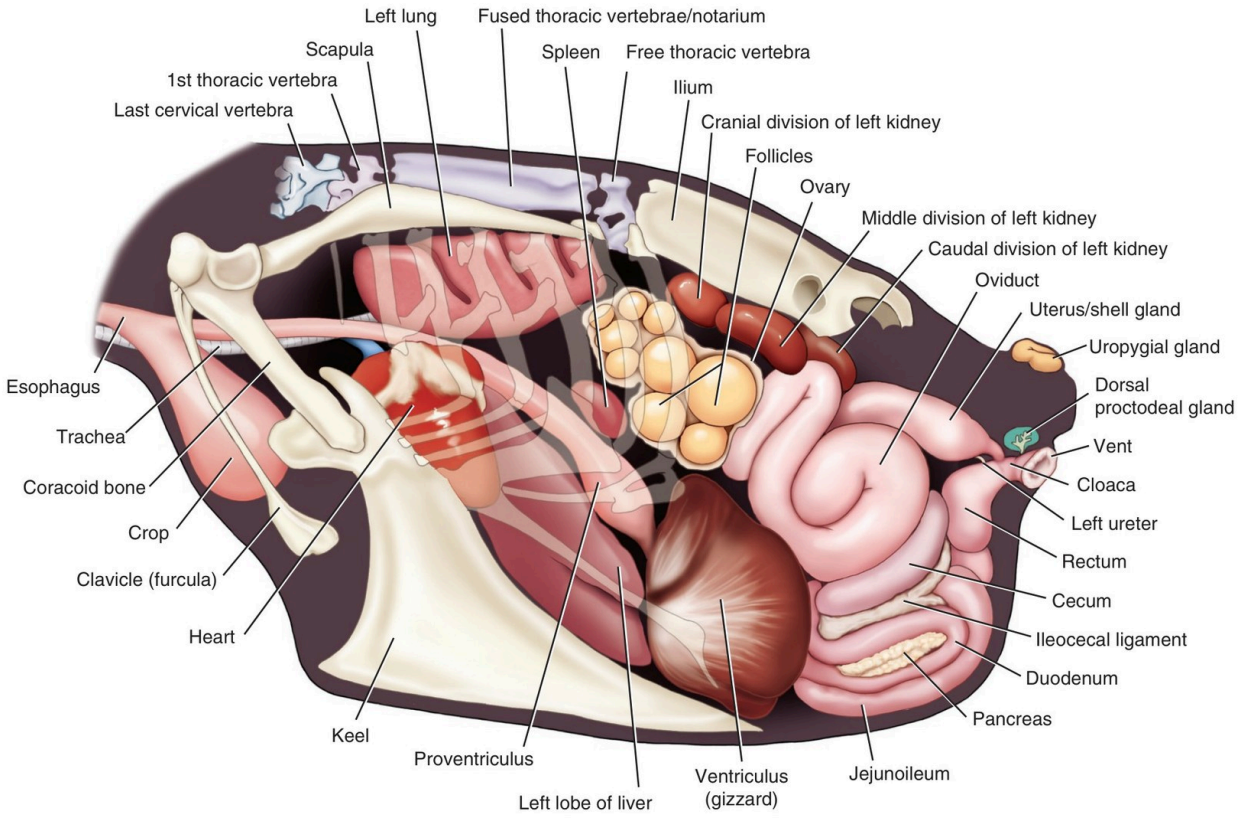



**FIG. 6-5** Left view of the avian thoracic and abdominal cavities and pelvis—Female.

**Fig 23 — The avian cavities, left view — and no diaphragm at all.** The plan at its most edited. Along the digestive tract: **esophagus**, **crop**, **proventriculus** (the glandular stomach), **ventriculus (gizzard)** — the muscular mill that replaces chewing — then **duodenum**, **pancreas**, **jejunoileum**, **cecum** with its **ileocecal ligament**, **rectum** and **cloaca**, ending at the **vent**. The reproductive tract of the hen is in view — **ovary** with graded **follicles**, **oviduct**, **uterus/shell gland** — alongside the three divisions of the **left kidney**. Structurally, note the **keel**, the **coracoid** and **clavicle (furcula)**, the **notarium**, and above all that there is **no diaphragm** dividing the body cavity.

