Is this winged lion a flight of fancy? Not really: if you understand the anatomy of an animal, any creature you make will be believable

TIPS & TRICKS

Anatomical perfection

Getting under the skin of an animal will help you to better express form and posture, and enable you to realise more accurate renders

BY SCOTT EATON

Every character and concept artist should study anatomy. Why? Because without a sound knowledge of anatomy, your creations will lack credibility. And if you are working in a creature pipeline, an understanding of the fundamentals is absolutely essential.

At the top of the pipeline, the concept artist illustrates the final form of the creature. Of course, not everything can be conveyed in a single or even multiple drawings, so the modeller must pick up the pieces and interpret, adding his own artistic touch to the concepts. It is critical for the modeller to be able to accurately interpret the concept art and, where necessary, correct or add to the anatomical forms that are being built in 3D. Modellers must understand the underlying structure and muscles that create the masses and planes of the animal. Equally, the rigger needs to understand the same information to accurately articulate the model: where the joints are, what masses deform and what masses remain rigid. Finally, the animator takes the rig and works within the constraints laid down by the skeleton and controls. If knowledge is lacking in any of these waypoints in the pipeline, then the final result is compromised. 3D imposes more demands than any other medium, because very little information can be left out: we need to know it all.

The task is difficult given the tremendous variation there is in the animal kingdom: from hippopotamus to mouse to dinosaur. The important thing is to study and understand the commonality between them. Once this is understood, the variations become simple to grasp. Likewise, once the basic structures are understood, they can easily be extended to imaginary creatures, grounded in functional anatomy that is learned from the diversity of nature.

Our expert this issue…

Scott Eaton
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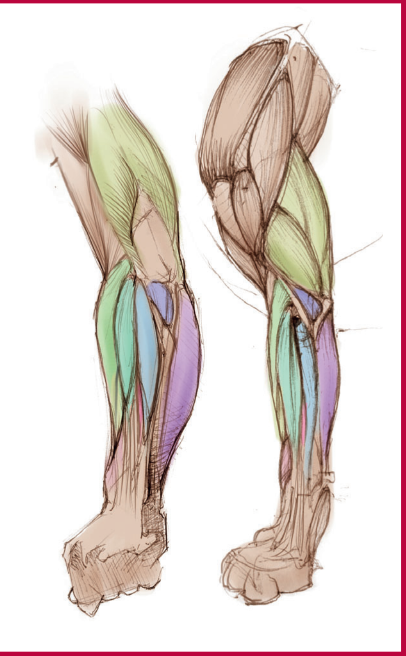
● The hamstring muscles of the horse are highlighted and the insertion is located (it generally spans over the nearest joint)

IN FOCUS | Human versus quadruped anatomy

Humans and animals have striking similarities between their anatomy. The most effective starting point for studying animal anatomy is to study human anatomy first.

With a firm grounding in human anatomy, the anatomical variations among animals are easy to spot and commit to memory. For example, the forearm muscles of a dog might seem a daunting tangle of thin extensor and flexor muscles, but they correspond exactly to the flexors and extensors in a human forearm. If you know the human forearm, the forearm of a dog is only a simple change of proportions.

If we extend this example and consider horses, we know that they don't have multiple fingers (or toes), but a set of single bones that correspond to human finger and metacarpal (hand) bones. Also horses have evolved to restrict the movement in their wrists to just a forward and back swinging motion, giving them great speed and stability in their front legs. These two adaptations have eliminated the need for a number of forearm muscles that are common to man, felines, and canines.



● The drawing above shows a human and dog forearm side by side. Because dogs have the same forearm bones and digits, the muscles also match

CREATING A BODY PLAN

The body plan is a simplified representation of the major masses and joints of an animal. Understanding the body plan of a subject is the place to start when drawing, modelling, rigging or animating an unfamiliar animal. Simply, the body plan is a schematic diagram of an animal in profile, which blocks in the masses of the ribcage, pelvis, and skull in relation to each other.

