Animation Mentor

Animal Anatomy and Locomotion for Animators
With Dr. Stuart S. Sumida

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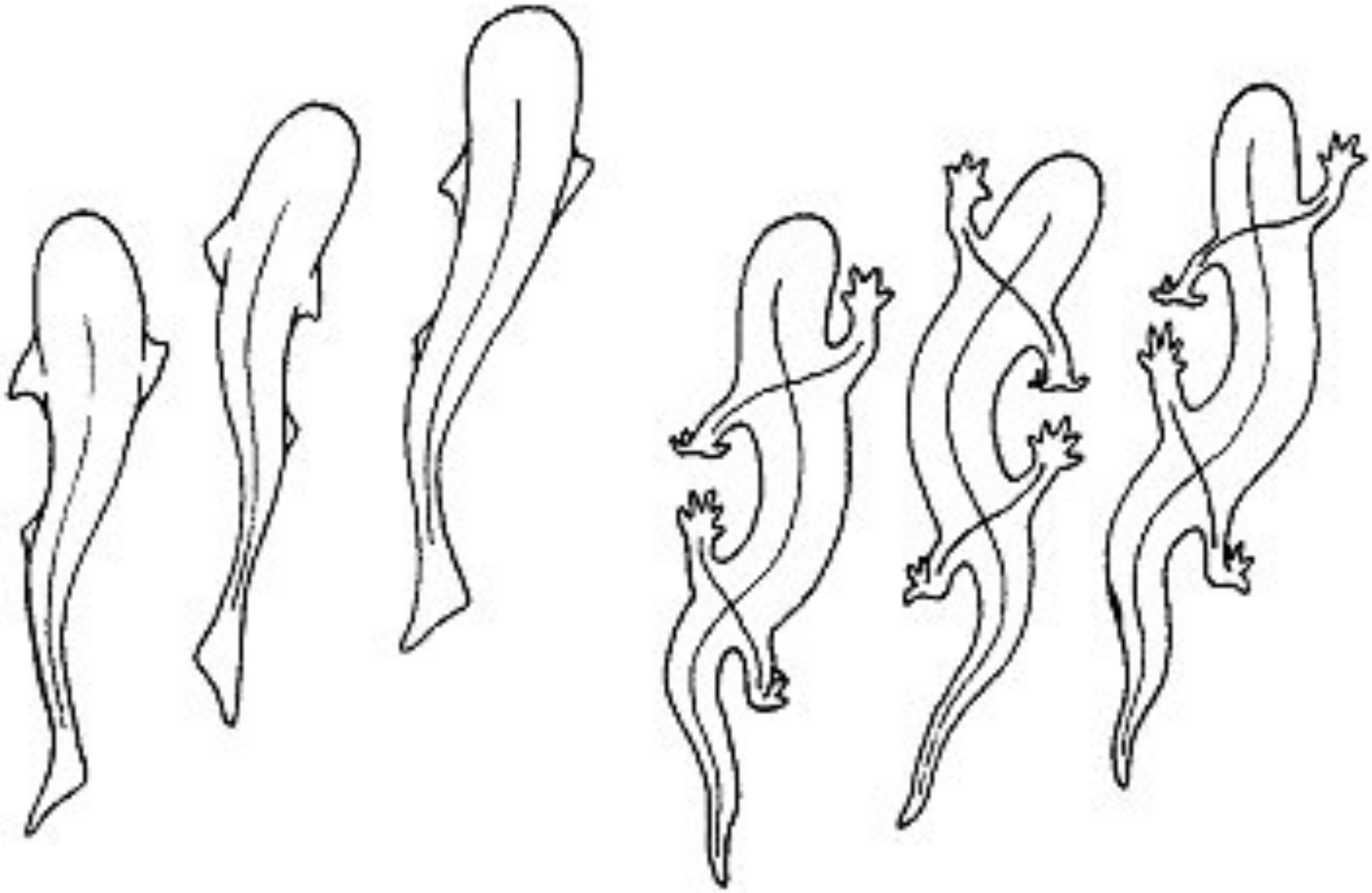


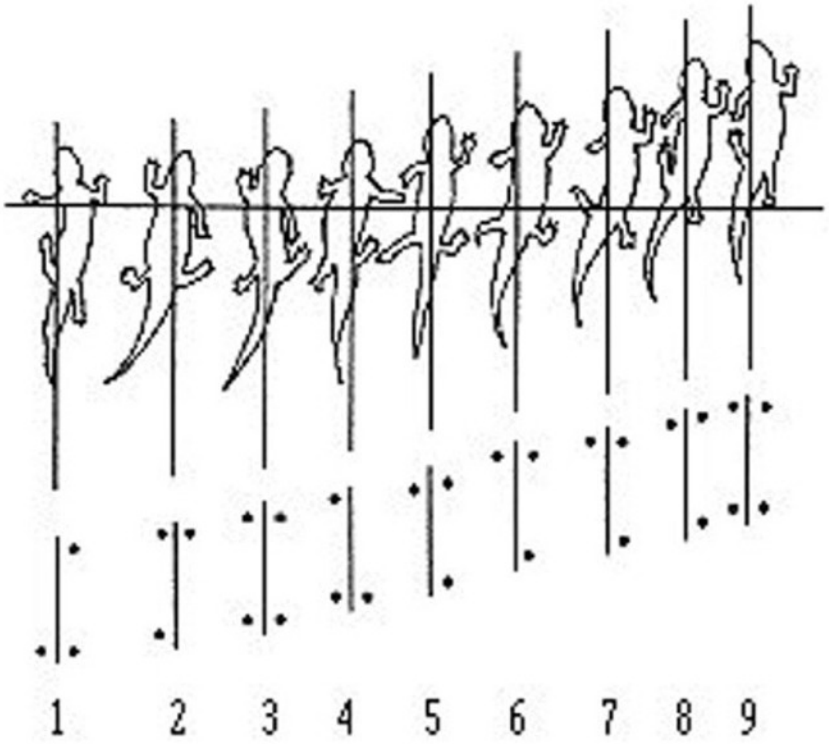
Salamander locomotion

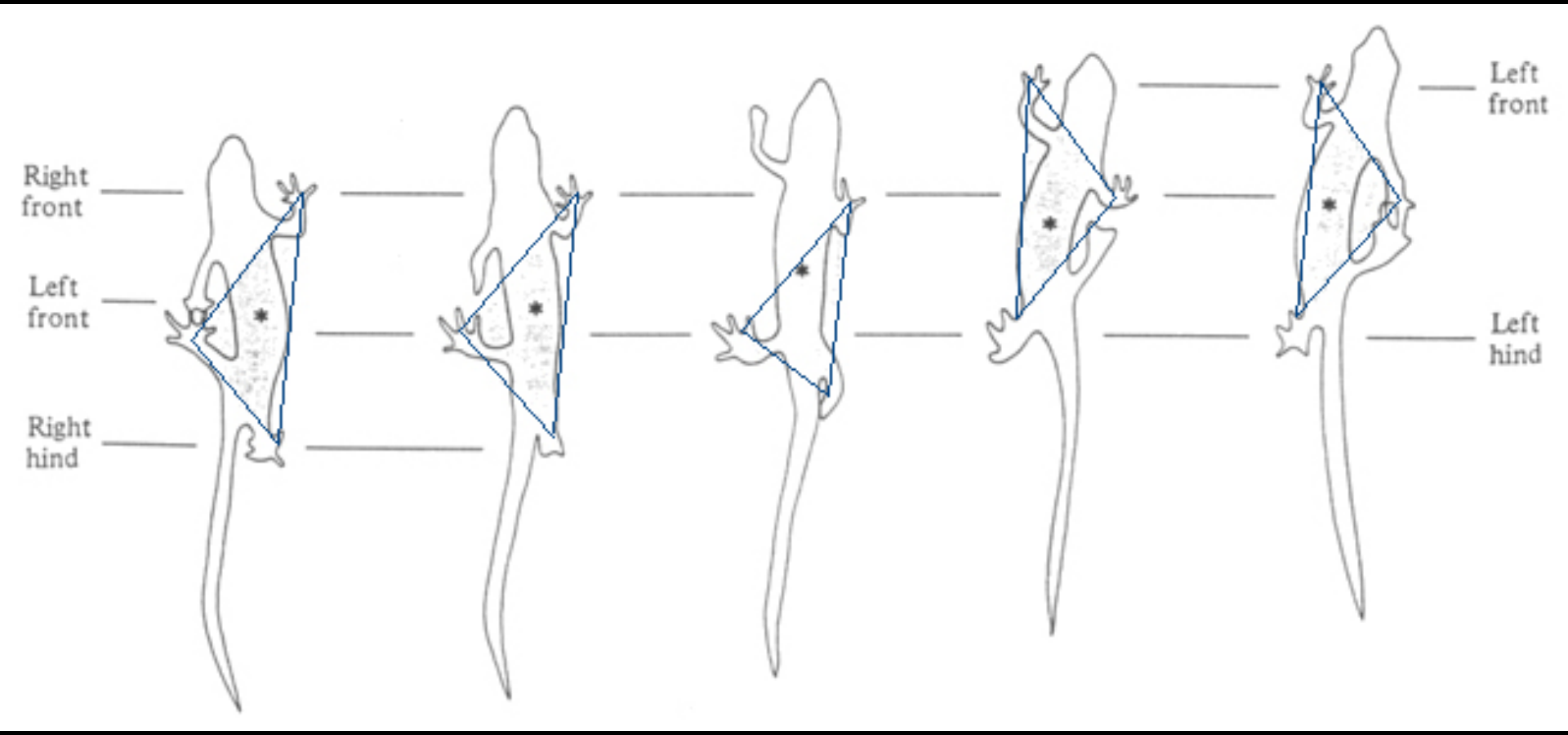
The figure shows a sequence of movements taken from a film. Note that the body is concave on the left when the left hind and right forefeet step down (frame 1). The weight of the body is then carried by the right front and the left hindfeet, while the other two legs move forward.

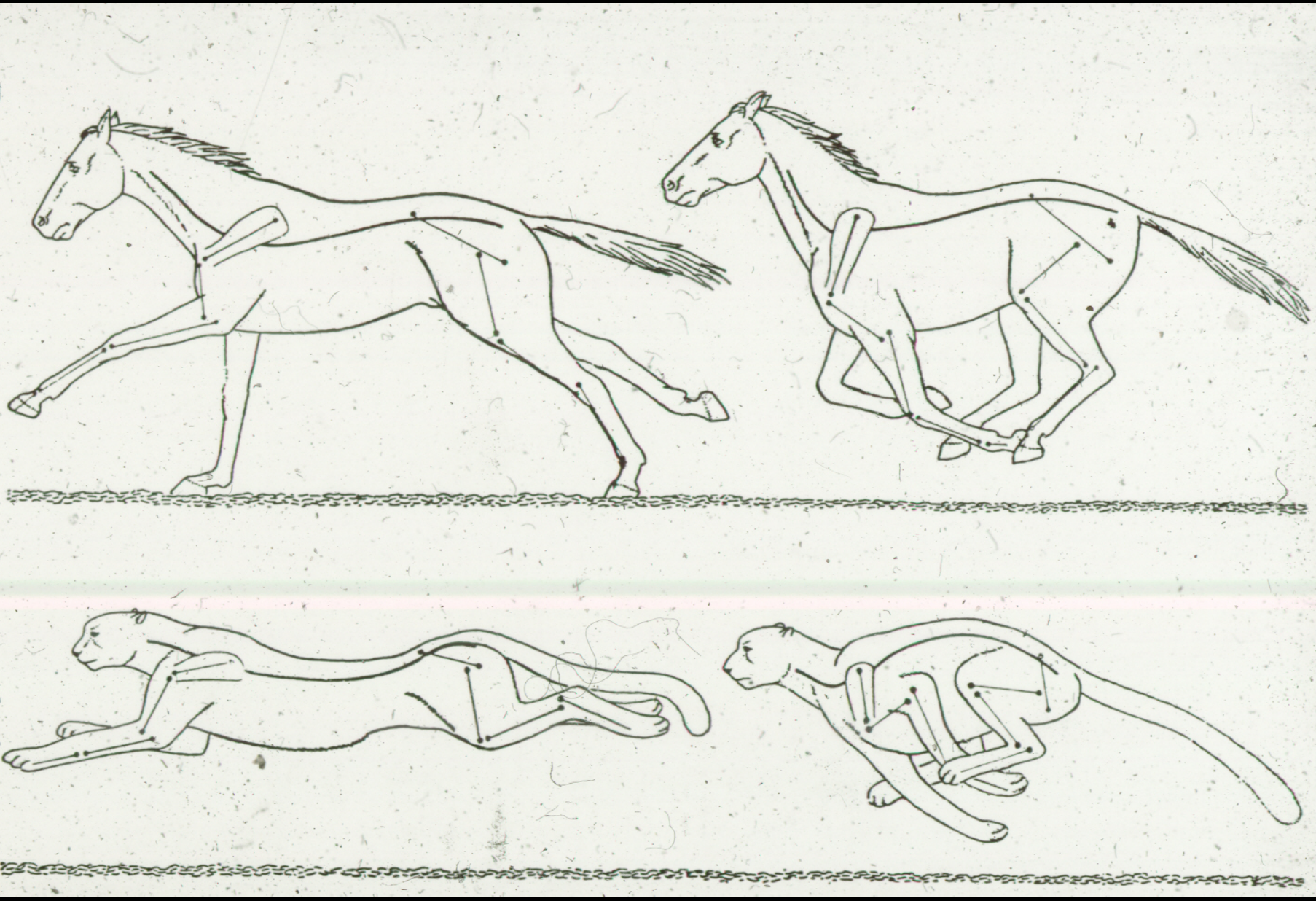
The body then bends to become concave on the right beginning in frame 3 when the right hindlimb touches down and the weight of the body is chiefly carried by the left front and right hindfeet - the other two legs are then moved forward in turn. This pattern reverses again in frame 7 when the left hindfoot touches down.

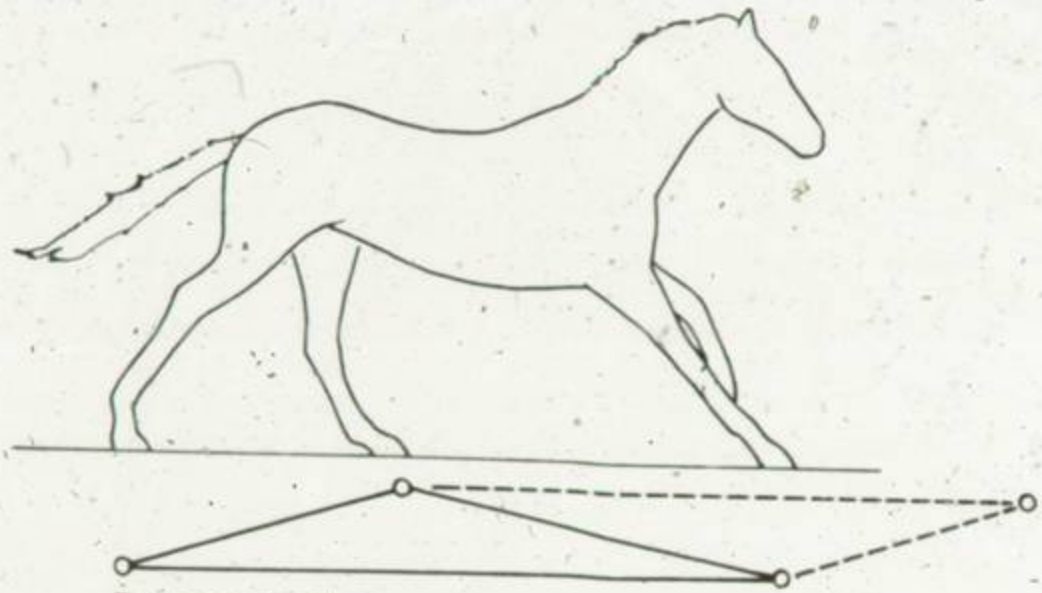
What does the bending of the spine accomplish?