Image — Orsini JA, Grenager NS, de Lahunta A (eds). Comparative Veterinary Anatomy: A Clinical Approach . Academic Press/Elsevier — Fig 6–5, left view of the avian thoracic and abdominal cavities and pelvis (female). Reproduced for educational reference.

| SPECIES | STRATEGY | THE ORGAN THAT DOMINATES THE ABDOMEN | CONSEQUENCE YOU CAN SEE |
|---|---|---|---|
| **Dog & cat** | Simple-stomached carnivore | Nothing dominates. A small stomach, short intestine, and a liver that fills the cranial abdomen | Gut length relative to body length is the shortest of the domestic species — and dietary fibre (fiber) does very little for them |
| **Horse** | **Hindgut** fermenter | The **large colon** — a vast, sacculated tube with fixed flexures | Those flexures and the mobile, unattached segments are exactly where displacement and impaction colic happen |
| **Ox** | **Foregut** fermenter | The **rumen**, filling the entire left abdomen, divided by pillars into dorsal and ventral sacs | Fermentation happens *before* the true stomach, so ruminants live off microbial protein — and off feed that would starve a horse |
| **Sheep & goat** | **Foregut** fermenter | The rumen again — but the chambers behind it are proportioned differently. The abomasum takes **13%** of stomach volume against the ox's 7%, and the omasum only **4%** against 8% | The omasum is the ox's organ and the abomasum is the small ruminant's. It is no accident that displaced abomasum is a dairy-cow disease and that abomasal problems in lambs present differently |
| **Pig** | **Omnivore**, with real hindgut fermentation | Nothing dominates, but the stomach carries a **conical diverticulum** off the fundus that no other domestic species has, and the ascending colon is coiled into a spiral | The only one of the seven that is genuinely built for a mixed diet — the most complete dentition in front, a spiral colon behind |
| **Bird** | Lightweight, high-throughput | No single dominant organ, but a **crop**, a glandular **proventriculus** and a muscular **ventriculus** (gizzard) | Chewing is outsourced to the gizzard, there is **no diaphragm**, and the whole gut empties into a **cloaca** |

Read those four plates in sequence and the logic is unmistakable. **No vertebrate makes its own cellulase**, so any animal living on plant fibre has to rent the enzyme from microbes — and the herbivores here rent it in different places. The horse houses the fermentation vat **after** the small intestine; the ox houses it **before** the true stomach. The bird takes a different route entirely, grinding hard feed in a muscular mill rather than fermenting it at volume. The dog and cat, being carnivores, never needed the arrangement and never evolved it. The organs are homologous throughout; the strategy is not.

For the ruminant version in depth, see our ruminant stomach anatomy guide and the companion piece on how the rumen actually works; for the equine abdomen and the surgical geography of those flexures, our horse anatomy guide.

> **Clinical note**The absence of an avian diaphragm is not a detail. A bird does not ventilate by dropping a muscular partition, so anything that restricts sternal movement — including the way you hold it — restricts breathing. Our avian anatomy guide covers the air-sac system that replaces the mammalian arrangement.

## 12 The aortic arches: the clearest case of a plan modified

If you want a single example that makes the whole comparative argument, use the great vessels. Every vertebrate embryo lays down the same series of paired vessels running through the pharyngeal arches; every adult vertebrate then deletes and remodels a subset of them. Six pairs is taken as the basic embryonic pattern, numbered **I to VI** in Roman numerals.