A schematic representation of the front and hind legs is laid over the top of the rib cage and pelvis. The masses of the limbs can be simply represented using boxes. Usually a single dot is used at each joint to locate the point of rotation.

Establishing the body plan of an animal is a quick way to grasp the large proportions that are characteristic to individual species.

EVERYTHING SHOULD BE IN THE CORRECT PROPORTION

Proportions work hand-in-hand with the body plan and establish the overall shape of the animal's body. Similar to proportional systems for humans, the length of the skull can be used to measure the large proportions of an animal's body, helping to position critical masses and landmarks.

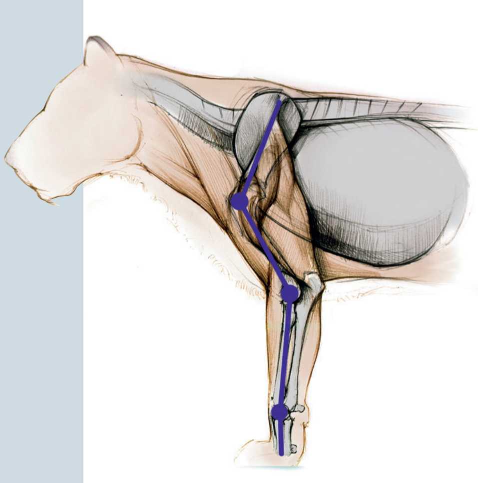
Critical measurements to consider are: the length of the ribcage relative to the overall length of the body; the relative length of the upper versus lower arm; the location of the point of the shoulder relative to the bottom of the ribcage; the relative height of the elbow versus the knee; and the length and angle of the neck.

SKELETON: RIBCAGE AND SCAPULA

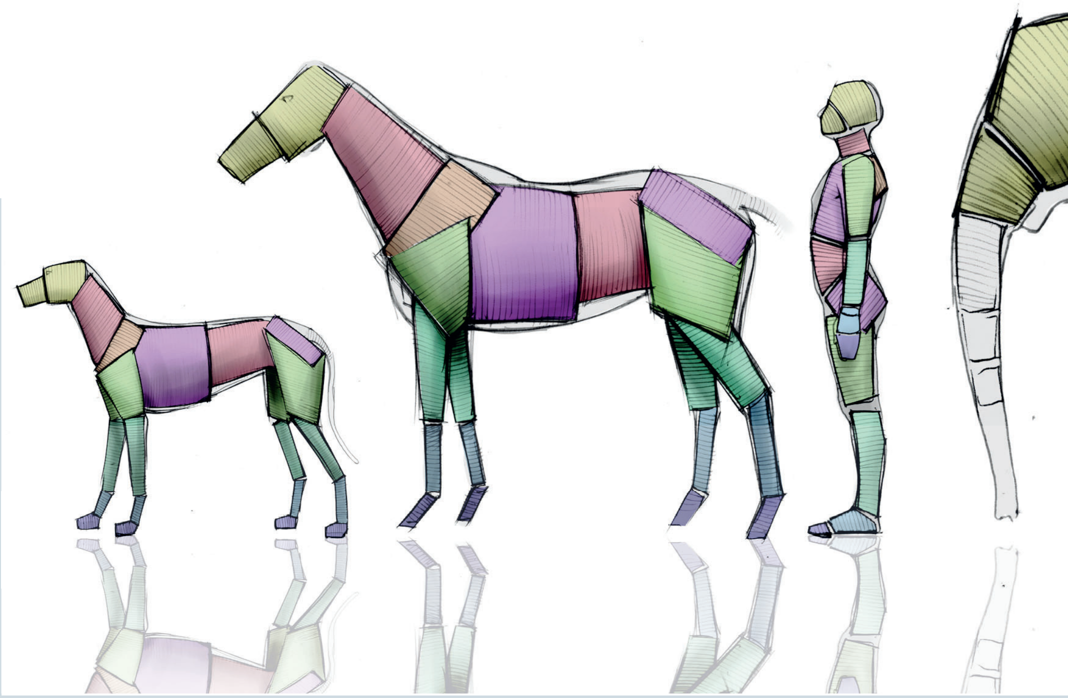
If we compare a human torso with an animal torso, we find that they are remarkably similar. Mostly only their proportions and shapes change, but there are some critical differences in the ribcage and scapula (shoulder blade). For a start, the ribcage in quadrupeds tends to be narrow side to side and deep top to bottom, the opposite to the wide ribcage found in humans. Also, the narrow sides of the ribcage found in animals make a perfect sliding surface for the scapula. And because quadrupeds lack a clavicle (collar bone), the scapula has a wide range of motion over the side of the ribcage. A human's scapula slides along the back of the ribcage and is constrained by the clavicle. This sliding in the quadruped's form allows the scapula to advance the entire front leg as it moves forward, and then slide upward and backwards as the leg takes the weight of the body.

