

THE RUNNING-GEAR OF THE DOG'S RACING-MACHINE.

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JUST a word or two as to the couplings and running gear, by which the dog's levers are fastened together, in the racing machine. You thought they were just "jointed on to his body?" Certainly they are, but they have had much to do with moulding the shape of his body, and indeed if you will look at this skeleton, or bony "core," of the dog you will see that a large part of it is simply a series of rods and girdles, for binding his racing-levers together properly.

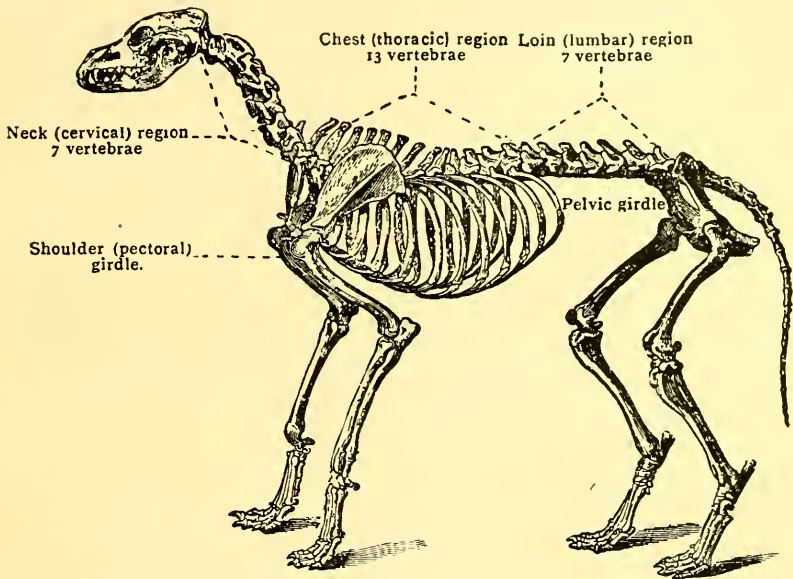
It is a frame-work which is put together very much on the plan of an ordinary farm- or express-wagon. In the place of the wheels you have the four legs, which indeed as we have seen swing backward and forward, just like the spokes of a wheel which would roll half way round and then back again constantly. Each pair of these spokes is jointed on to an "axle" at the "hub" or shoulder-joint, only the "axle," instead of being a straight bar, is a hoop or complete circle and, instead of running through the "hubs," is hollowed out on each side into sockets, into which the spokes run and play.

If you were to take the box off a toy-wagon and run a bar across the tops of the standards, or uprights, on the axles, you would have a "square circle," to the lower corners of which the wheels were attached. Turn that square into a circle and drop it down between the wheels, so that the hubs are attached nearly half way up its sides, and you would have a fair, rough imitation of the skeleton-plan of an animal.

Each pair of legs is attached to a circle of bones running right round the body, known as the "shoulder-girdle" and the "hip-girdle," and the body and its contents are slung inside them and

carried just as the wagon-box and its load of corn, we will say, are carried inside the axle, the standards and the bar across the top of them.

Now how are front axle and standards of the wagon and its hind ones held together? By a coupling-rod or bar, of course, which runs under the bed of the box from one axle to the other. The dog's running gear is held together by a similar rod, only instead of running along *below* the wagon-box and load, it runs above them and they are slung from it, like a hammock from a ridge-pole, instead of resting entirely upon the axles.



SKELETON OF THE DOG.

After Strangeway. Showing regions of the back-bone, and shoulder- and hip-girdles.

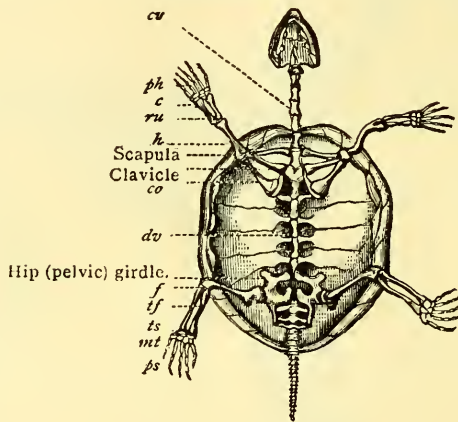
This brings the "coupling-rod" on the upper surface of the dog's body along his back, and hence we call it the "back-bone." And to complete our racing-frame, the back-bone runs forward, from above the front axles, out to the head, which uses it to steer the racing-machine just as your hand uses the handle or "tongue" of the toy-wagon to steer it.