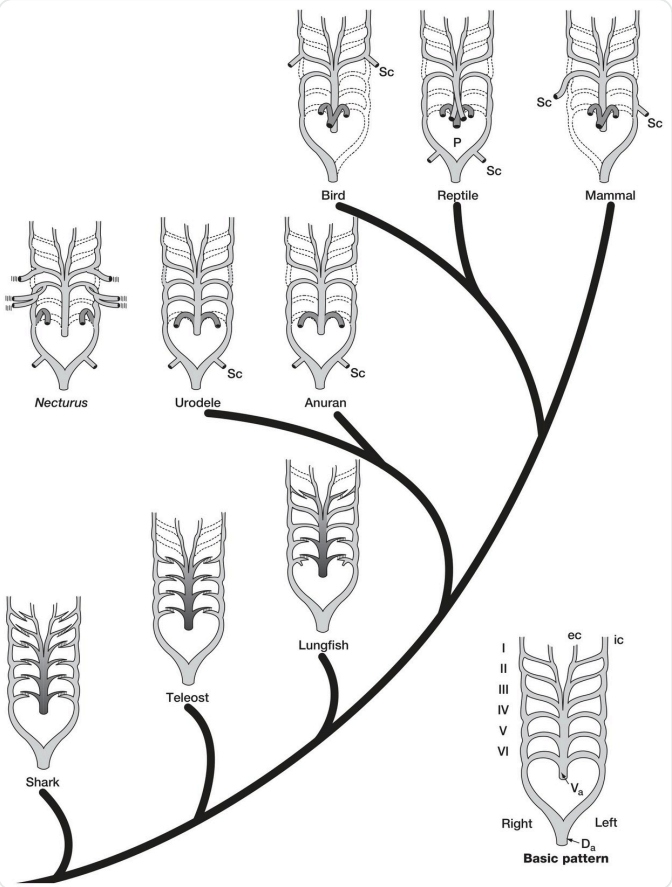



**Fig 24 — Evolution of the aortic arches from a single six-arch plan.** The inset at lower right is the starting point: the **basic pattern**, viewed from the ventral surface, with a **ventral aorta ($V_a$)**, six paired arches numbered **I–VI**, paired **dorsal aortae ($D_a$)**, and the **external (ec)** and **internal (ic) carotid** arteries. Everything else on the plate is that pattern edited. Follow the branches up from **shark** and **teleost** — where the arches still serve gills, drawn as vertical lines — through **lungfish**, then **Necturus**, **urodele** and **anuran**, and on to **bird**, **reptile** and **mammal**. **Dashed vessels are those lost from the basic pattern in the adult**; **Sc** marks the subclavian arteries and **P** the pulmonary. Note that the bird and the mammal end up mirror images of one another.

Image — Kardong KV. Vertebrates: Comparative Anatomy, Function, Evolution , 6th ed. McGraw-Hill — Fig 12.19, evolution of the aortic arches, after Goodrich. Reproduced for educational reference.

| EMBRYONIC ARCH | FATE IN THE ADULT AMNIOTE | WHAT IT MEANS CLINICALLY |
|---|---|---|
| **I and II** | Lost early in development | Present in the embryo, gone in the adult — a reminder that the pattern is laid down before it is edited |
| **III** | The **internal carotid**; the **common carotid** is the length of ventral aorta between arches III and IV, and the **external carotid** its forward continuation | Every carotid you palpate or catheterise is arch III |
| **IV** | The **systemic arch** — the aorta itself. Mammals keep the **left**; birds keep the **right** | A persistent **right** aortic arch in a mammal traps the oesophagus and produces regurgitation in a weanling — the bird pattern appearing in the wrong species |

| EMBRYONIC ARCH | FATE IN THE ADULT AMNIOTE | WHAT IT MEANS CLINICALLY |
|---|---|---|
| V | Lost | Transient; do not look for it in the adult |
| VI | The **pulmonary arteries**, plus the **ductus arteriosus** linking pulmonary trunk to aorta in the fetus | Failure of that duct to close is **patent ductus arteriosus** — one of the commonest congenital cardiac defects in the dog |

The asymmetry is the punchline. Symmetrical in the embryo, the arches become asymmetrical in the adult from reptiles onward, and the fourth arch is where most of the editing happens. **Mammals retain the left systemic arch; birds retain the right.** Two species can therefore have an aorta in mirrored positions while sharing the identical embryonic vessel.