Notice that there are three feet in contact with the ground at most stages of motion. This is a very stable method of locomotion, but is slow and laborious.

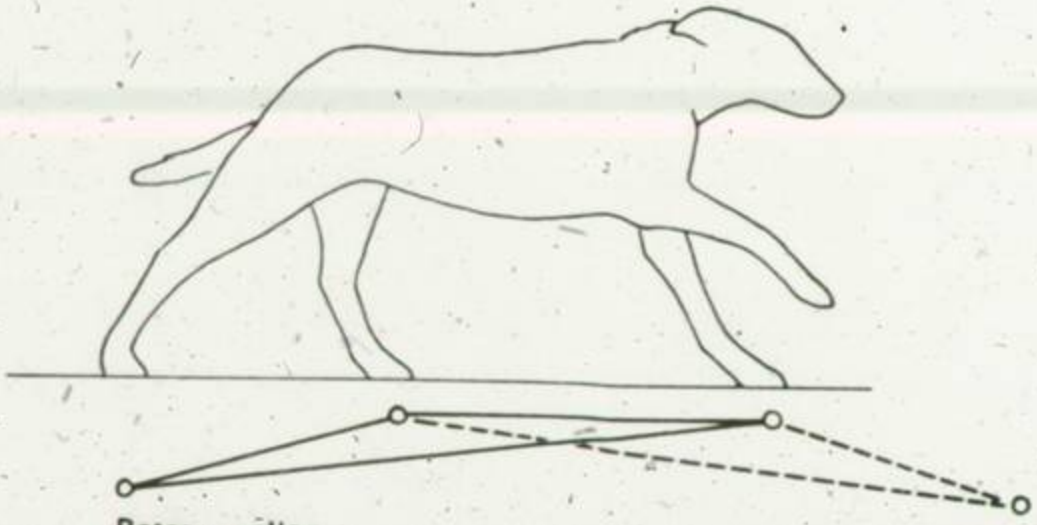



Right front
Left front
Right hind
Left front
Left hind





Transverse gallop



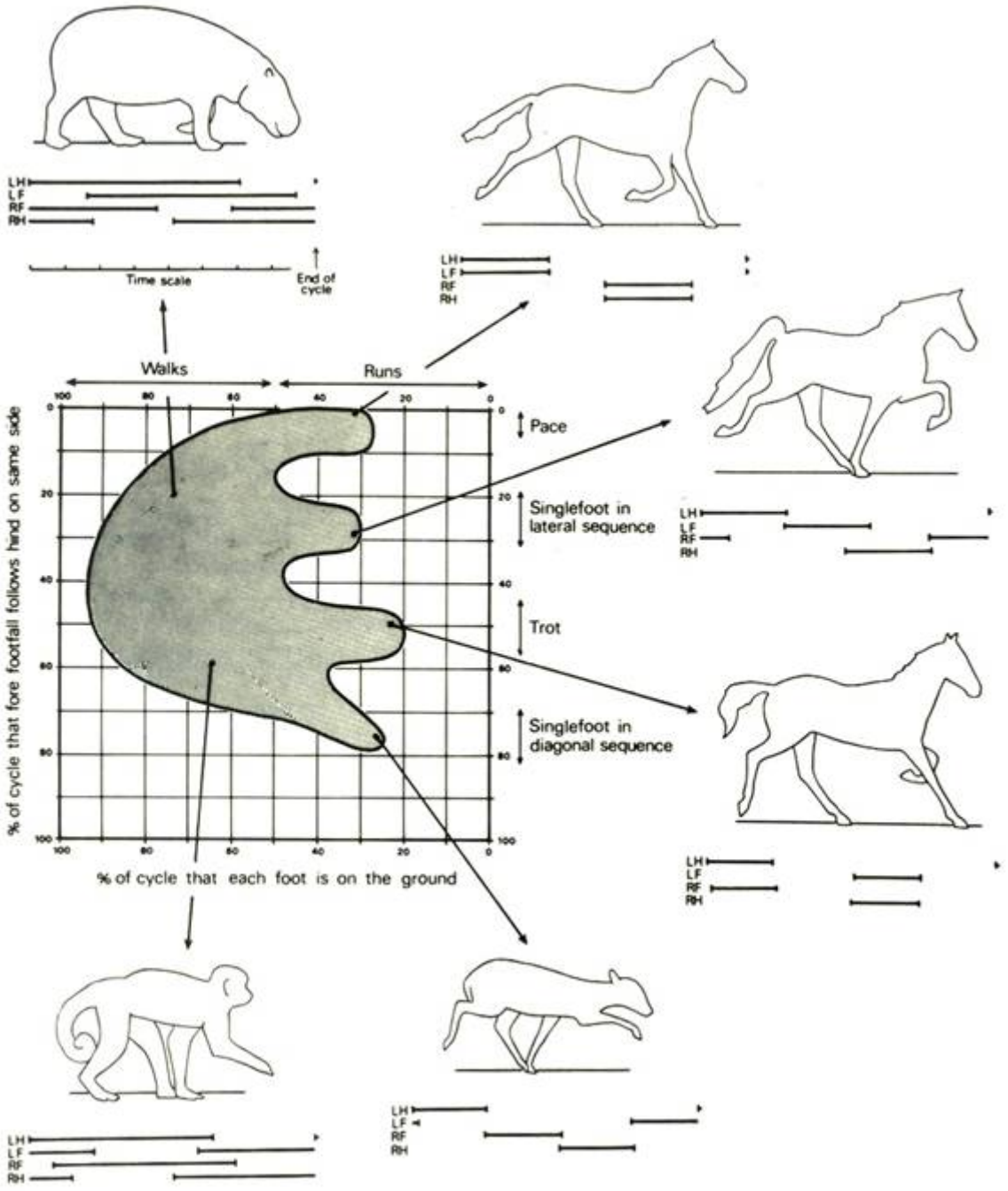
Rotary gallop

SYMMETRICAL GAITS:

Gaits are said to be SYMMETRICAL when the foot falls of two feet of any given pair are evenly spaced in time.

Generally, natural symmetrical gaits are associated with slower speeds and when at least one or more of the four feet are on the ground at any given moment.

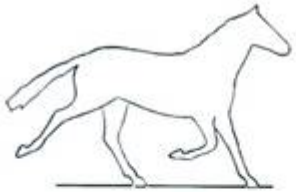
Walk

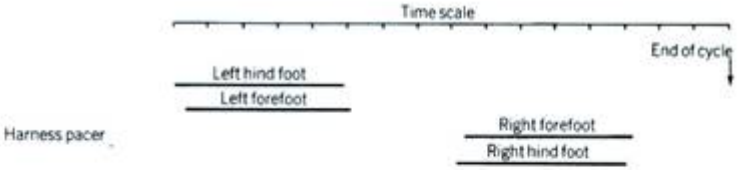


Pace

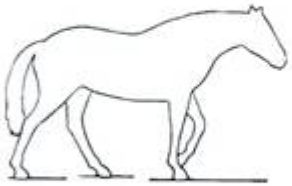
Lateral Trot

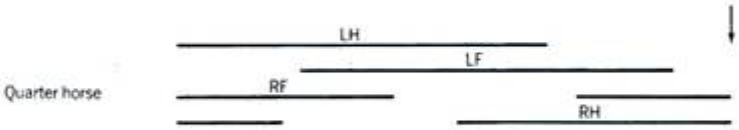
(Normal = “Diagonal ” Trot



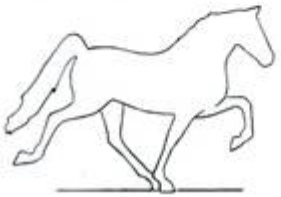


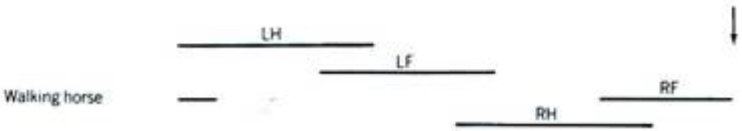
MODERATE RUNNING PACE



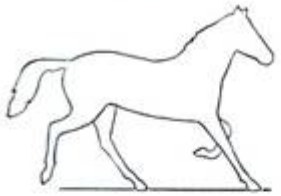


MODERATE WALKING LATERAL SEQUENCE SINGLEFOOT

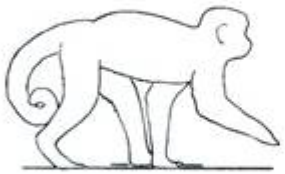


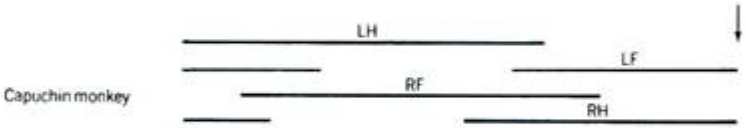


MODERATE RUNNING LATERAL SEQUENCE SINGLEFOOT

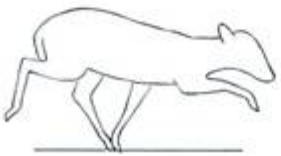


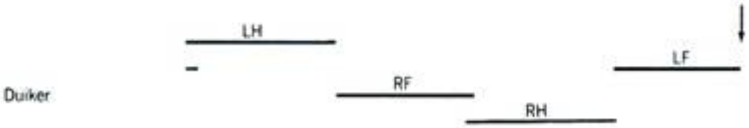
FAST RUNNING TROT





MODERATE DIAGONAL SEQUENCE WALK



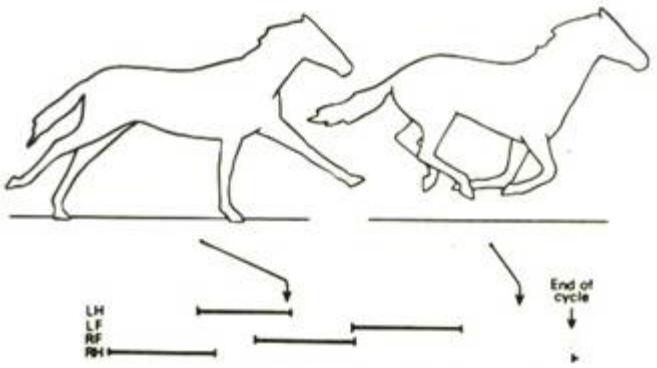


FAST RUNNING DIAGONAL SEQUENCE SINGLEFOOT

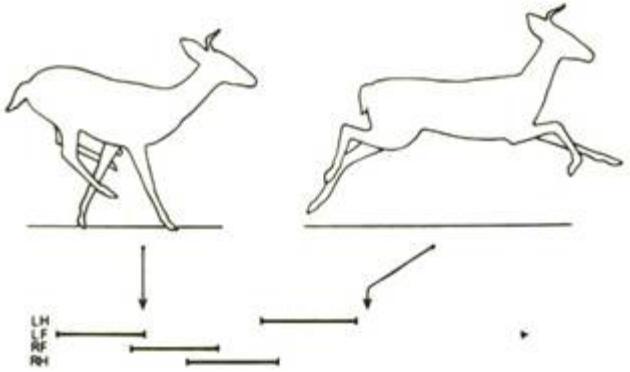
ASYMMETRICAL GAITS:

Gaits are said to be ASYMMETRICAL when the foot falls of two feet of any given pair are unevenly spaced in time.

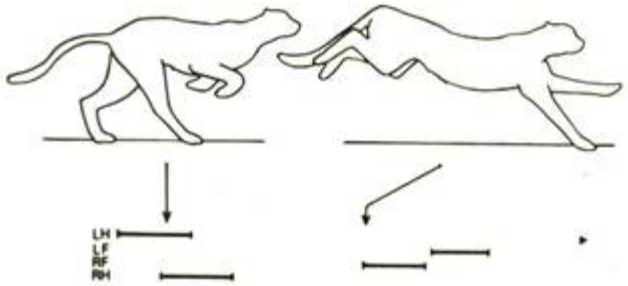
Generally, asymmetrical gaits increase the length of stride by introducing periods of suspension when all feet are off the ground.



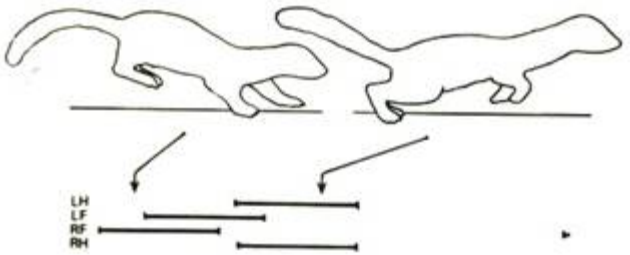
HORSE: Transverse gallop with gathered suspension



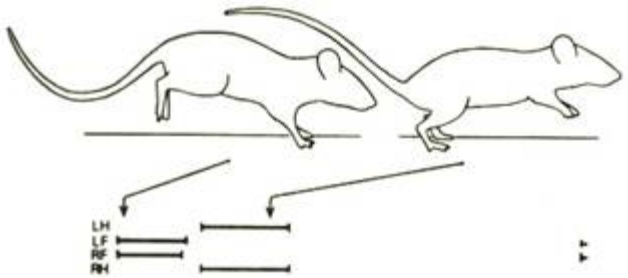
DEER: Rotary gallop with extended suspension



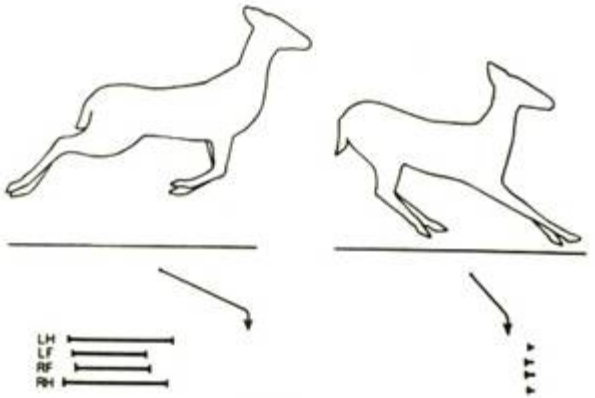
CHEETAH: Rotary gallop with both suspensions



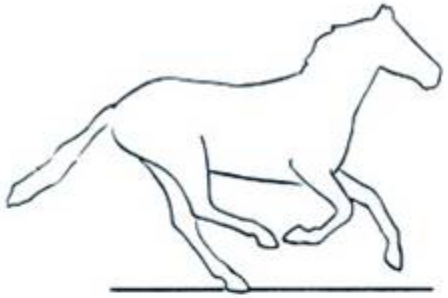
WEASEL: Half bound with extended suspension