SKELETON: PELVIS AND TAIL

As the name suggests, a quadruped uses four legs to move around, and the pelvis is adapted for locomotion on four legs. Unlike humans' ▶



● The shoulder girdle of a lion: note the angle of the scapula and humerus. The triceps, the dominant muscle of the upper arm, lies between the body of these two bones



nearly vertical pelvis, a quadruped's pelvis takes on a large forward lean. This inclination helps to transmit the locomotive force of hind legs into the spinal column and onto the mass of the front of the body. When studying a species that you are not familiar with, make note of the angle and the bony points of the pelvis. Combined with the tail, this mass establishes the profile of the hind quarters.

RANGE OF MOTION

The major joints of the skeleton of any quadruped function very similarly to those of a human bent over and walking on fingers and toes. If you keep this in mind when you are establishing the direction and range of motion of your joints, it is hard to make a mistake. The elbow of an animal always opens to the front just as in a human, and the knee always opens to the back, making the shape of two opposing parentheses, like so:) (

Because the scapula is free floating on the side of the ribcage – held in place by a system of muscles – the entirety of the front leg can slide forward, back, up and down. Therefore any rig that you build should reflect this range of motion.

DISTRIBUTION OF THE UPPER ARMS

How are the masses of the upper arm distributed in quadrupeds? Functionally, quadrupeds have little requirement for lifting with their arms, palm up, so the biceps – a prominent muscle on humans – becomes a minor shape on an animal's front leg. The triceps, however, bear the continuous load of walking, standing, running and jumping and are therefore powerfully developed, creating the dominant mass of the upper front leg.

We locate the mass of the triceps by looking at the underlying bones. The bone of the upper arm (the humerus) projects backwards

● **This sketch show the variation of body plan between species. Notice how fairly small and simple changes in proportion result in entirely different species**

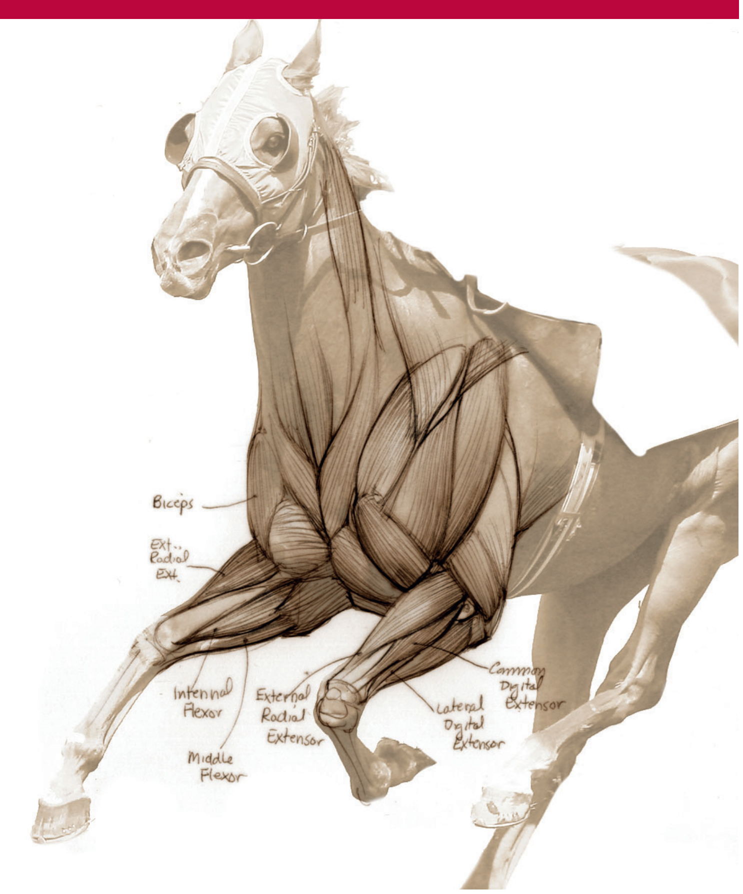
IN FOCUS | An écorché approach to animal anatomy