Now let us look for a moment at the back-bone or tie-rod. At first sight it looks almost as if it were all in one piece, from head to tail, but on looking closer you will easily see that it is made up of a large number of short bones or sections about three-quarters

of an inch long. You may count them if you like and will find seven in the neck, thirteen in the chest length, seven in the small of the back, three between the "uprights" of the hip-girdle and from seventeen to twenty-two in the tail.

Now why should the rod be divided into such tiny pieces, like one of these toy-snakes of wood and string which wriggle so alarmingly? To permit movement of course, and if you will look again at the sections in each division of the back, you will find that wherever the movement is greatest the little sections are most distinct and most loosely bound.

In the neck, which has to move a great deal they are quite loose and movable one upon the other. In the chest-region they are



SKELETON OF A TURTLE.

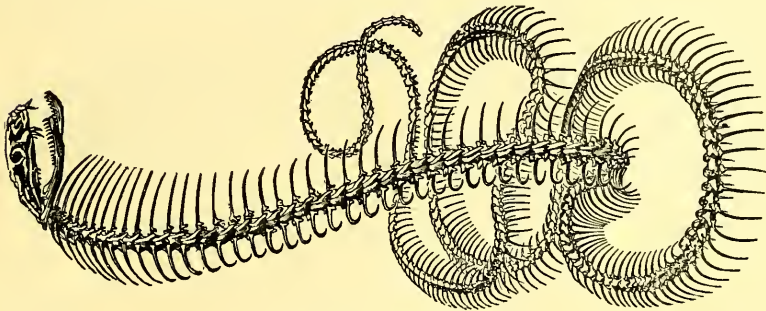
cv, cervical vertebrae; *ph*, phalanges; *c*, carpus; *ru*, radius and ulna; *h*, humerus; *co*, coracoid bone; *dv*, dorsal vertebrae; *p*, pelvis; *f*, femur; *tf*, tibia and fibula; *ts*, trassus; *mt*, metatarsus; *ps*, phalanges.

closely packed together and so locked into each other by little spurs and overlapping spikes that the rod can hardly be bent at all. In the small of the back which arches up and down when the dog runs, the little bones move easily upon one another, but between the broad hips of the hip-girdle they have actually glued themselves together, and the four become one bone, with only little ridges across it to show where the divisions used to be.

In the tail they are much longer and slenderer and each moves very slightly upon the next except at the base where the chief movement is in wagging, etc., and they glide past each other quite freely. And because being made up of these little separate bones allows the back-bone to turn or bend, they are called by the clumsy Latin name

of *vertebrae*, from *vertere*, "to turn," (*version*, *versatile*, *divert*, etc.) and the string of them is known as the *vertebral column*.

This vertebral column has, however, another use besides acting as stiffening-rod to the racing-machine. In this mounted skeleton you see the vertebrae are all strung together upon a wire, which runs through a rather large hole in each of them, like beads on a string. In the tube formed by all these rings runs the spinal cord, or great telegraph cable, running from the brain clear to the root of the tail and giving off branches to supply the body between each pair of vertebrae, throughout the whole length. At the head-end this bony but flexible tube expands into the brain-box or *cranial* portion of the skull and at the end of the hip-girdle it disappears entirely so that the vertebrae of the tail have no opening through them, but are simply solid little "fingers" of bone.



SKELETON OF THE COBRA.

Notice that all vertebrae bear ribs except those of the tail.

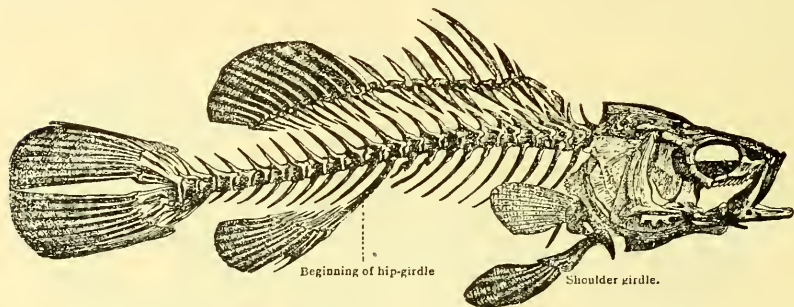
So important a structure is this hollow rod, first for stiffening and afterwards for protection of the nerve-cable and batteries, that its presence or absence has been made to divide all animals into two great classes, the "Back-boned" and the "Back-boneless" or *Vertebrates* and *Invertebrates* (*In* meaning "not" in Latin). Fishes, frogs, snakes, birds and warm-blooded animals of all sorts are vertebrates; jelly-fish, starsfish, oysters, lobsters, worms and insects are invertebrates.