HOUSE MOUSE: Bound



DEER: Pronk



Time scale

End of cycle

Left hind foot

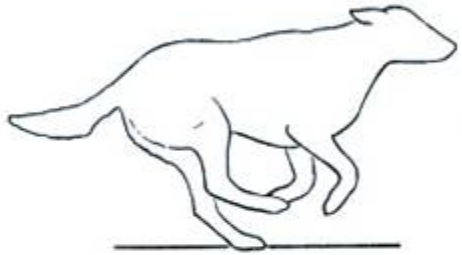
Left forefoot

Right forefoot

Right hind foot

Race horse

FAST GALLOP: SAME LEAD FORE AND HIND; SUSPENSION IN GATHERED POSITION



LH

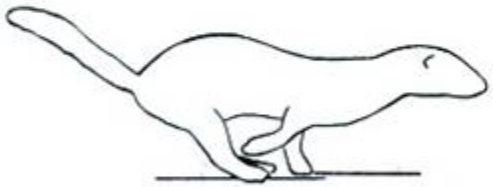
LF

RF

RH

Shepherd dog

MODERATE GALLOP: DIFFERENT LEAD FORE AND HIND; SUSPENSION IN GATHERED POSITION



LH

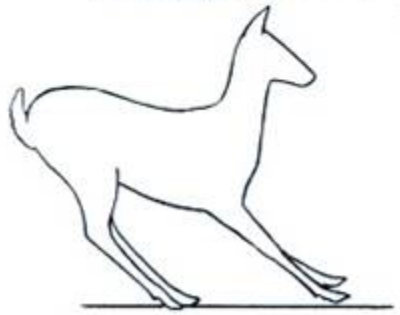
LF

RF

RH

Weasel

HALFBOUND: ONLY FOREFEET HAVE LEAD; SUSPENSION IN EXTENDED POSITION



LH

LF

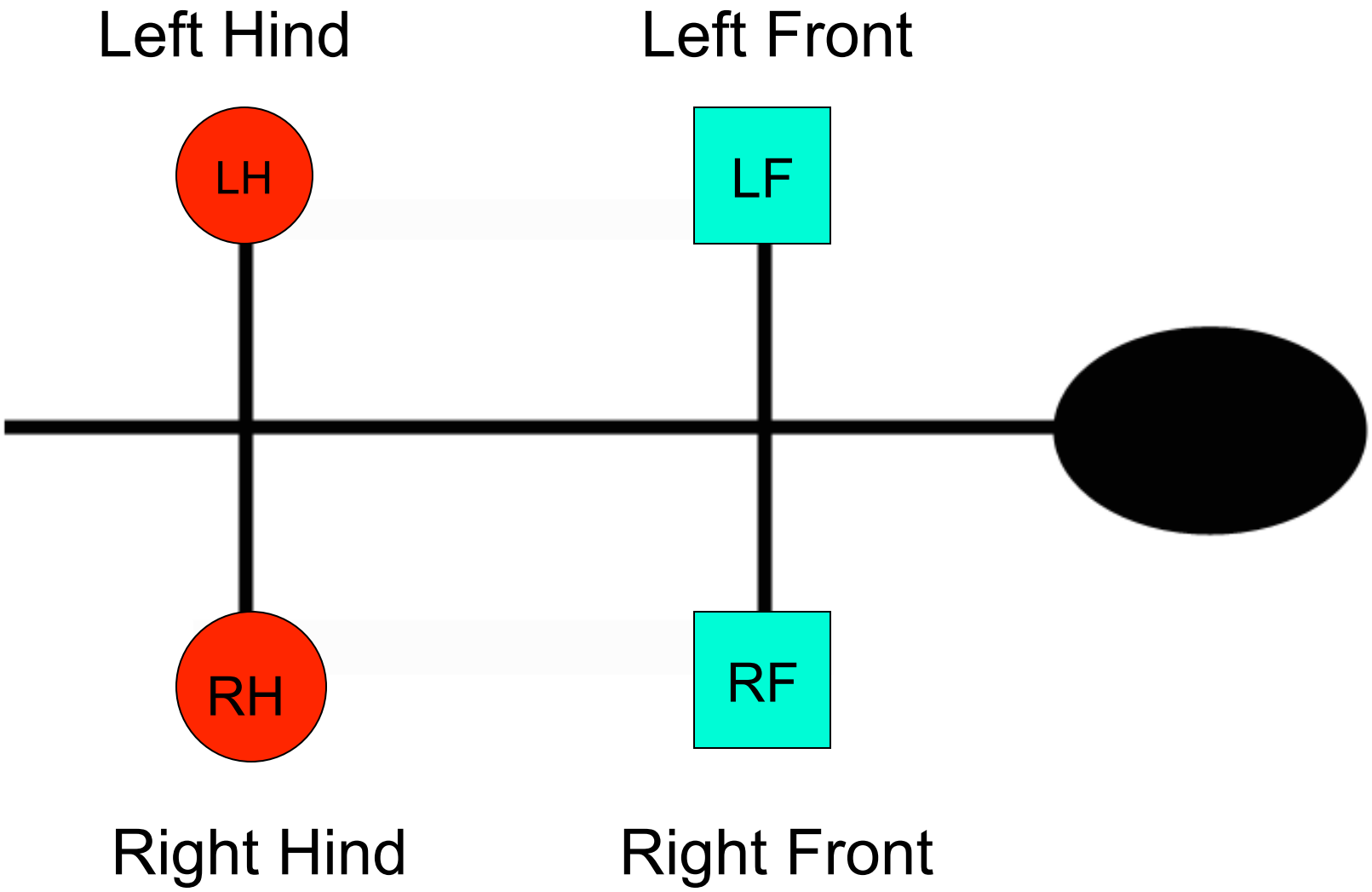
RF

RH

Mule deer

PRONK: ALL FEET MOVE IN UNISON

CONVENTIONS



WALKING

•In four-legged mammals, a walk is usually characterized by having some stage of the step-cycle including a three-point under support – or triangular under support. In other words, at some point three feet are touching the ground. (Human walking is when right and left feet are both in contact at the same time during some part of the step-cycle.

•Walking is considered the slowest of the quardupedal gaits.

•The standard mammalian walk is remarkably consistent from species to species – from mouse to mammoth: footfall sequence in order: Right Hind, Right Front, Left Hind, Left Front; Repeat.

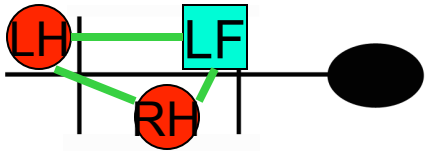
NORMAL/STANDARD WALK

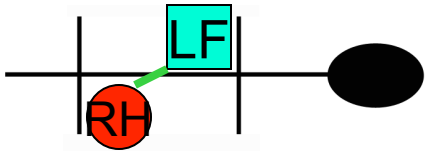
•The standard mammalian walk is remarkably consistent from species to species – footfall sequence in order: Right Hind, Right Front, Left Hind, Left Front; Repeat.

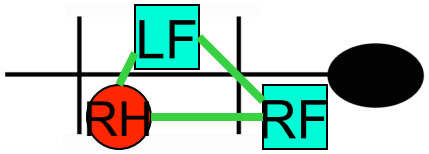
•In four-legged mammals, a walk is usually characterized by having some stage of the step-cycle including a three-point under support – or triangular under support. In other words, at some point three feet are touching the ground.

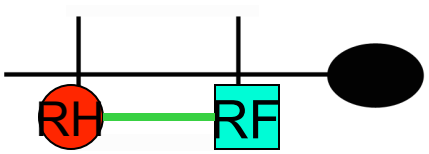
STANDARD MAMMALIAN QUADRUPEDAL WALK

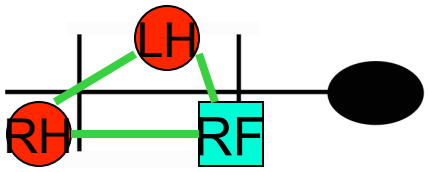


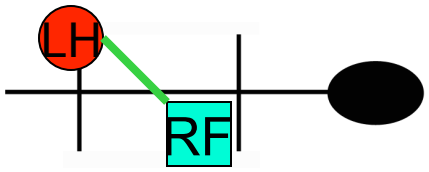


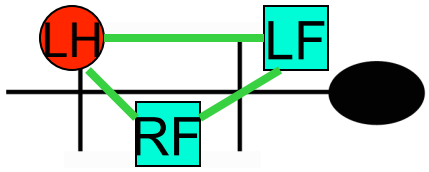


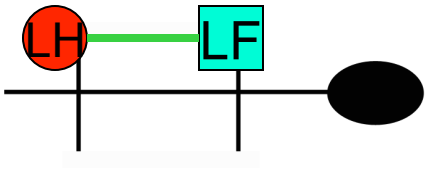




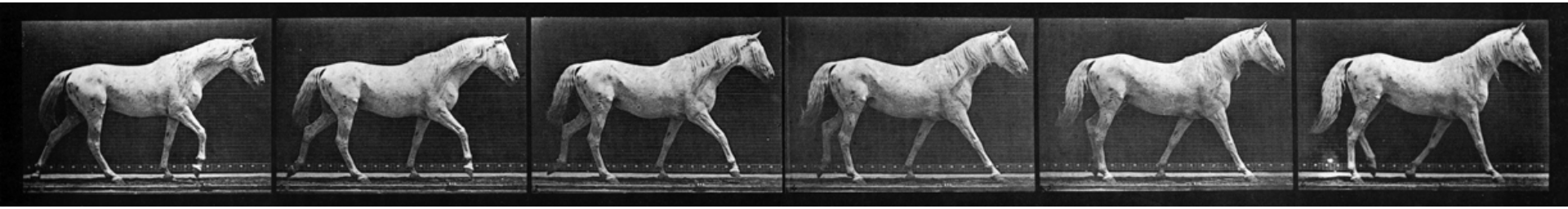


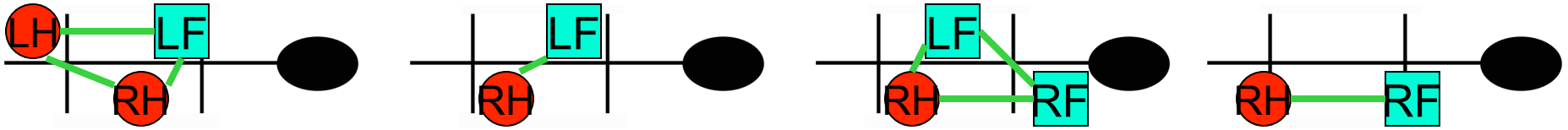


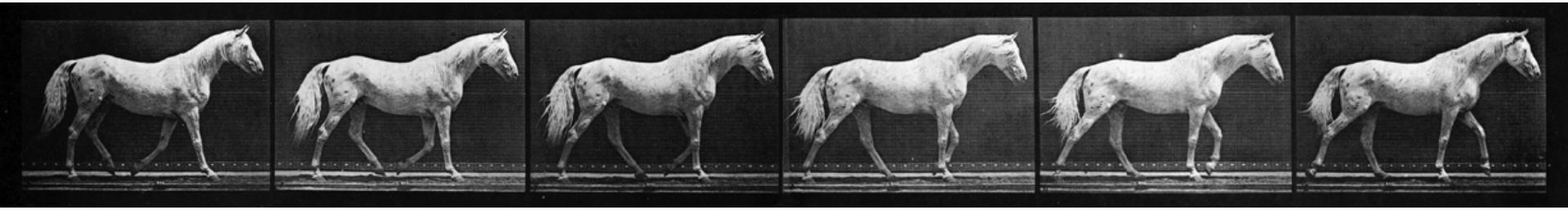


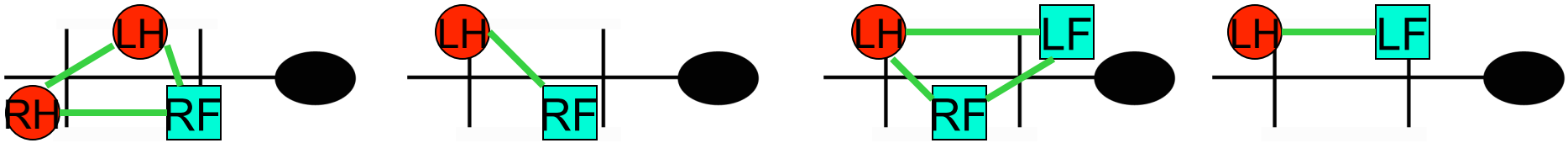


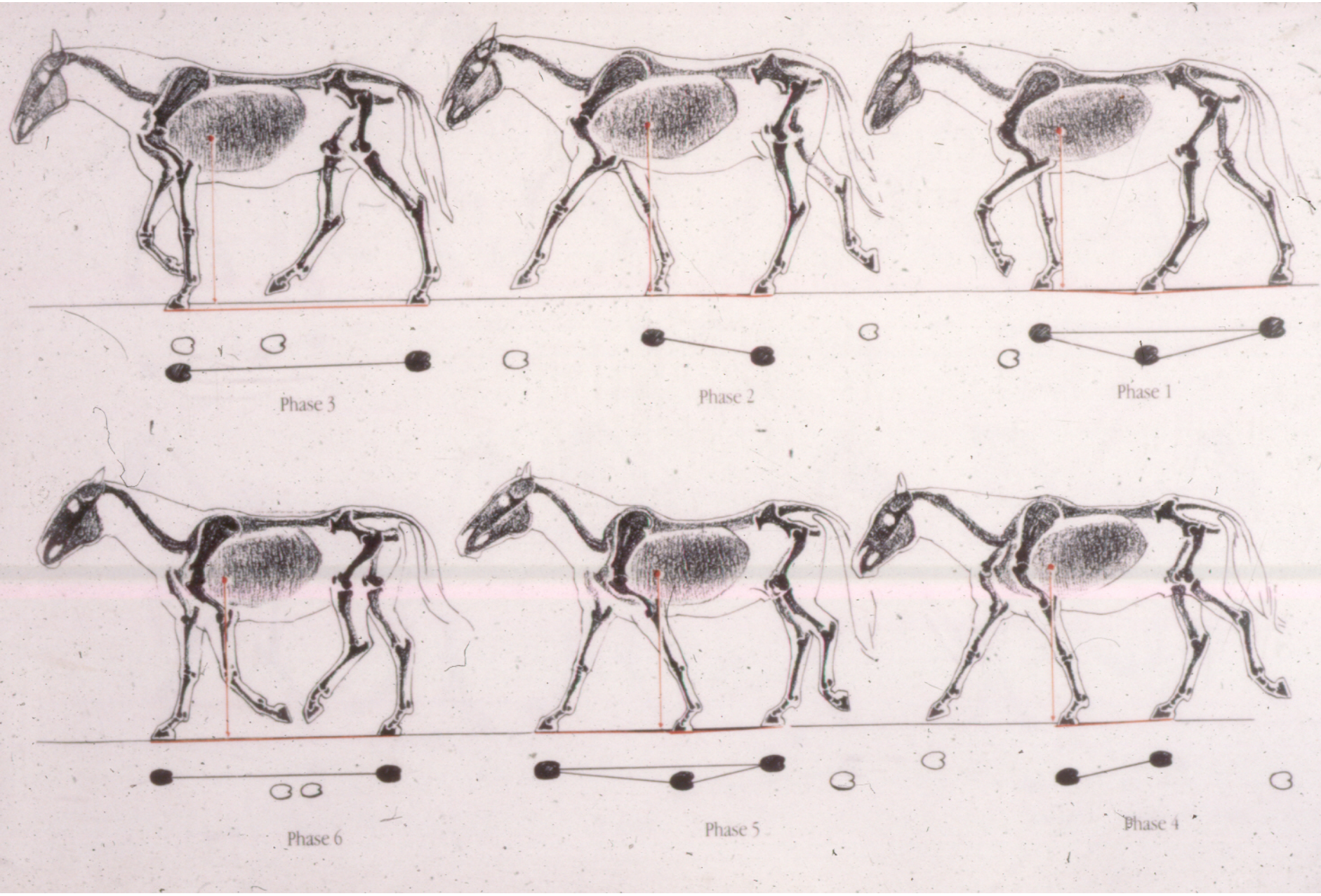
STANDARD MAMMALIAN QUADRUPEDAL WALK










Phase 3
Phase 2
Phase 1
Phase 6
Phase 5
Phase 4

THE AMBLE

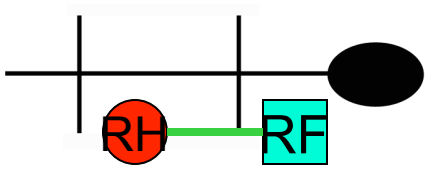
- The AMBLE is essentially a "sped-up" walk.