One of the best ways to study anatomy - be it human or animal - is by a process called drawing in écorché. It's the French word for 'flayed', but it has become synonymous with the technique of drawing or sculpting figures without skin.

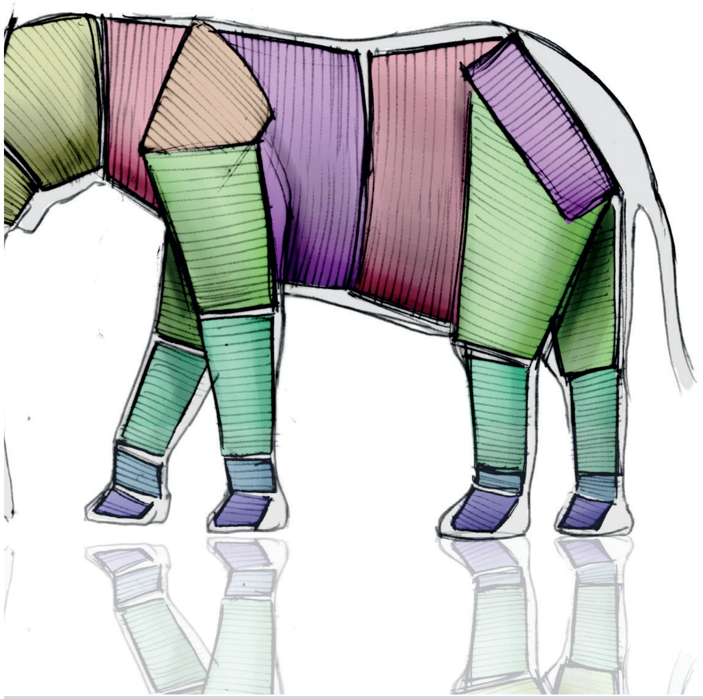
The process is simple in concept, but not nearly as easy as it sounds. Start with a good reference image that has enough contrast to highlight some landmarks and muscular definition. Overlay a piece of tracing paper, or add a blank layer if working digitally, and begin your detective work.

Locate any bony points or landmarks that can serve as a reference point for locating muscle masses. Draw in the outline of the muscle group, taking its origin, insertion and volume into account. And finally draw in the fibres of the muscles. Reference anatomy plates as often as you have to. You may find that you need to use these frequently in the beginning, but as your knowledge increases you will be able to complete entire images without external reference.

It is often instructive to draw from an image of a sculpture or painting by an old master who was knowledgeable in animal anatomy. Two of the best are George Stubbs, a 17th-century English painter of horses, and Antoine-Louis Barye, an 19th-century French sculptor who made his reputation sculpting animals. Equally, drawing écorché images from the plates out of *An Atlas of Animal Anatomy* by W Ellensburg (see Further Reading at the end of this article) gives you a chance to directly compare the skinned versions of the animal with the anatomical plate in the same pose.