> **Clinical note**This is why a **persistent right aortic arch** matters in a puppy. The mammal has kept the wrong one of the two, and the resulting vascular ring encircles the oesophagus — producing regurgitation of solid food at weaning, with a dilated oesophagus cranial to the heart on radiographs. It is not a random malformation; it is the avian pattern appearing in a mammal.

The same logic explains the **ductus arteriosus**. Arch VI supplies the lungs, but a fetus does not use its lungs, so a short-circuit carries blood from the pulmonary trunk into the aorta. At birth it should close. When it does not, the result is **patent ductus arteriosus** — and the continuous murmur you hear is a piece of embryonic plumbing that failed to be deleted on schedule.

## 13 Why comparative anatomy matters clinically

It would be easy to file all of this under “interesting background”. It is more than that, because the plan tells you which cross-species assumptions are safe and which are not. **Conserved features travel well; edited features do not.** Nerves, muscle innervation, the order of limb bones and the identity of the great vessels are conserved, so reasoning across species about them is usually sound. Counts, fusions, proportions and the size and position of the gut are edited, so reasoning across species about *those* will eventually hurt a patient.

| THE TRAP | WHY COMPARATIVE ANATOMY EXPLAINS IT |
|---|---|
| **“It worked in the dog.”** | A flank approach that is routine in the ox is a poor choice in the dog, because the ruminant’s rumen presents itself at the left flank while the dog’s viscera do not present anywhere in particular |
| **Counting ribs to find the heart** | Thoracic vertebral counts differ — 13 in the dog and ox, **18** in the horse. A landmark counted from the last rib lands in a different place in each species |
| **Blocking a nerve by memory** | Nerves are conserved but the bones they run against are not. The same nerve lies against a fused metacarpus in the ox and a cannon bone in the horse |
| **Assuming a diaphragm** | Birds have none. Positive-pressure ventilation, coelomic surgery and even restraint all change once you accept that the avian body cavity is not a mammalian one |
| **Reading a radiograph across species** | The equine sacrum has five fused segments and the canine three; the avian spine is fused in three separate places. “Fused” is normal in one species and pathology in another |

The habit worth building is simple. When you meet a new species, do not start from zero and do not assume it is a large dog. Ask four questions: **How many digits, and which? What are the vertebral counts, and what is fused? Where is the fermentation, if any? What is different about the thorax?** Those four answers place almost any vertebrate against the plan quickly enough to be useful on a clinic floor.

> **A note on scope.**
>
> This is a comparative anatomy guide, not a clinical manual. Where a section mentions a condition — patent ductus arteriosus, a vascular ring, colic, digital lameness — it is to show what the anatomy predicts, not to guide diagnosis or treatment. For the clinical detail, work from Comparative Veterinary Anatomy: A Clinical Approach and the species texts listed in the sources.

## 14 Species-by-species guides

This article is the plan; the guides below are the species. Each one takes a single animal and works through it region by region with labelled atlas plates, and each will make more sense now that you can see what it has in common with the others.

## 15 Quiz: test yourself

Twenty-six questions across the seven-species reference, homology, the limb, the vertebral column, the skull, the muscles and the great vessels. Answers are beneath each question — cover them and work down.