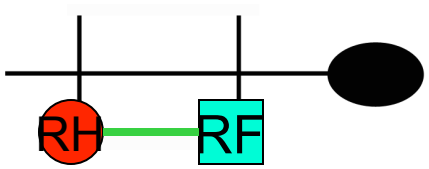
- It is a gait that is usually transitional between a normal walk and a trot.

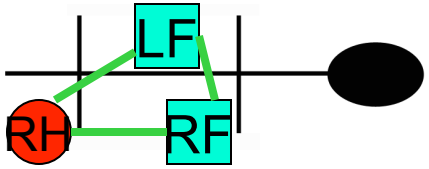
- This sped up walk is what animals do when constrained to walking but when they want to move fast (think Stitch skittering along when he first gets to Lilo's house).

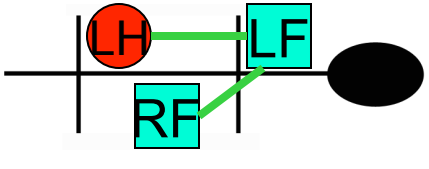
- This sped up walk is what animals do when they are very large (e.g. elephants) and can't truly trot.

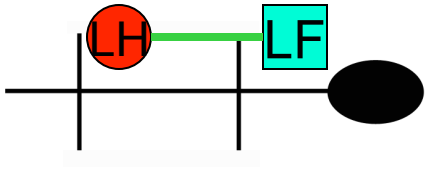
THE AMBLE

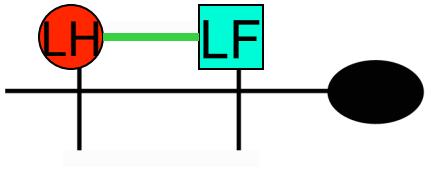


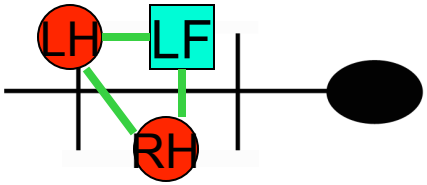


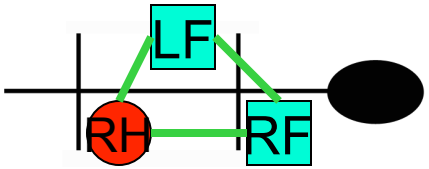












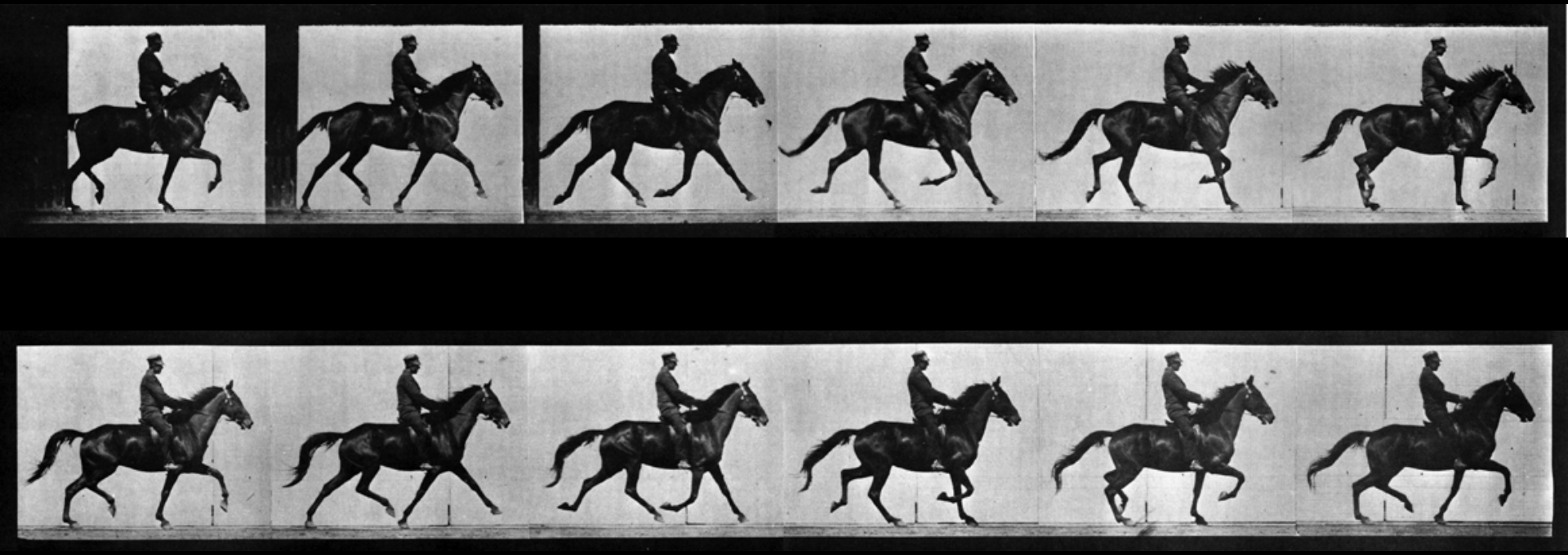
THE HIGH LEAD AMBLE

•The HIGH LEAD AMBLE is more common in large animals (e.g. horses, but is occasionally seen in medium to larger dogs)

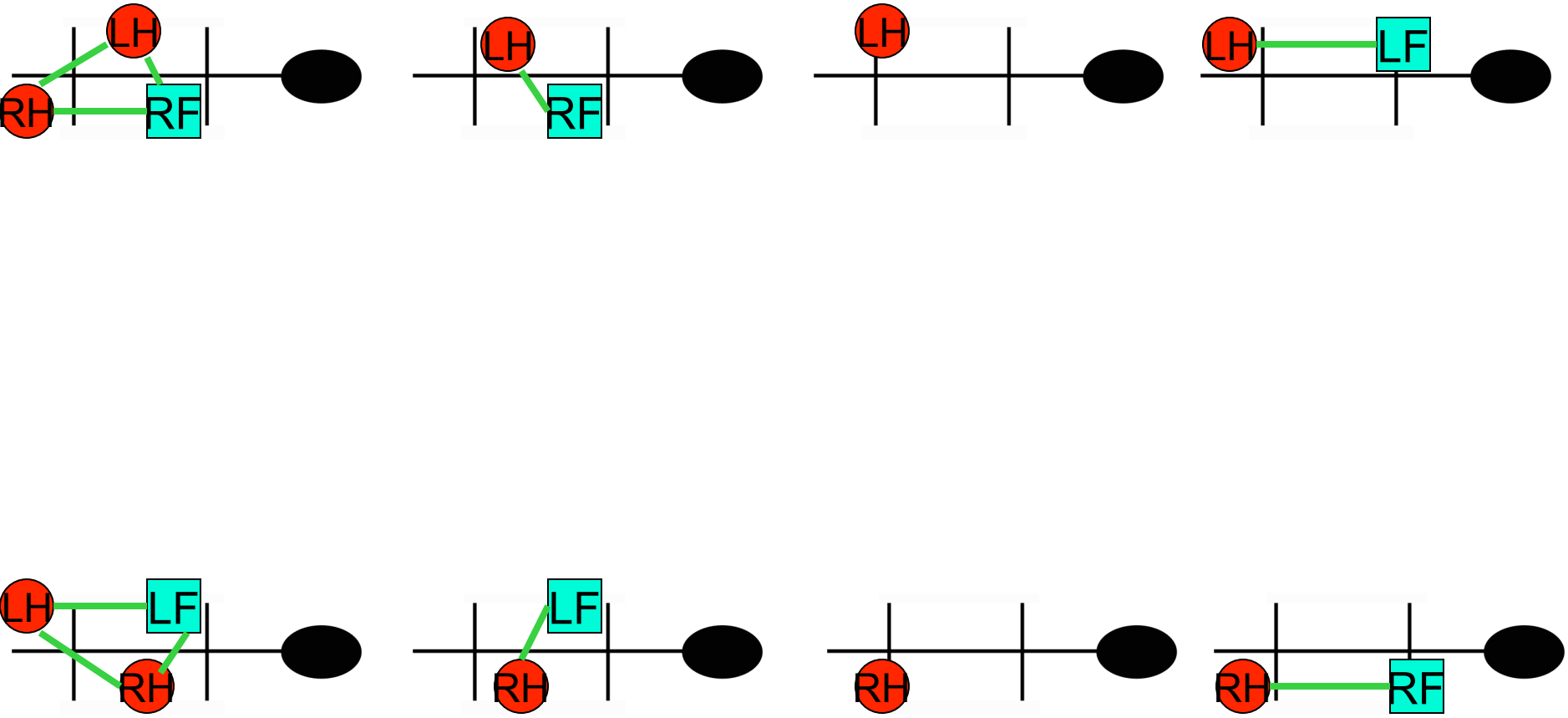
•The walking gait is still a succession of hind-font couplets that alternate sides, but done at a higher speed – a high enough speed so that the animal doesnt’ tip from one side to the other.

•This gait has only a very brief and smaller triangular under support.

High Lead Amble



THE HIGH LEAD AMBLE



Mammalian Locomotion

Pacing and Trotting
Transitions to Trotting

PACING

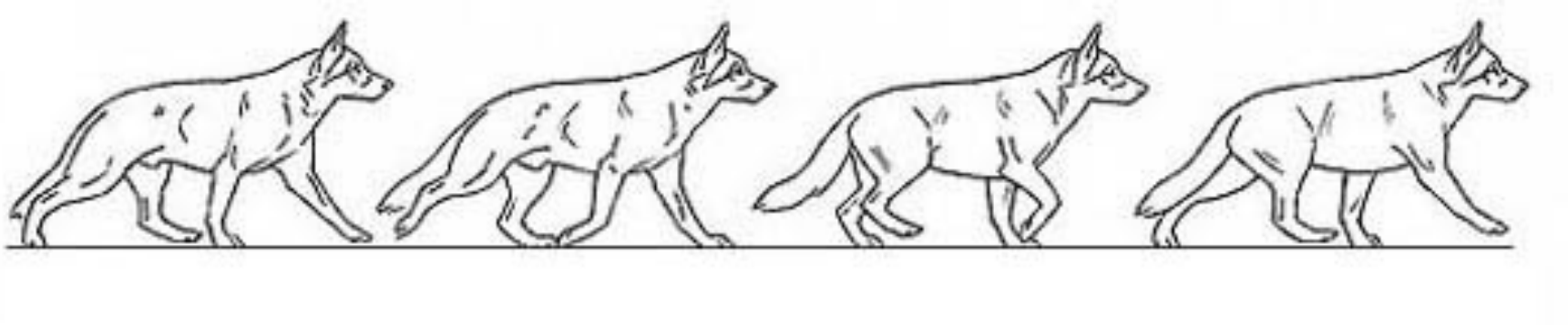
•In four-legged mammals, a pace is characterized by the step-cycle being dominated by alternating right and left couplets with the fore- and hind limbs on each side moving in register (almost parallel) with one another.

•Pacing is considered a slow to medium speed quadrupedal gait.

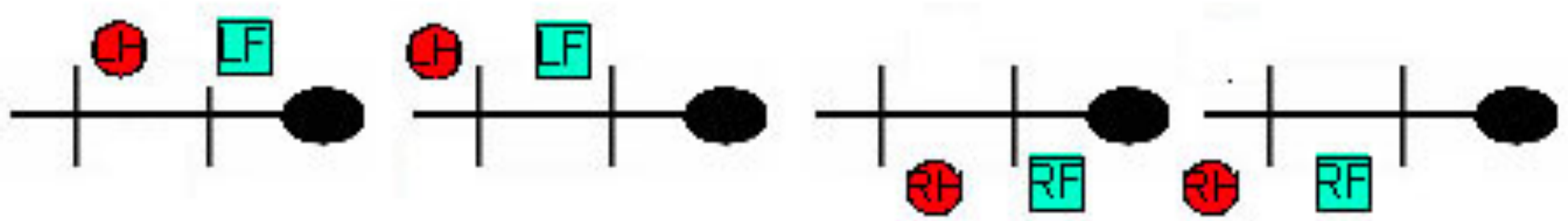
•Medium to larger sized dogs often pace to avoid banging and front limbs together on the same side.

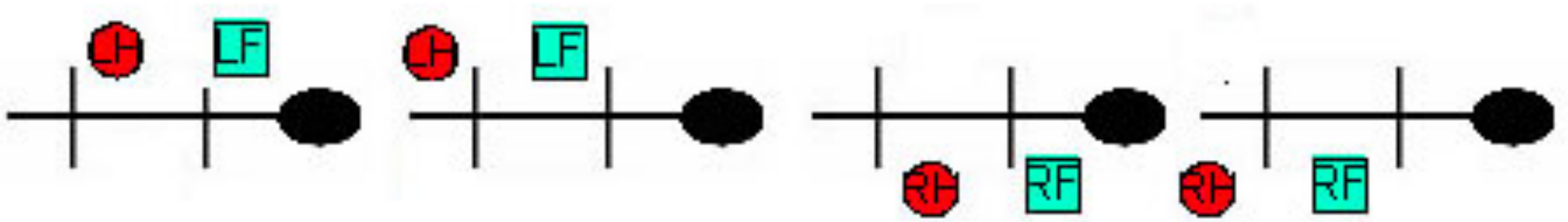
•The mammalian pace is often considered to be somewhat less stable than the diagonal support found in a typical trot..