● **Animal painter and anatomical draftsman George Stubbs created écorché drawings similar to this one, which shows the muscles on the chest and shoulder of a horse**



from the shoulder at an angle, sometimes as much as 45 degrees. The scapula also continues along back from the shoulder at an angle. Together they create a closed angle for the mass of the triceps to sit. Usually one head of the triceps – a three-headed muscle – lies directly on the humerus; the others fan backwards and attach onto the scapula.

ADDING SOME MUSCLE TO THE HAMSTRINGS

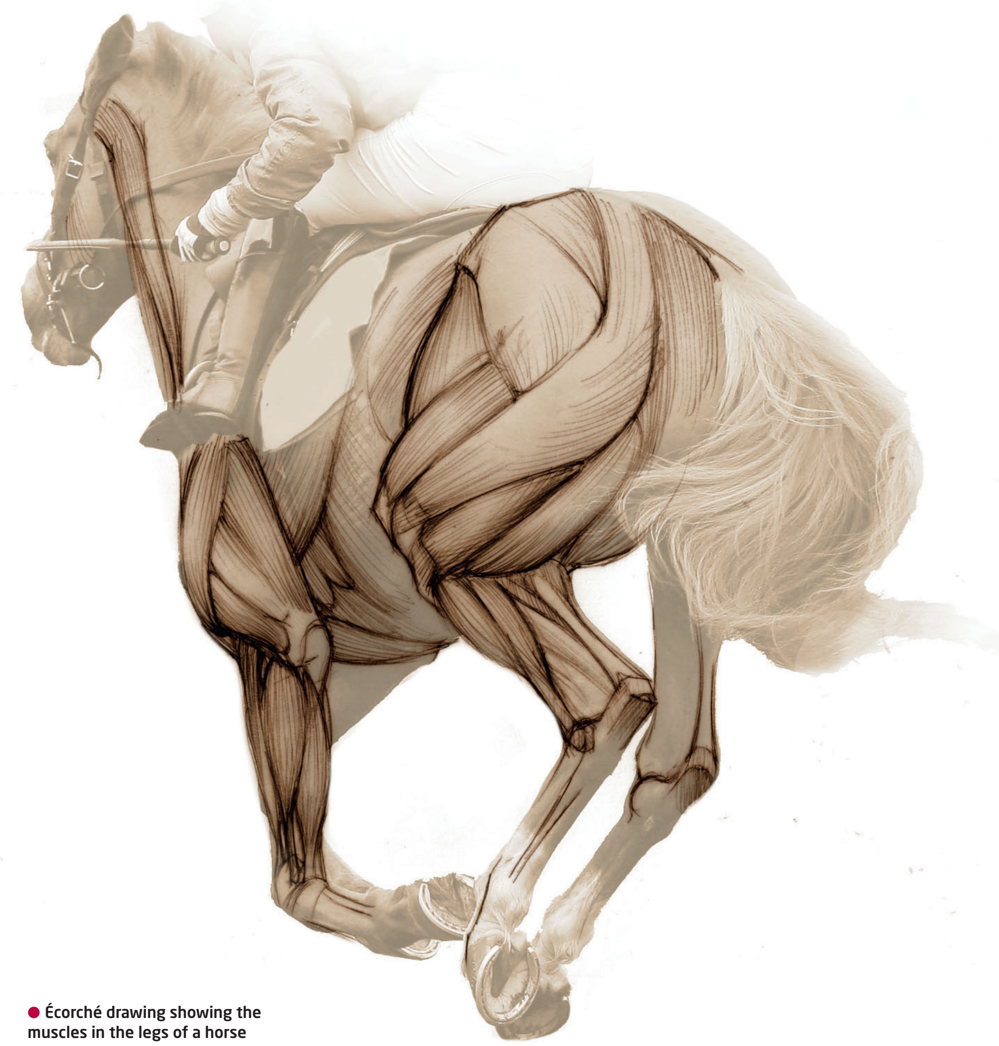
An animal's legs have a similar set of muscles to our own, but because of functional differences, the proportions are entirely changed. In animals, the hamstring muscles are the dominate leg mass when viewed from the side; in humans, the quadriceps dominate in profile. In humans, the hamstrings insert at the top of the lower leg, just below the knee. But in animals, the hamstrings insert anywhere up to two thirds of the way down the lower leg. Functionally, this helps quadrupeds to powerfully drive the leg backwards when running.