1. What does it mean to say two structures are homologous?**Answer:** That they can be traced back to **the same structure in a common ancestor**. Homology is about **ancestry**, not about function or appearance.2. A bird's wing and an insect's wing — homologous or analogous?**Answer: Analogous.** They perform the same function but share no wing-bearing ancestor. The bird's wing is homologous with a mole's forelimb, not with an insect's.3. What is serial homology?**Answer:** Similarity between **successively repeated parts within the same animal** — the chain of vertebrae down one backbone, or the pharyngeal arches of one embryo.4. Name the three segments of the pentadactyl limb.**Answer: Stylopodium** (humerus / femur), **zeugopodium** (radius+ulna / tibia+fibula) and **autopodium** (carpus or tarsus, metacarpus or metatarsus, and phalanges).5. How many digits did the earliest tetrapods have?**Answer: More than five.** *Ichthyostega* has **seven** digits in the hindlimb and *Acanthostega* **eight** in the forelimb. Five is not the starting point — it is an early settlement.6. Which digit does the horse stand on?**Answer:** Digit **III**. Metacarpal III is the cannon bone; metacarpals **II and IV** remain as the medial and lateral **splint bones**.7. What is the ox's "cannon bone", really?**Answer:** The **fused third and fourth metacarpal** bones. The fusion line and the paired distal articulations give it away, and the animal walks on digits **III and IV**.8. Why do dogs have five digits in front and four behind?**Answer:** Because digit **I** — the **dewclaw** — is small, non-weight-bearing and **commonly absent in the pelvic limb**. The weight-bearing digits are II–V.9. Give the canine vertebral formula.**Answer: C7 T13 L7 S3 Cd20–23.** The cat matches it as far as the sacrum (C7 T13 L7 S3), differing only in the tail.10. How does the equine vertebral formula differ, and why does it matter?**Answer: C7 T18 L6 S5 Cd15–21** — five more thoracic vertebrae and one fewer lumbar than the dog. Any landmark counted from the ribs therefore lands somewhere different in the horse.11. Name the three vertebral fusions found in birds.**Answer:** The **notarium** (thoracic), the **synsacrum** (lumbosacral) and the **pygostyle** (caudal). Fusion, not a fixed count, is the constant feature of the avian column.12. Which skull type do mammals have, and what does its bony bar become?**Answer: Synapsid** — a single temporal opening. The bar above it, formed by the **squamosal** and **postorbital** bones, is the ancestor of the **zygomatic arch** you palpate on every patient.13. What is the strongest single criterion for muscle homology?**Answer: Nerve supply** (with embryonic origin). A muscle keeps its nerve even when its attachments migrate. Shared *function* is the weakest criterion.14. Why are the reptilian depressor mandibulae and the mammalian digastric not homologous?**Answer:** Both open the jaw, but their **nerve supply differs** — so despite identical function they cannot be traced to the same ancestral muscle.15. Which aortic arch becomes the aorta, and which side is kept?**Answer:** Arch **IV**. Mammals retain the **left** systemic arch; birds retain the **right**. A persistent right arch in a mammal is a vascular ring.16. Which arch gives rise to the ductus arteriosus?**Answer:** Arch **VI**, which also forms the **pulmonary arteries**. Failure of the duct to close after birth is **patent ductus arteriosus**.17. What is the difference between a mesaxonic and a paraxonic limb?**Answer:** In a **mesaxonic** limb the axis runs down the middle of **digit III**, so reduction converges on a single central digit — the **perissodactyl** pattern, ending in the horse. In a **paraxonic** limb the axis runs **between digits III and IV**, so reduction converges on a symmetrical pair — the **artiodactyl** pattern, ending in the cloven hoof.18. Which bones form the mammalian zygomatic arch, and which synapsid bone is missing?**Answer:** The **zygomatic (jugal) bone** and the **zygomatic process of the temporal bone**. The **postorbital** bone — which in early synapsids formed the bar *above* the temporal fenestra — is **lost** in mammals, which is also why carnivores have an **open orbit** completed by the orbital ligament.19. Where does the spinal cord end in the dog, the cat and the ox?**Answer:** Between **L6 and L7** in the dog (more cranial in large breeds), between **L7 and the sacrum** in the cat, and at **S1–S2** in the ox. The cord is always shorter than its canal, and by a different amount in each species.20. Foregut or hindgut — which is the horse, and which the ox?**Answer:** The horse is a **hindgut** fermenter (the large colon); the ox is a **foregut** fermenter (the rumen, before the true stomach). Same body plan, opposite solutions to the same problem.21. Which of the seven domestic mammals has no upper incisors?**Answer: The ox, the sheep and the goat** — all three. They oppose a **dental pad** instead, which is why a ruminant tears grass rather than biting it off cleanly.22. A pig and a dog: which has more teeth, and why?**Answer: The pig**, 44 to the dog's 42. The pig keeps the full eutherian complement in both jaws — the most complete dentition of any domestic animal.23. Roughly what fraction of a cow's stomach is rumen, and how large is the whole organ?**Answer:** About **80%** of a total of roughly **60 L**. Reticulum 5%, omasum 8%, abomasum 7%.24. Name a proportional difference between the stomach of an ox and that of a sheep.**Answer:** The small ruminant has a proportionally much larger **abomasum** — 13% of stomach volume against the ox's 7% — and a much smaller **omasum**, 4% against 8%.25. In which species does the spinal cord end most cranially, and in which most caudally?**Answer:** Most cranial: the **pig**, at L5–L6. Most caudal: the **horse**, at S2. The small ruminant is the one to be careful with — its cord may occupy almost the whole sacrum.26. Which of the seven has no gall bladder? **Answer: The horse**, alone among the seven. Its bile duct compensates with a wide calibre.