PACING - In four-legged mammals, a pace is characterized by the step-cycle being dominated by alternating right and left couplets with the fore- and hind limbs on each side moving in register (almost parallel) with one another.



PACING - In four-legged mammals, a pace is characterized by the step-cycle being dominated by alternating right and left couplets with the fore- and hind limbs on each side moving in register (almost parallel) with one another.





TROTTING

•In four-legged mammals, a trot is usually characterized by most of the step-cycle dominated by alternating diagonal under support (also known as “diagonal couplets”).

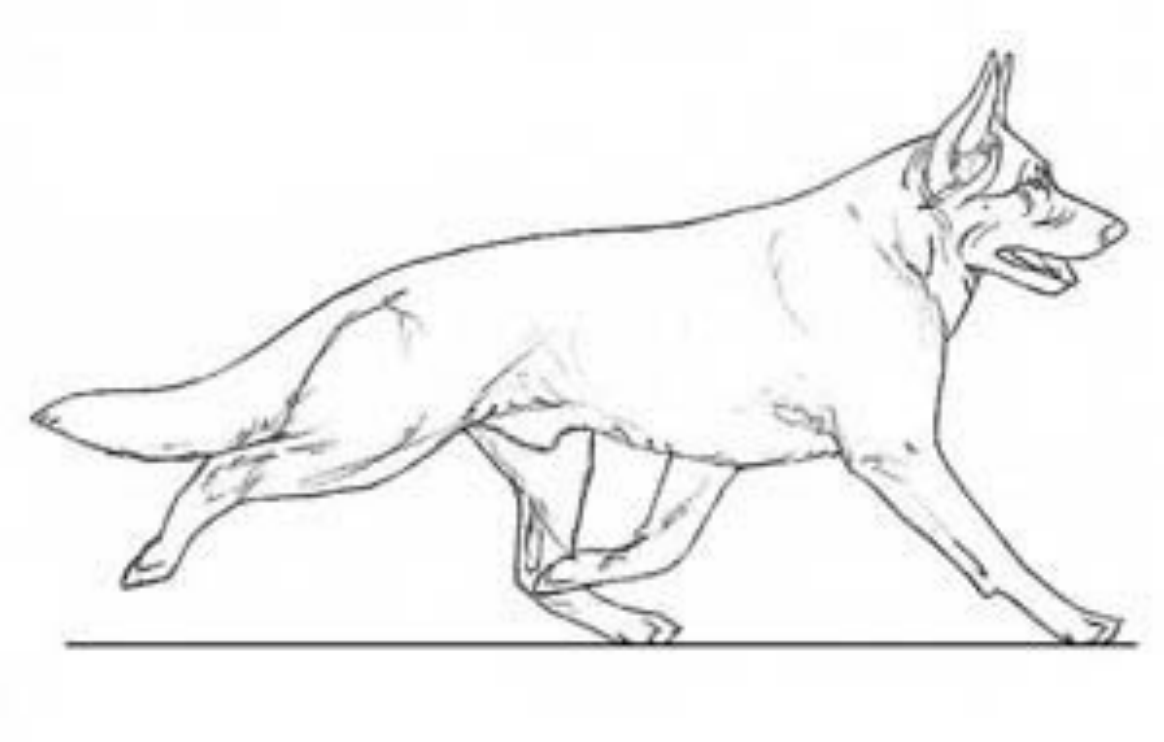
•Trotting is considered a slow to medium speed quadrupedal gait.

•Trotting is dominated by alternating contact with the ground of [right-hind+left-front] and [left-hind+right-front].

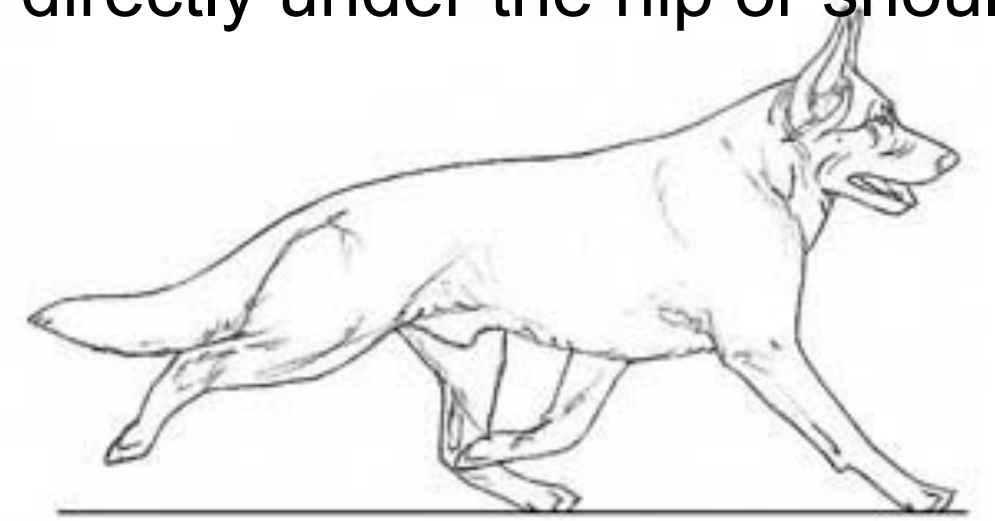
•The mammalian trot is often subdivided into a perfect “two-beat” trot (potential to be more cartooney) and a “four-beat” trot.

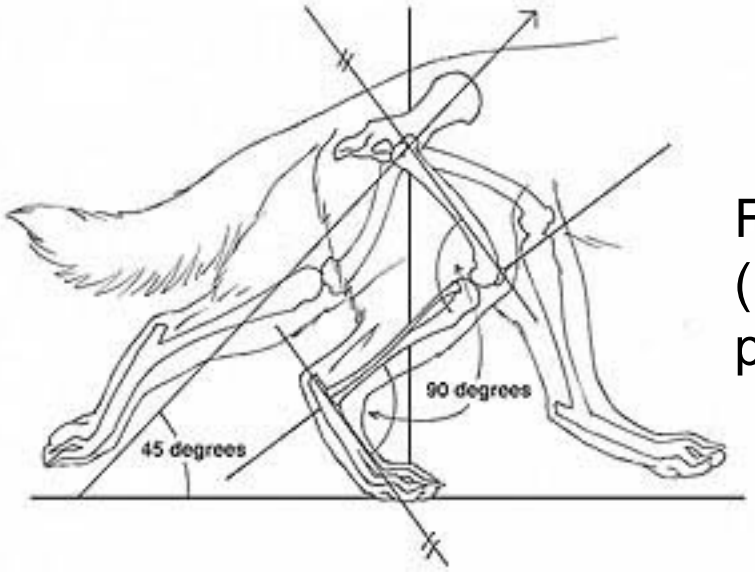
TROT

•Trotting is dominated by alternating contact with the ground of [right-hind+left-front] and [left-hind+right-front].



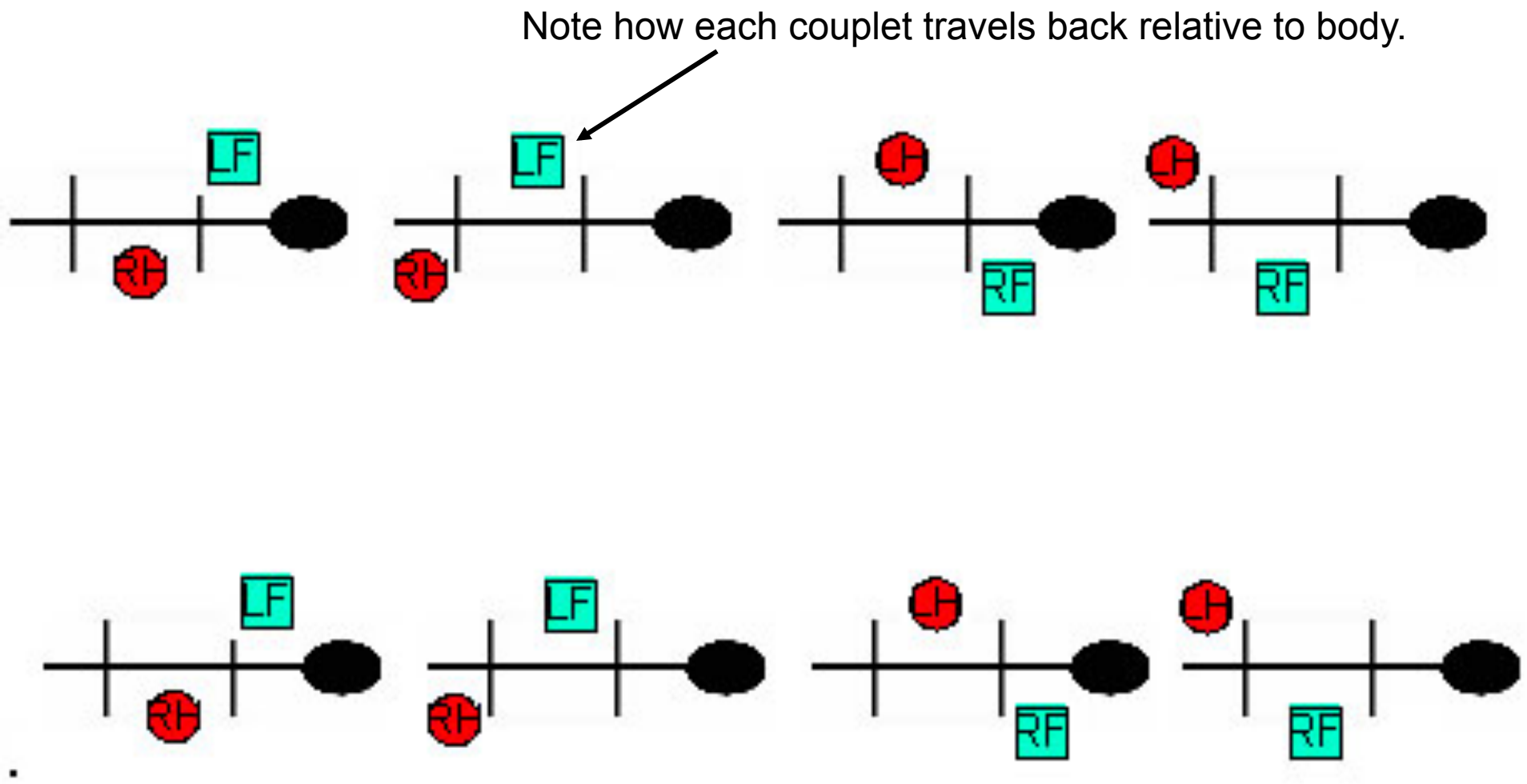
When moving at speed, each limb must overshoot the typical plane directly under the hip or shoulder joints.





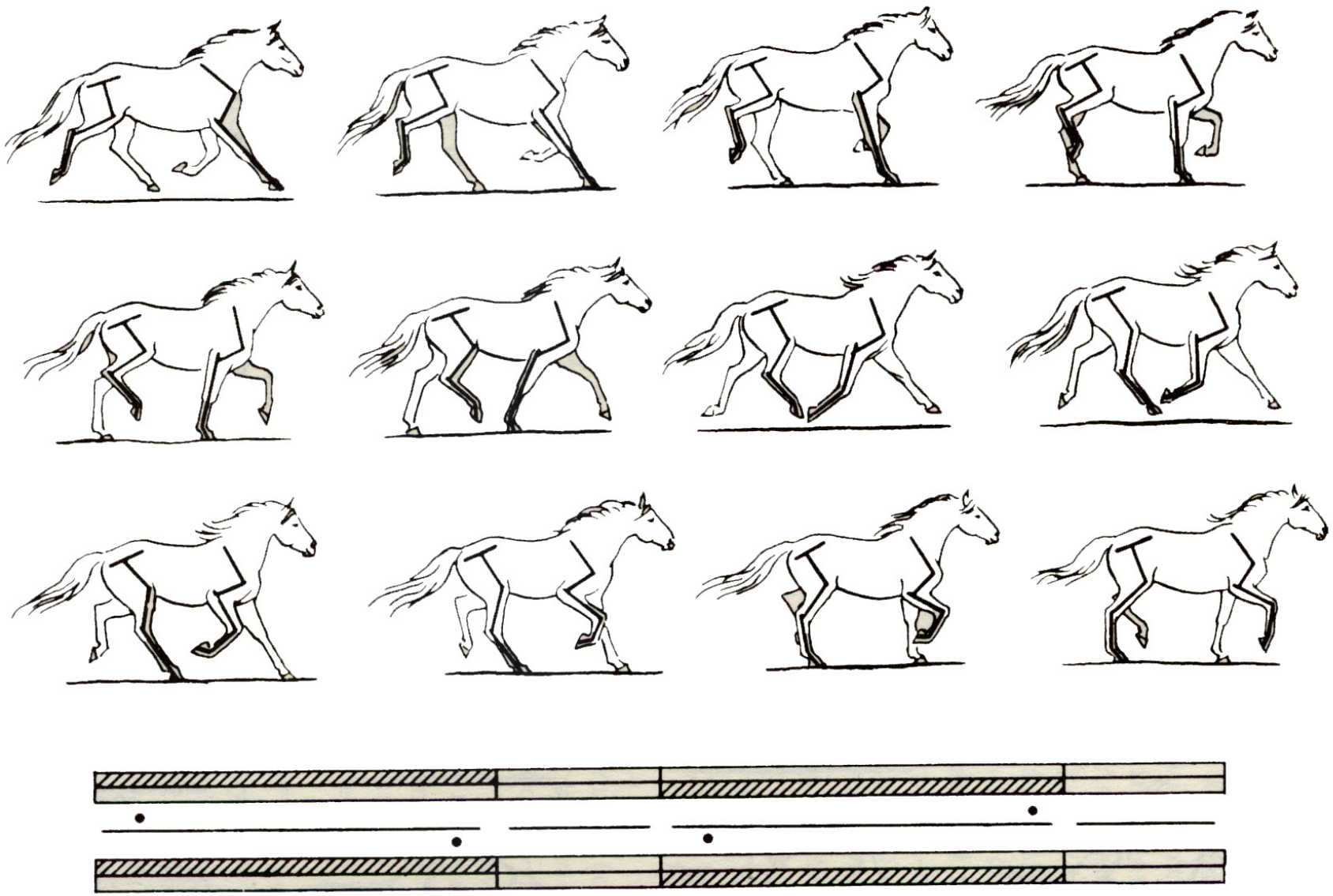
Femur and foot almost (not quite, but almost parallel with one another.

A BASIC 2-BEAT TROT: Note that diagonal couplets are alternating in a very symmetrical manner.

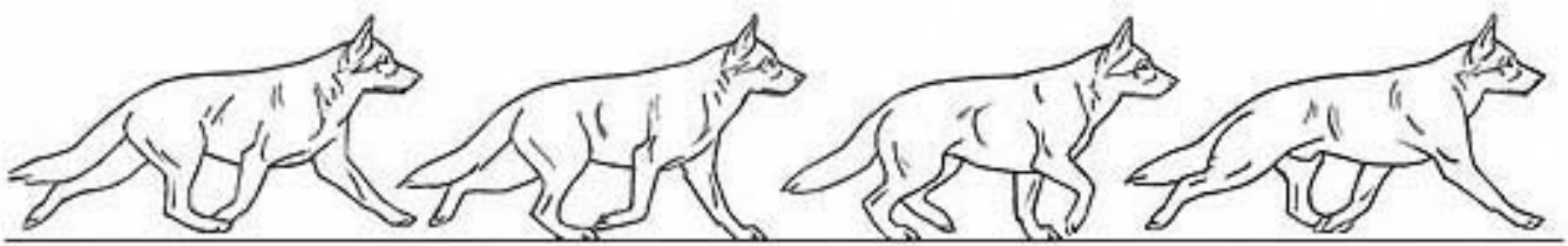


Cat trots are not at all “bouncy” – the back stays extremely stable.