You can break or cut any of them right across and not find a trace of back-bone running through them. But though lobsters, worms and insects have no back-bone, you will find one thing about them which curiously resembles the jointed rod of higher animals. And that is that their entire bodies are made up of rings or *segments* one behind the other just like the dog's vertebral column. You can count from fifty to a hundred and fifty in a worm, fewer in a lobster

or crayfish, but even more distinct, and still fewer in an insect unless it be a "Hundred-legger." On the hind-body of the grasshopper or the bee, for instance, the rings can be easily counted. Most back-boneless animals which move rapidly get their body-stiffening by hardening these outside rings, instead of a central core. The lobster for instance hardens his with lime salts and makes his "shell," the grasshopper with a horny substance called *chitin*.

Still more curiously, each of these rings has a tendency to sprout something in the way of legs, bristles in the worm, claws and swimmerets in the lobster and real legs in the bees and spiders.

In the original back-bone each segment carried a pair of ribs, as now in the fish and snake, and in the chest-region of the bird and dog.



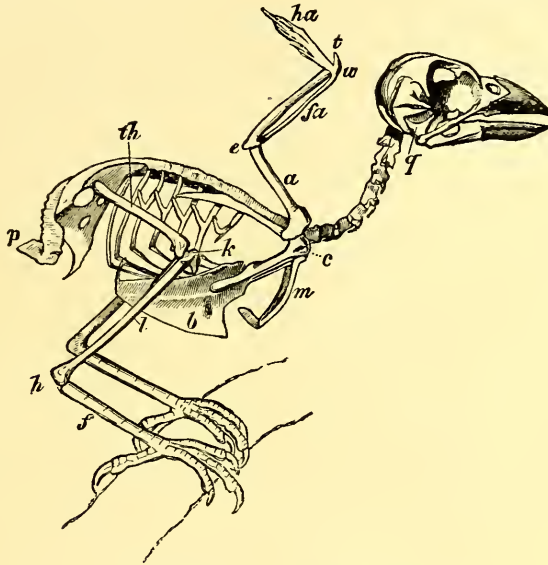
SKELETON OF A SEA-PERCH.

There is a strong tendency for all sorts of animal bodies to grow in segments or successive rings and a deeper reason for the many pieces in the dog's back-bone than mere flexibility. The back-bone is literally the central stem or "key-stone" of the vertebrate skeleton, and if you will compare these skeletons of the fish, the snake, the bird, the dog with this stiffening-rod as the basis of them, you will be surprised to find how closely alike they really are at bottom.

All of them have the jointed rod running the whole length of the body and tapering off more or less gradually in the tail. A canal for the spinal cord or nerve-cable runs through the rod near its upper surface in all, becoming an open groove toward the rear of the body and disappearing in the tail. If you take the rod to pieces you will find that this "upper" position of the canal makes each of the pieces or *vertebrae* consist of a rounded lozenge below, the *body*, and a ring above, the *arch*, with little handles or *transverse processes* on each side, for the attachment of muscles and

smaller spurs standing out from its front and hind surfaces to lock the bones of the rod together. From the top of the ring runs out a spike of bone called the *spine*, which often slopes backward, and the successive ends of which you can easily feel in the dog's or your own back like a string of beads under the skin.

The vertebrae carry ribs the entire length of the rod except the tail in the fish and snake, but only in the chest region in the bird and dog. All of them except the snake have a front- or shoulder-girdle and a hind- or hip-girdle of two to four bones, to which a



SKELETON OF THE SPARROW.