## 16 Comparative veterinary anatomy — frequently asked questions

### What is comparative veterinary anatomy?

The study of animal anatomy **across species** rather than one species at a time — identifying the body plan that all vertebrates share, and then the modifications each species has made to it. In veterinary training it is the framework that lets you carry knowledge from the dog to the horse, the ox, the bird and beyond, instead of learning each animal from scratch.

### What is the difference between homology and analogy?

**Homology** is similarity due to **common ancestry**: two features are homologous when they trace back to the same feature in a shared ancestor, whatever they now do. **Analogy** is similarity of **function**, whatever the ancestry. A bird's wing and a mole's forelimb are

homologous; a bird's wing and an insect's wing are analogous. A third term, **homoplasy**, covers parts that simply look alike.

### What is the pentadactyl limb?

The five-digit tetrapod limb, built in three segments: the **stylopodium** (humerus or femur), the **zeugopodium** (radius and ulna, or tibia and fibula) and the **autopodium** (carpus or tarsus, metacarpus or metatarsus, and the phalanges). Every tetrapod limb — wing, flipper, hoof or hand — is a modification of it.

### Did the first tetrapods have five digits?

No. *Ichthyostega* had **seven** digits in the hindlimb and *Acanthostega* **eight** in the forelimb. Five became the standard early in tetrapod history, and the domestic species have reduced from there — to four in the pig, two in the ox and one in the horse.

### Do all mammals have seven cervical vertebrae?

Almost, but not quite — and the exceptions are worth knowing precisely because the rule is so strong. **Seven** holds in the dog, cat, horse, ox, and famously in both the giraffe and the whale, with neck length changed by altering the *size* of the seven rather than their number. The recognised exceptions among mammals are **sloths (six to nine)** and **sirenians — manatees and dugongs — (six)**; in armadillos and jumping mammals such as kangaroo rats the seven may be **fused** together. No domestic species departs from seven, so it is safe to rely on in practice. Birds, by contrast, vary their cervical count freely — from about eight to twenty-five — which is part of why they have such mobile necks.

### What is the vertebral formula of the dog, horse and ox?

Dog **C7 T13 L7 S3 Cd20–23**; cat **C7 T13 L7 S3 Cd18–20**; horse **C7 T18 L6 S5 Cd15–21**; ox **C7 T13 L6 S5 Cd18–20**. Birds are too variable between species for a single formula to be useful, but they consistently show three fusions: the **notarium**, the **synsacrum** and the **pygostyle**.