PINPOINTING THE BONY LANDMARKS

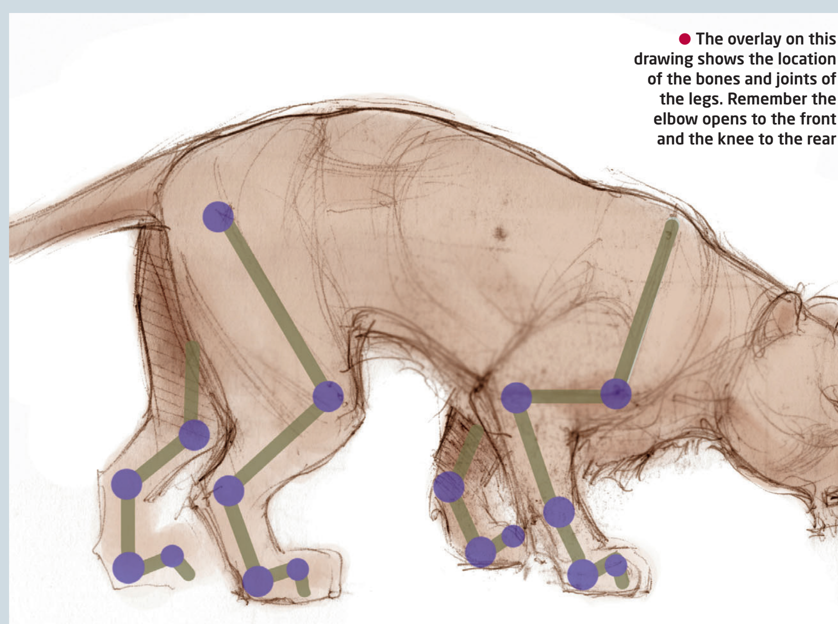
Bony points, the places where the skeleton is directly under the skin (subcutaneous), should be located on your models and used as reference points to place the muscles and establish the proportions of the subject's body. As the bony points are located where the skeleton lies straight under the skin, they shouldn't deform when rigging: they should only move rigidly with the joint.

The most important landmarks are: the spine of the scapula; the elbow; the front point of the pelvis (iliac crest); the rear point of the pelvis (ischium); the knee (patella); and the heel bone.

Once these points are resolved on your model, the process of placing the muscles masses becomes nearly trivial. In some ways, it is like connecting dots: first, find the origin of a muscle and relate it to the nearest bony landmark; next, identify the insertion of the muscle, which generally spans over the nearest joint; finally, place the body of the muscle over the bone using these two points as reference. Understanding the muscular attachments will help you to determine the direction of the pull of the muscle.



● Écorché drawing showing the muscles in the legs of a horse



● The overlay on this drawing shows the location of the bones and joints of the legs. Remember the elbow opens to the front and the knee to the rear

● The skull, made up of two parts – the cranium and the mandible – supports the structures of the face and protects the brain against injury

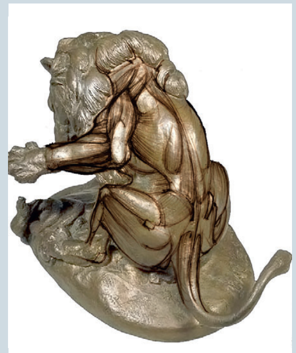
STUDYING THE SKULL

The skulls of animals share a common structure. They have evolved to protect the brain and give a secure housing, for the sensory organs (eyes, nose, ears, and mouth), and also to allow animals to eat whatever their diet dictates.