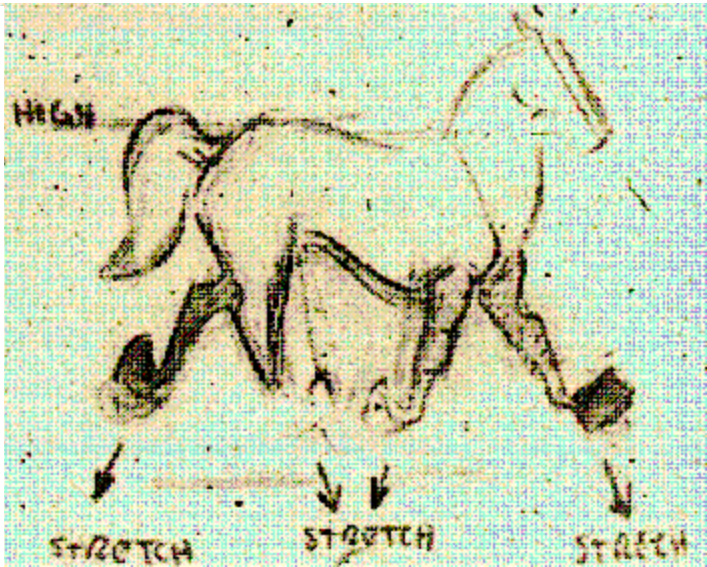
Cats will continue to trot at relatively higher speeds than will dogs. A dog of similar size will break into a gallop whereas a cat will maintain a fast trot for longer and at higher speeds.



In faster “trots” the body/feet can leave the ground. This is usually referred to as a “***suspended trot***”. It is often a 4-beat trot. Horses don’t do this really, but it can be done to achieve a more “cartoony” look.



(Suspended)



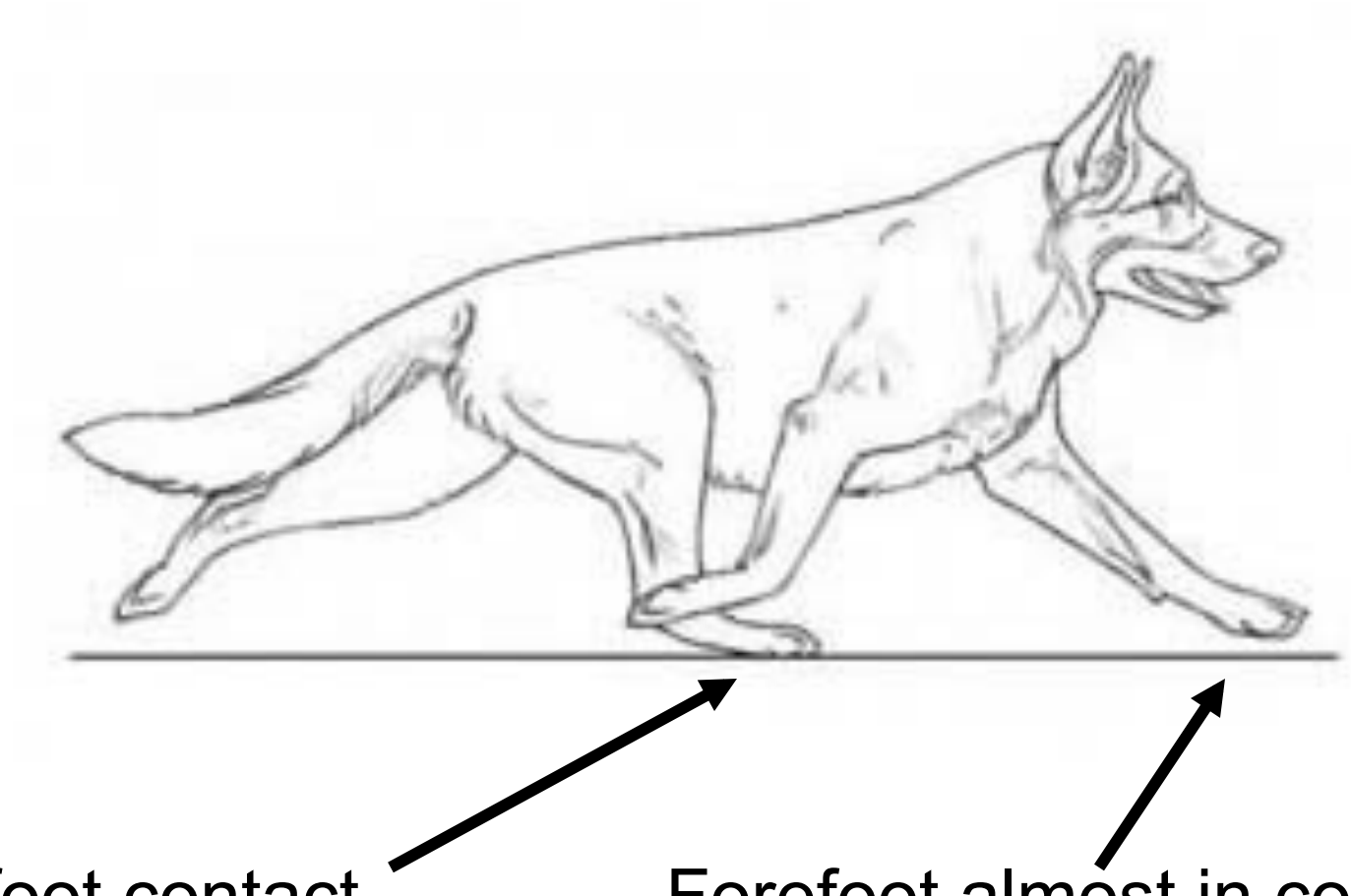
THE FOUR-BEAT TROT

•It is important to note that animals are rarely PERFECTLY symmetrical in nature.

•The four-beat trot is indeed dominated by diagonal couplets [right-hind+left-front] and [left-hind+right-front], but not that the hind member of each couplet lands a split second ***before*** the fore member of each.

•Additionally, the fore member of each couplet leaves the ground a split second ***after*** the hind member of each.

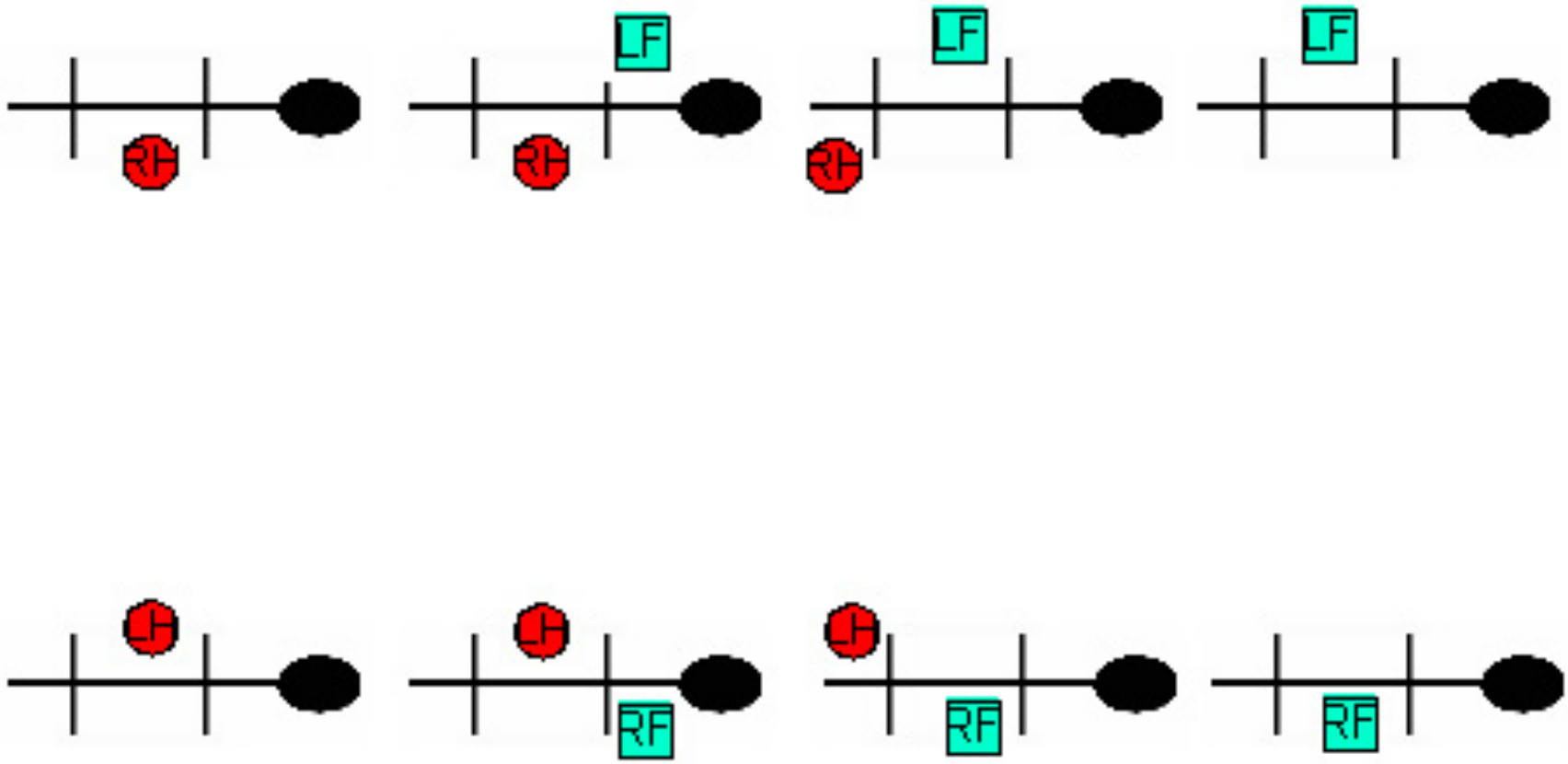
In the FOUR-BEAT TROT it is important to note that the hind member of each couplet lands a split second before the fore member of each.



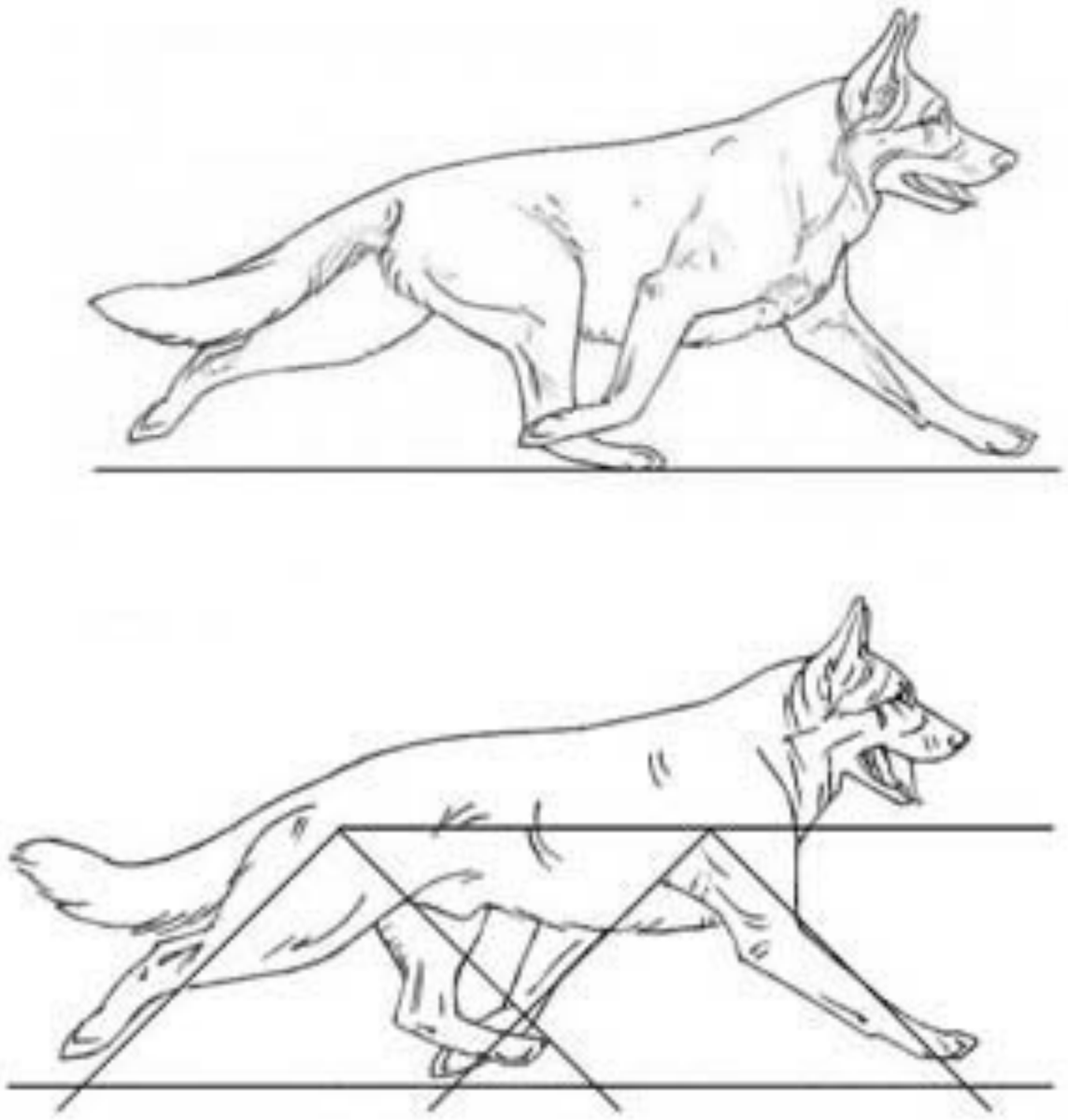
Hind foot contact.

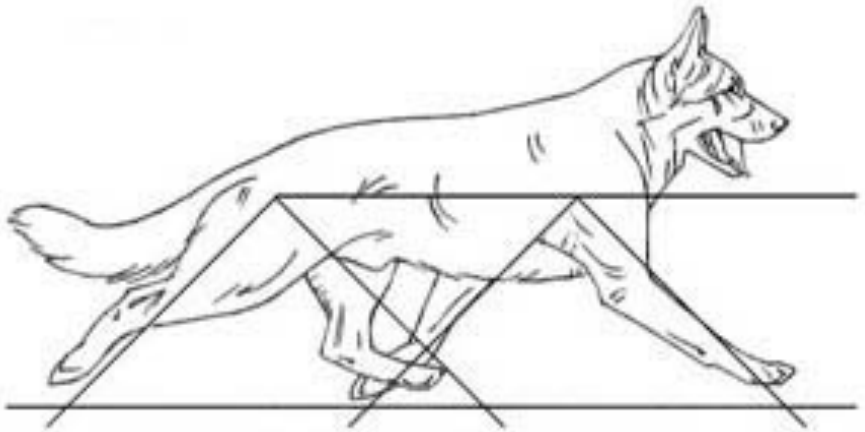
Forefoot almost in contact.