### Does the spinal cord end at the same place in every species?

No, and this is one of the most practically important comparative facts there is. The cord is always **shorter than the canal** that holds it, and it stops at a different level in each species: between **L6 and L7** in the dog (more cranial in large breeds, more caudal in small ones), between **L7 and the sacrum** in the cat, and at **S1–S2** in the ox, whose dura then continues to about the 4th caudal vertebra. In the bird the cord runs on as a small extension into the **pygostyle**. Behind the cord's tapered end — the **conus medullaris** — the remaining roots continue alone as the **cauda equina**.

### Which digit does a horse walk on, and which does a cow?

The horse walks on digit **III** alone; metacarpal III is its cannon bone and metacarpals II and IV persist as the **splint bones**. Cattle walk on digits **III and IV**, whose metacarpals are **fused** into one bone with paired distal ends, while digits II and V remain as **dewclaws**.

### How do you prove that two muscles in different species are the same muscle?

By **nerve supply** and **embryonic origin**, principally. A muscle keeps its innervation even when its attachments move, so shared nerve supply is strong evidence of homology and different nerve supply is strong evidence against it. Similar *function* is the weakest criterion: the reptilian depressor mandibulae and the mammalian digastric both open the jaw and are nonetheless not homologous.

### What happens to the six aortic arches in an adult mammal?

Arches **I, II and V** are lost. Arch **III** becomes the **internal carotid**, with the common carotid formed from the ventral aorta between arches III and IV. Arch **IV** becomes the **systemic arch** — the aorta — and mammals keep the **left** while birds keep the **right**. Arch **VI** becomes the **pulmonary arteries** and the **ductus arteriosus**.

### Why is a persistent right aortic arch a problem?

Because the mammal has retained the arch that birds keep and discarded the one it should have kept. The retained right arch, with the ligamentum arteriosum, forms a **vascular ring** around the oesophagus. Affected puppies typically regurgitate solid food as they are weaned, with oesophageal dilation cranial to the heart.

### Do birds have a diaphragm?

No. The avian body cavity is not divided by a muscular diaphragm, and ventilation depends on movement of the sternum and ribs driving air through a system of air sacs. It has direct consequences for restraint, anaesthesia (anesthesia) and coelomic surgery.

### What is the dental formula of the dog, cat, horse, ox and pig?

Per half-mouth, upper over lower, in the order incisor–canine–premolar–molar: **dog** 3–1–4–2 / 3–1–4–3, giving 42 teeth; **cat** 3–1–3–1 / 3–1–2–1, giving 30; **horse** 3–1–3(4)-3 / 3–1–3–3, giving 36–42 because the wolf tooth is variably present and canines are often absent in mares; **ox, sheep and goat** 0–0–3–3 / 3–1–3–3, giving 32; **pig** 3–1–4–3 / 3–1–4–3, giving 44.

### Why do cattle, sheep and goats have no upper front teeth?

They have a **dental pad** instead — a firm plate of tissue that the lower incisors tear grass against. The lower canine sits alongside the incisors and acts as a fourth incisor, so the lower jaw carries eight teeth in a continuous crescent.

### Are ox, sheep and goat anatomy the same?

Not quite, and the differences matter clinically. They do share a dental formula and an identical foot. But the ox devotes 8% of stomach volume to the omasum and 7% to the abomasum, while the small ruminants invert that to 4% and 13%; the sheep has four sacral vertebrae to the goat's five; and where the bovine spinal cord ends around the first sacral vertebra, the small ruminant's may run on through almost the whole sacrum.

### Which domestic animal has no gall bladder?

The **horse**. It is the only one of the seven domestic mammals without one; its bile duct is correspondingly wide and bile flows continuously into the duodenum.

### How big is a horse's stomach compared with its caecum?

The stomach holds **5–15 L** — strikingly small for the animal and for the volume of forage it eats. The caecum alone can exceed **30 L** in a large horse. That inversion is the whole logic of a hindgut fermenter.