The widest part of the skull is established by the cheek bone, called the zygomatic arch. The arch starts from the bottom of the orbit, below the eye, and spans backwards to the ear. It never appears as an arch in life, because the powerful muscle of mastication (chewing) fills in underneath and below the arch, giving many animals muscular-looking jaws.

Forward of the zygomatic arch and the orbits are the nasal bone and the mandible (lower jaw). The projection of these two skull bones establishes the length of the skull in profile, which, in turn, dictates the shape of the muscle. Variations in these major structures establish the main differences between heads of different species.

● An example of an écorché drawing composited over a bronze by Barye. Once the form of an animal is understood, muscle groups fall into place



● An example of an écorché drawing composited over a bronze sculpture by French romantic artist Antoine-Louis Barye. It is instructive to be able to work from two different views, such as this one and the one below

NATURAL SELECTION

An animal's form and function cannot be separated from the environment in which it exists. The kangaroo, for example, evolved its hop as an energy-efficient means of traversing the arid climate of Australia. The hopping mechanics are created by an extremely elongated lower leg (tibia) and lengthened foot bones (metatarsals). Combine these proportions with an extremely resilient Achilles tendon and calf muscle, and the result is powerful leg thrust. Use these amazing adaptations of nature as inspiration when imagining your own creatures.

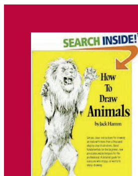
SPEED AS RELATES TO PROPORTION

A quick inspection of the body plan of a horse versus an elephant reveals a little bit about how certain animals have evolved for speed. Fast, efficient runners tend to have muscles masses on or near the trunk and pass the force of the muscles down long slender bones via tendons. Of course, certain cats and dogs are extremely fast, but their speed relies on power over a short distance and is less efficient because of the distribution of weight along the legs.

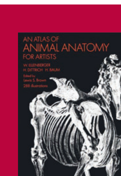
HANDS AND FEET

The hands and feet of animals are analogous to our own in that they have wrist and ankle bones, foot and hand bones, and fingers and toes. The numbers and proportions of these bones vary depending on species. Dogs and cats walk on four fingers and four toes, with their hands and feet elevated off the ground. Hoofed animals, called ungulates, like horses or deer evolved one or two very strong, elongated metatarsals, with their last finger digits becoming their hooves. Other strange ungulates have three or four toes like rhinos and hippos respectively. ●

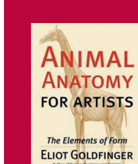
FURTHER READING | Best books on animal anatomy



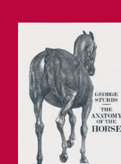
How to Draw Animals by Jack Hamm
ISBN: 0-399-50802-3
- Fantastic introductory book that explores the forms of many different kind of animals
- Packed full of useful info relating to different species



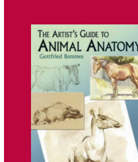
An Atlas of Animal Anatomy for Artists by W Ellensberg
ISBN: 0-486-20082-5
- The classic reference for animal anatomy plates
- However, there's very little text and gives no explanation of function



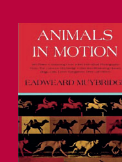
Animal Anatomy for Artists, the Elements of Form by Eliot Goldfinger
ISBN: 0-195-14214-4
- Comprehensive classification of all muscles for a variety of species
- Best resource for studying comparative anatomy



The Anatomy of the Horse by George Stubbs
ISBN: 1-83468-003-3
- Master anatomical plates in various stages of écorché
- Accompanying text is reprinted in the back of the book. It is tiny, and very difficult to read



The Artist's Guide to Animal Anatomy by Gottfried Bammes
ISBN: 0-486-43640-3
- Abbreviated version of the longer German original
- Excellent schematic drawings of animal skeletons and musculature



Animals in Motion by Eadweard Muybridge
ISBN: 0-486-20203-8
- Sequential photographs capturing animals at various stages in their gate.
- Valuable reference for riggers and animators