The four-beat trot is dominated by diagonal couplets [right-hind+left-front] and [left-hind+right-front], but not that the hind member of each couplet lands a split second ***before*** the fore member of each. Additionally, the fore member of each couplet leaves the ground a split second ***after*** the hind member of each.



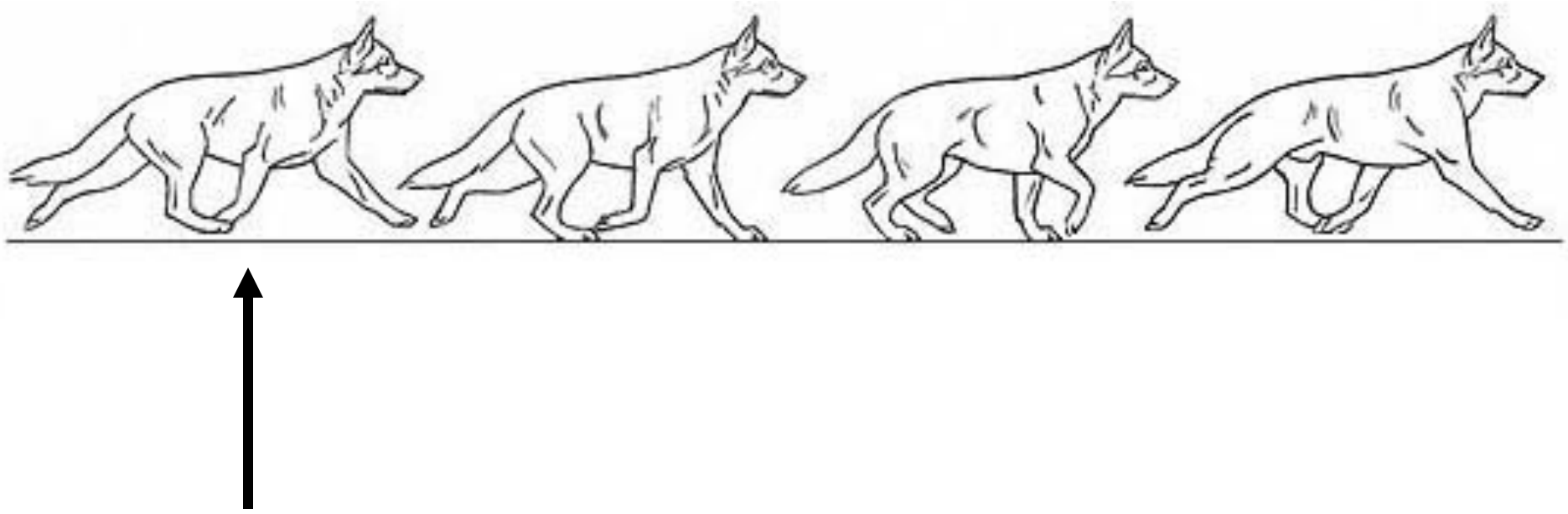
The trot is an extremely symmetrical gait.





The very slowest of the “trots” is a fast walk at best, with the body never leaving the ground. If there is no period when all four feet are off the ground, it’s usually referred to as a “***supported trot***”.

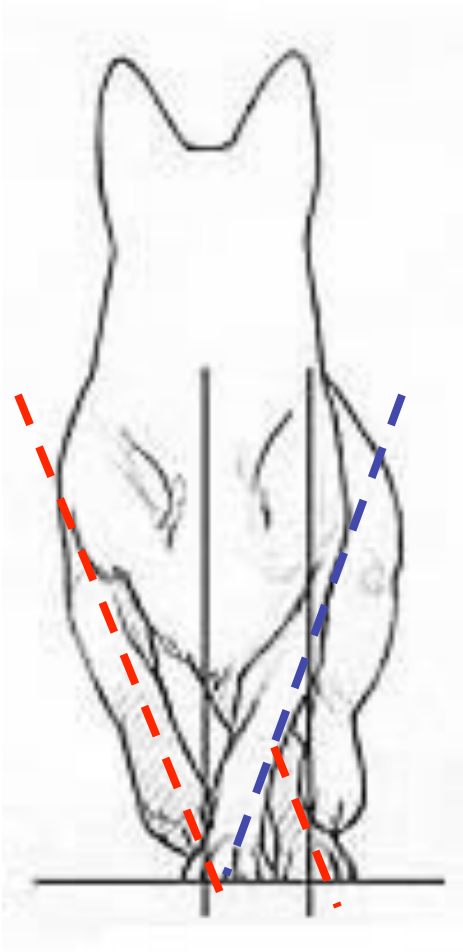
In faster “trots” the body/feet can leave the ground. This is usually referred to as a “***suspended trot***”. It is often a 4-beat trot.



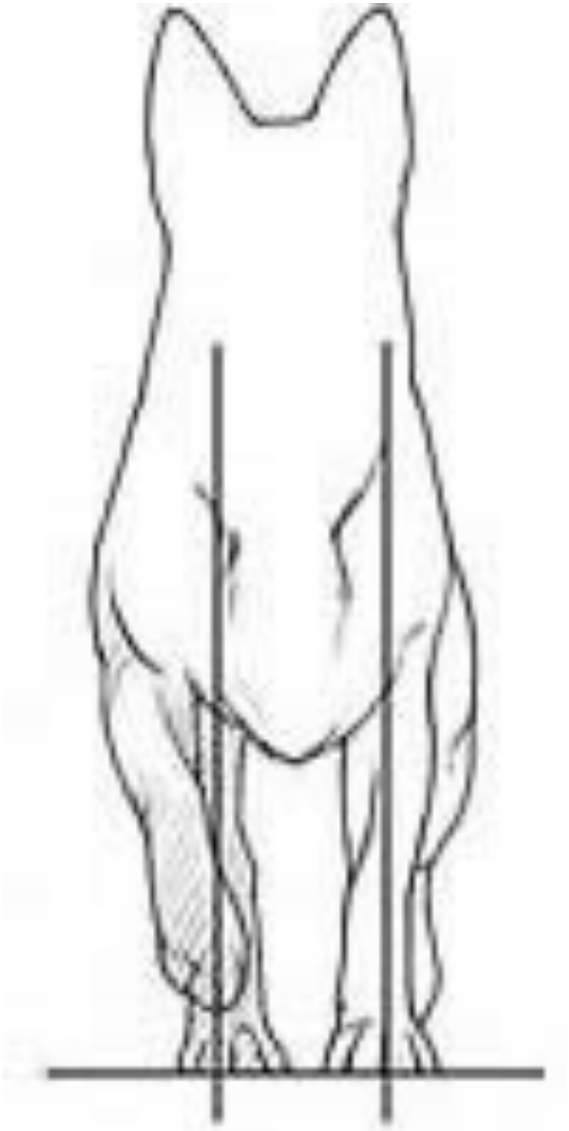
(Suspended)

TRACKING AT MODERATE SPEED

- Dogs are known to “single track”, “double track”, and “triple track”, depending on the situation.

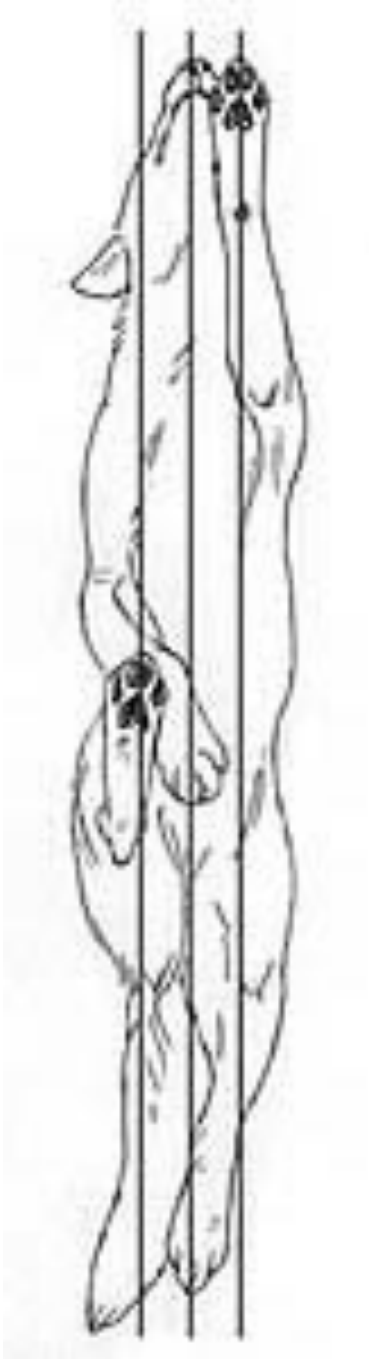


Single tracking requires moderate adduction of the limbs to the midline under the animal’s body.



Double tracking occurs in medium speed trots.

All four limbs project approximately straight down to the ground, perpendicular to ground.

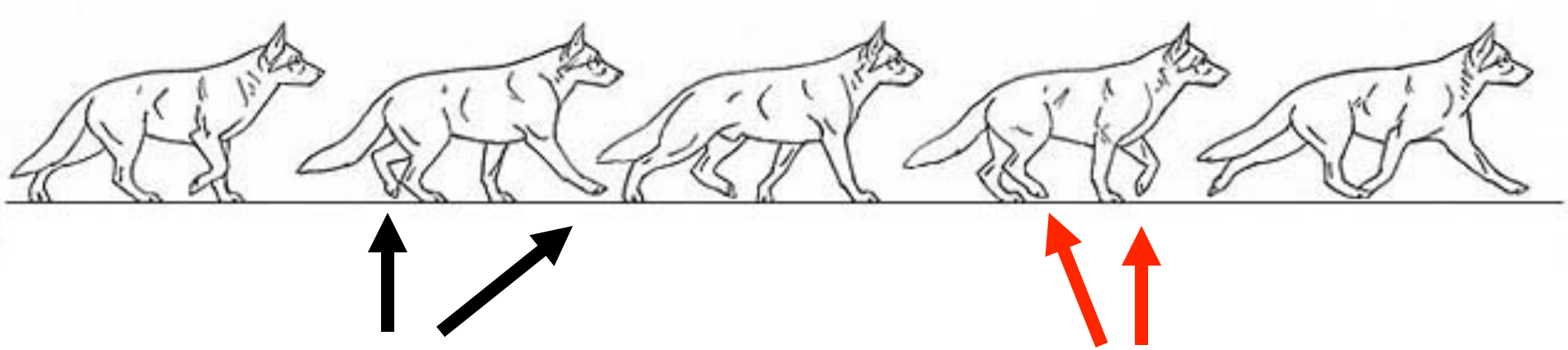


Triple tracking is done at the higher trotting speeds to that limbs don't bump into one another.

Some animals keep one couplet central, others the other couplet.

Again, all four limbs project approximately straight down to the ground, perpendicular to ground.

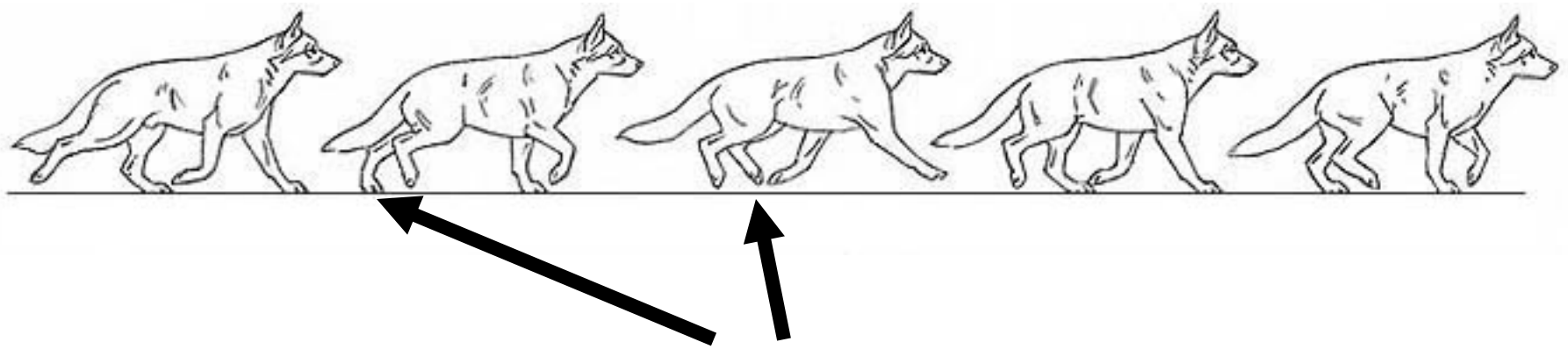
WALK TO TROT TRANSITION:



Hind limb picked up somewhat more quickly to bring into register with ipsilateral fore limb.

Fore limb on same side picked up somewhat more quickly to bring into register with its ipsilateral hind limb.

PACE TO TROT TRANSITION:



A skip of one of the hind limbs forward very quickly to pass other hind limb allows it to come into register with ipsilateral fore limb.

Mammalian Locomotion

High Speed Gaits
Galloping
Canter: Transitions from Gallop

RUNNING GAITS

•In four-legged mammals, a running gait is one where some part of the step cycle is spent in suspension – with all for limbs out of contact with the ground

•The most standard high-speed gait in dogs is the rotary gallop.

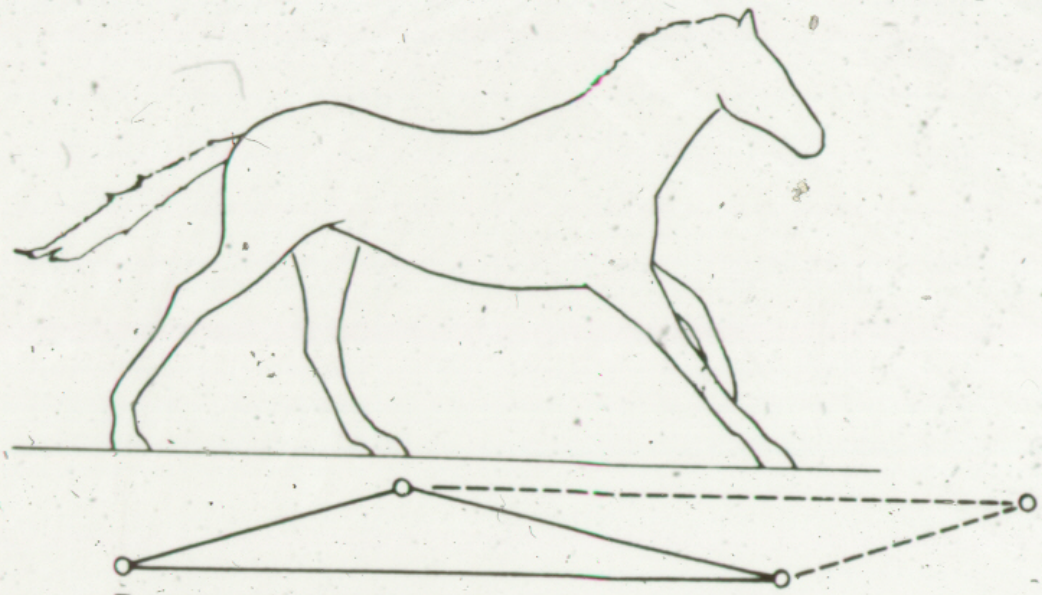
•The canter is an asymmetrical and infrequently used gait in dogs. When used it is often as a transition from the gallop as the animal is slowing down. It is also sometimes used when playing and the impression of speed is combined with interaction with other animals.