### What is the best book for comparative veterinary anatomy?

For the veterinary, species-by-species treatment, Comparative Veterinary Anatomy: A Clinical Approach (Orsini, Grenager & de Lahunta) is the current standard and the source of the species plates here. For the evolutionary framework underneath it — homology, the limb, the arches — Kardong's Vertebrates. Both are free on vet-ebooks.com, along with Dyce, Sack and Wensing and Sisson and Grossman for the domestic species in detail.

**When to refer**

- **Homology** — same ancestry. **Analogy** — same function. **Homoplasy** — same appearance.
- **Limb** — stylopodium, zeugopodium, autopodium. Variation lives in the third.
- **Digits** — dog 5/4, pig 4, ox 2 (+2), horse 1. All subtractions from five.
- **Cervical vertebrae** — seven, in almost every mammal.
- **Thoracic** — dog and ox 13, horse 18. Count ribs at your peril.
- **Bird fusions** — notarium, synsacrum, pygostyle.
- **Skull** — mammals synapsid, birds diapsid. The bar becomes the zygomatic arch.
- **Muscle homology** — follow the nerve, not the function.
- **Fermentation** — horse behind, ox in front, bird not at all.
- **Arch IV** — aorta. Left in mammals, right in birds.
- **Arch VI** — pulmonary arteries and the ductus arteriosus.

# Sources


1. Kardong KV. *Vertebrates: Comparative Anatomy, Function, Evolution*, 6th ed. McGraw-Hill, 2012 — source of the vertebrate archetype, convergence of design, the pentadactyl limb, the polydactylous early tetrapods, the manus variations, the amniote skull types, the criteria for muscle homology, the bird vertebral column and the aortic arches, with the homology/analogy/homoplasy definitions, the mammalian cervical-count exceptions (sloths six to nine, sirenians six) and the unresolved position of turtles among the amniote skull types.
2. Orsini JA, Grenager NS, de Lahunta A (eds). *Comparative Veterinary Anatomy: A Clinical Approach*. Academic Press/Elsevier, 2022 — source of the canine, feline, equine, bovine and avian skeletons and their vertebral column formulae, the body-cavity plates for dog, horse, ox and bird, the canine superficial muscle layer, the digit and metacarpal detail for each species, the levels of spinal cord termination in dog, cat, ox and bird, the avian vertebral formula (C8–25 T7 L/S1 Cd4–9 P1) and the absence of an avian urinary bladder, and the open carnivore orbit versus the complete equine orbital rim.
3. *Atlas of Feline Anatomy for Veterinarians*, 2nd ed. — used to confirm the feline vertebral formula (C7 T13 L7 S3 Cd18–20).
4. Dyce KM, Sack WO, Wensing CJG. *Textbook of Veterinary Anatomy*, 5th ed. Elsevier — the standard comparative text for the domestic mammals.
5. König HE, Liebich H-G. *Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas*, 7th ed. Thieme — source of the seven-species reference plates: crown height in the equine incisor against the feline canine and canine molar (Fig. 8.19), the distribution of gastric mucosa across dog, cat, pig, ox and horse (Fig. 8.49), the colour-coded manus of dog, pig, ox and horse (Fig. 4.17), the canine vertebral column and cord in median section (Fig. 15.3) and the porcine skeleton (Fig. 1.27). Sisson S, Grossman JD. *The Anatomy of the Domestic Animals* (Vols 1–2) — the classical comparative reference.
6. Evans HE, de Lahunta A. *Miller and Evans' Anatomy of the Dog*, 5th ed. Elsevier — the canine detail behind the baseline species.
7. Diogo R, Abdala V. *Muscles of Vertebrates: Comparative Anatomy, Evolution, Homologies and Development* — muscle homology in depth.
8. König HE, Korbel R, Liebich H-G. *Avian Anatomy: Textbook and Colour Atlas*, 2nd ed. — the avian reference behind the bird comparisons.
9. Pasquini C et al. *Anatomy of Domestic Animals: Systemic and Regional Approach*, 5th ed. — systemic and regional cross-species reference.


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