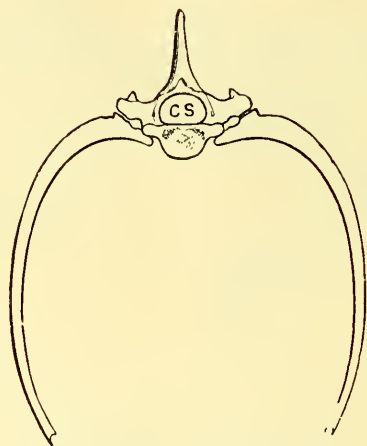
After Holder. *b*, breast-bone; *m*, merry-thought or collar-bone; *c*, coracoid bone, over which the tendon works to pull up the wing; *p*, plowshare-bone, on which the tail grows. Wing-bones: *a*, upper arm; *e*, elbow; *fa*, fore-arm; *w*, wrist; *t*, thumb; *ha*, hand. Leg-bones: *th*, thigh-bone; *k*, *l*, lower part of leg; *h*, heel; *f*, foot.

pair of hands are attached, known as fins, wings and feet respectively. In the fish the hand is joined directly on to the girdle and there is only one joint, the wrist. In all the others the hand has grown out a fore-arm and arm from the body with two more joints, elbow and shoulder, between it and the girdle.

In all, the shoulder-girdle is made up of two, longish, flat sabre-shaped *blade-bones* or *scapulae* (Latin for "spades") and is filled in by muscle above on each side of the back-bone, while in most of the warm-blooded animals there is another pair of bones below,

the *clavicles* or "collar-bones," which you can feel quite plainly at the upper part of your own chest, running across from the neck to the shoulder, although they have almost disappeared in the dog.

In the bird these *clavicles* grow together in front and form the *wish-bone* or "merry-thought," and because of the tremendous strain upon this girdle, due to its bearing the wings, it is strengthened in front by a second pair of bones below and much thicker than the collar-bones, called by carvers at table the "side-bones" and by uncomfortably wise men the "coracoids" from a long Greek word meaning "crow-like," on account of their alleged resemblance to a crow's beak. Your father can show them to you the next time you have roast chicken or turkey for dinner, but I am afraid you won't think them much like a crow's beak, so you may just remember them as "side-bones."



A VERTEBRA AND A PAIR OF RIBS.

After Holder. *cs*, cavity containing cerebro-spinal cord.

In the fish the hip-girdle is imperfect, only forming about a third of a circle below, and in some kinds is pushed forward in a curious fashion, close up to the shoulder-girdle, but in both the bird and the dog it is made up of two strong, broad, curved plates of bone firmly fastened to the back-bone above and coming toward one another in the middle line below, thus encircling a round space, like a basin without any bottom, from which the girdle is named the *pelvis* (Latin for "basin").

You can feel the upper edge or rim of this basin in your own body as the hips or hip-bones, upon which you are told *not* to rest your hands when you stand and talk in public. The sides of the

basin do not meet in front or below in the bird, for a reason which we shall talk about later, but come together firmly in the dog and all other four-footed animals, as well as ourselves.

And if you will just recollect the parts taken by the front and hind legs of the dog in running, you will soon be able to reason out why the girdle belonging to the front-legs is so light and loosely hung to the back-bone, to prevent jarring when they "prop" the body at full speed, while that belonging to the hind-legs is so heavy and firmly joined to the back-bone and welded in front to give firm attachments for the forward drive of the real propellers. In ourselves it is heavier and solider still because it has both to propel and bear the entire weight of the body as well.

I have said more about the skeleton than I at first intended, because if you look at it under the popular impression that because it is the hardest and most lasting part of the body, apparently giving it its shape, and is so much alike in all different kinds of animals, so "constant" as the wise men say, it is therefore the *foundation* of the entire body, upon which all its other structures have been moulded, you will not only make a great mistake, but also find it the hardest thing in the body to understand properly.

If, however, you can get clearly into your minds—though here some of the wise men would not agree with me—that with the partial exception of the head, *the movements of the dog's body have built his skeleton, as it was wanted, and each bone of it where it was wanted to carry them out properly*, you will have a key by which you can explain and understand, not only his skeleton but that of any other back-boned animal.

Every bone has a meaning and a reason for both its existence and its shape, which you can find out for yourselves, if you will only study it in this light. The skeleton was not laid down first and then the food canal, heart-pump, etc., tucked inside it and the muscles laid on over it, until a nice rounded body shape was filled out, but the food-tube came first, then the muscles to move it about after something to eat, and the muscles built the skeleton bit by bit, by some of them turning first into gristle then into bone in the middle, to make levers for the others to work with. *So that every bone in the body (except part of the head) is the lime-hardened core of a muscle or group of muscles.* Even the back-bone grew up originally, not as a sheath for the nerve-cable, but as a literal stiffening-rod for the body, in its movements forward by the leverage of the fins. The joints are simply places where the core of a limb or of the stiffening-rod didn't harden into bone.

Now all this time we have been taking for granted the most important thing in the dog's racing-machine, his muscles. We have done so for two reasons, first, that you can so easily see and feel them at work, that you know more about them than of any other part of the body. Second, that by watching them at work in the gallop, the trot, the walk, and seeing something of the machine they have built, we have learned more about them and are better prepared to guess their shape and position than even if we had dissected a dog and studied them directly.

But perhaps some of you may be a little puzzled as to just what muscle is, although you have always heard so much about it. Muscle is simply what in the butcher-shop or kitchen we call "meat" or more exactly lean meat. It is a clear, red body-stuff which covers the bones and makes half the weight of the entire body. By it every movement in the entire body, running, leaping, breathing, swallowing, barking is carried out, and it does all these by simple pulling, never pushing.

It is the only thing in the world that can move of itself. And it does this in a very curious way by simply changing its shape. It has the power of shortening itself, or "contracting" as the wise men call it. So that when one end of it is fastened to the bone above a joint, such as the elbow, and the other below, when it shortens it bends the arm. As it shortens it becomes thicker, as you can readily feel by placing your hand upon the front of your arm and sharply bending your elbow. The more it shortens, the more it swells in the middle, for it does not change its size at all, but only its shape. If you were to measure it exactly, you would find that it had gained in thickness just as much as it had lost in length, so that its bulk stays exactly the same.

It is easy to see how a muscle bends a limb by simply shortening, but how can it stretch or straighten one by pulling only? Look at your elbow again while it is bent. At the back of the joint is a strong spur of bone, the "point," like a handle, or lever, to pull the arm back straight again. And that is precisely what it is, for if you will put your hand on the back of your arm and then strike sharply downward with your fist, you can feel the muscle swell up under your fingers as it pulls the arm down by the elbow-lever.

And upon some form of this simple plan, every movement of the body of the dog is carried out. Each limb has a bundle of muscles, running from the body down the front of it, which swings it forward and lifts the feet from the ground, and another bundle down the back of it, which pulls the leg and foot backward, as in

scratching, or if the foot is held firmly against the ground, throws the body forward, as in running and leaping. So when the dog gallops, starting with his hind feet well forward under him, the powerful muscles on the back of his hind-legs, acting with the great bundles which make up the breadth and strength of his back or *loins*, straighten out his "C-spring" and launch his body forward; at the same time, those on the front of his fore-legs lift and pull them forward into position to catch the body and prop it, until the corresponding group on the hind-legs can swing them under and to the front once more, and the "wheel" swings round again.

Every "corner" of bone, that you can feel under the dog's skin or your own, is a lever or handle for the attachment of muscles. You will find a spur on the dog's elbow (which you remember is close up to his body) almost like your own. His "hind-knee" or hock has another lever on it, which corresponds to the "spur" of your heel and gives a hold, by which the great muscles of the calf or ham, can raise the body from the ground. These are tied to the end of the lever by a strong sinew, the "ham-string," which you can easily both feel and see in the back of your own heel. If you will place your hand on the calf of your leg, and then rise on tiptoe, you can feel the muscles swell and harden as they lift the heel, with the weight of the body upon it, from the ground. The angle of the jaw, just below and in front of the ear, is another lever, and placing your fingers on your cheek above it a short, thick muscle bulges up whenever you clench your teeth firmly together. This however is a lever of a different class from the others, the power being applied between the joint-fulcrum and the weight, instead of the weight at one end and the power at the other as in the elbow. Every joint in the dog's limbs, as well as in your own, is moved by some sort of lever, and if you will puzzle out one or two of them for yourselves by handling them, and feeling the muscles swell as they move them, you will gain a better idea of how every sort of living animal moves, than you could by hours of reading.