GALLOP

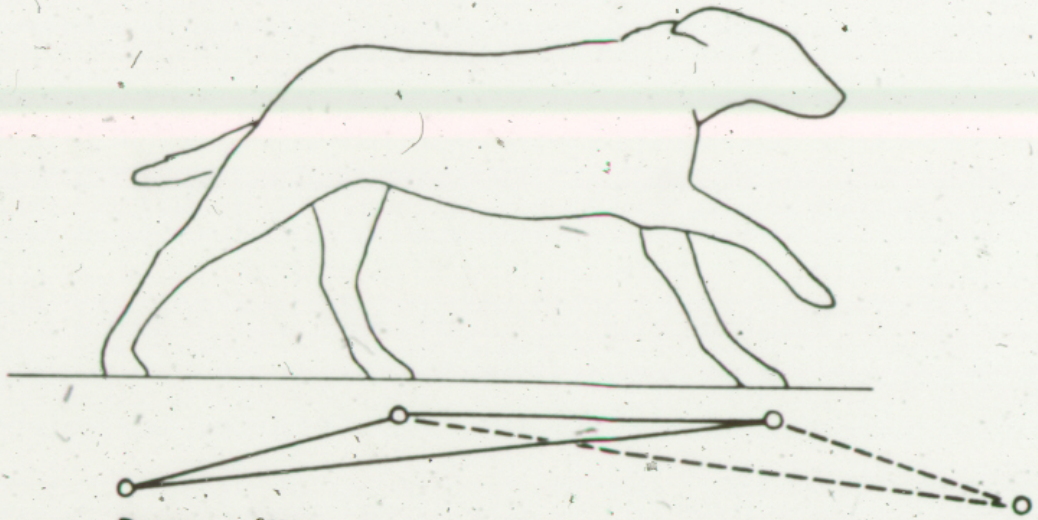
•In four-legged mammals, the highest speed gait is the gallop. It is a four-beat gait, with each limb contacting independant of the other three.

•In dogs, the gallop usually has a double suspension, or a floating phase with the limbs both gathered underneath as well as extended forward and back.

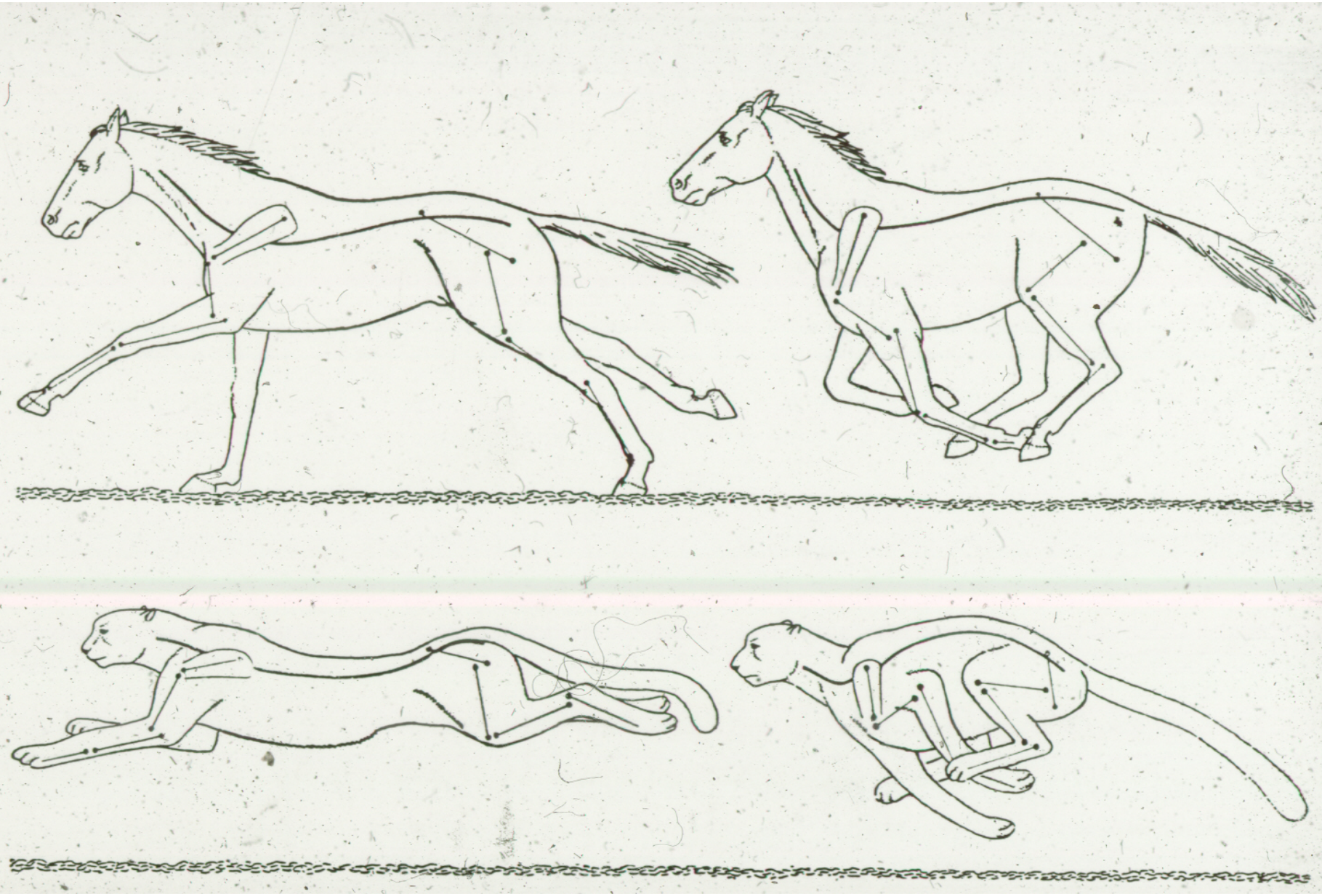
•The footfall sequence tends to be: right hind, left hind, left, front, right front. (Or left hind, right hind, right front, left front.)

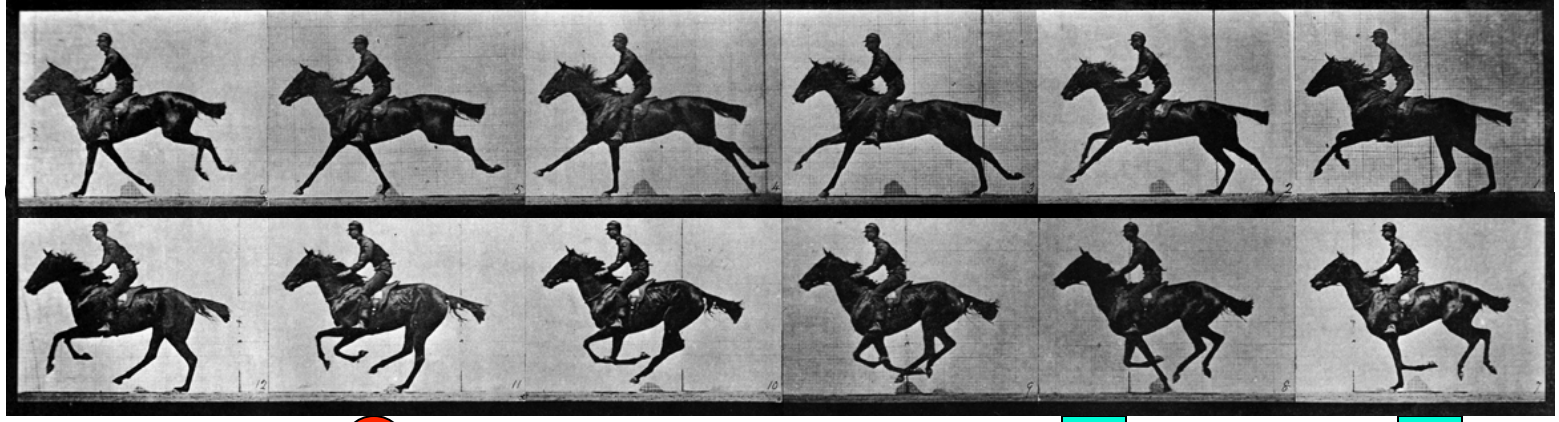


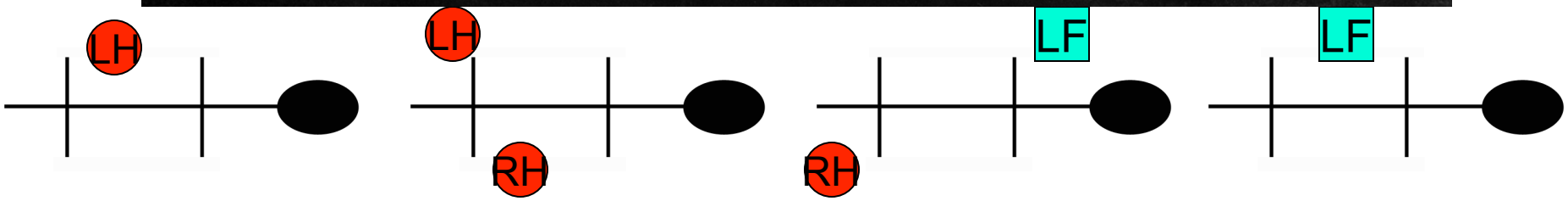
Transverse gallop



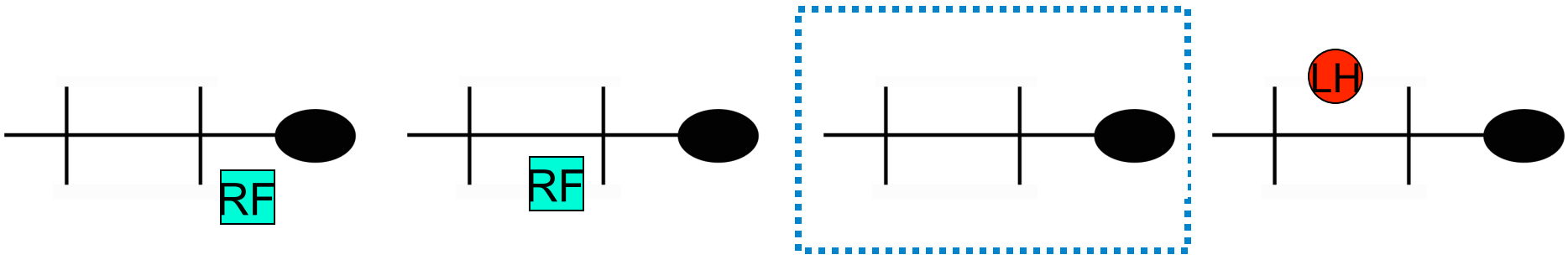
Rotary gallop

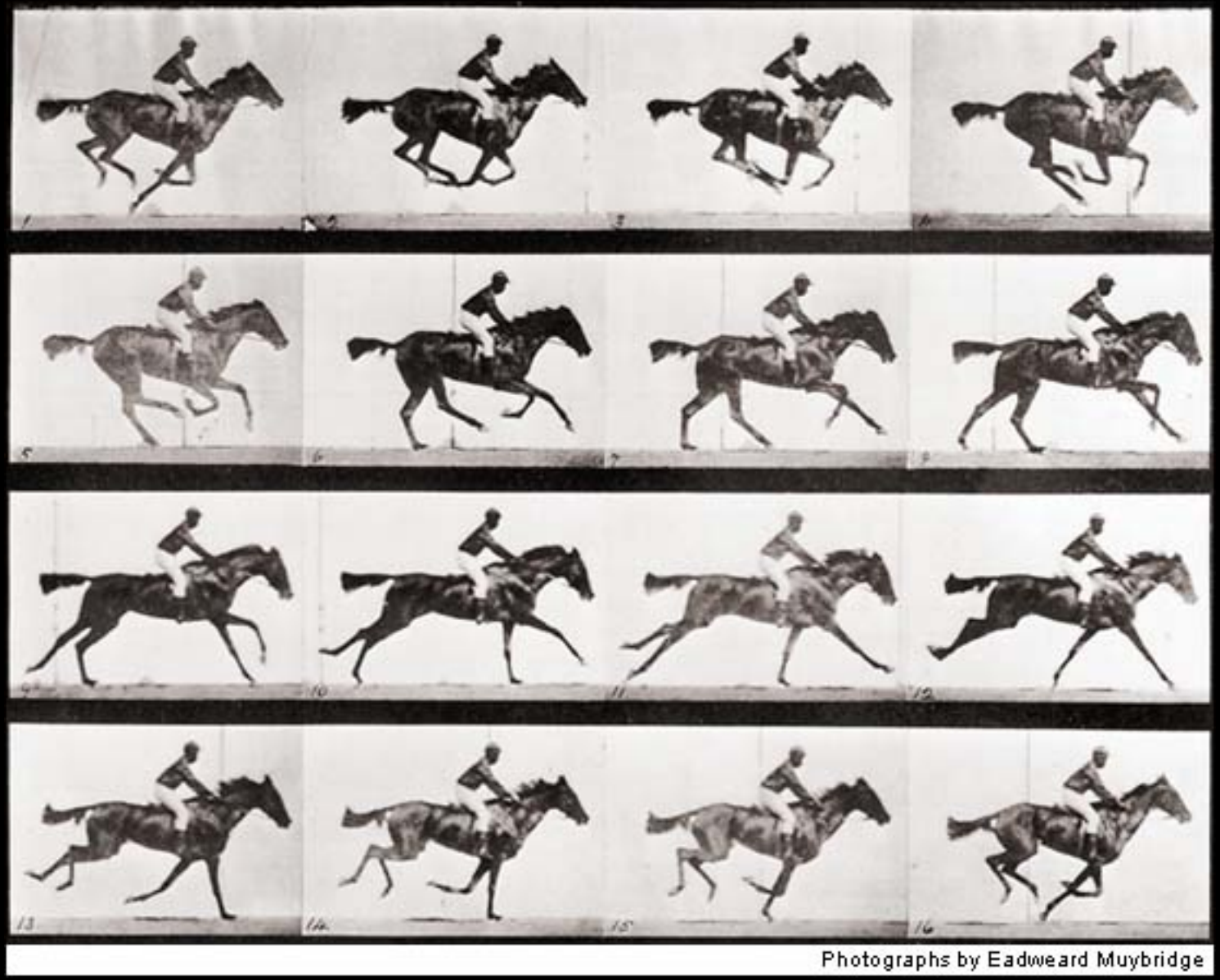






Equine Transverse Gallop with GATHERED floating phase.

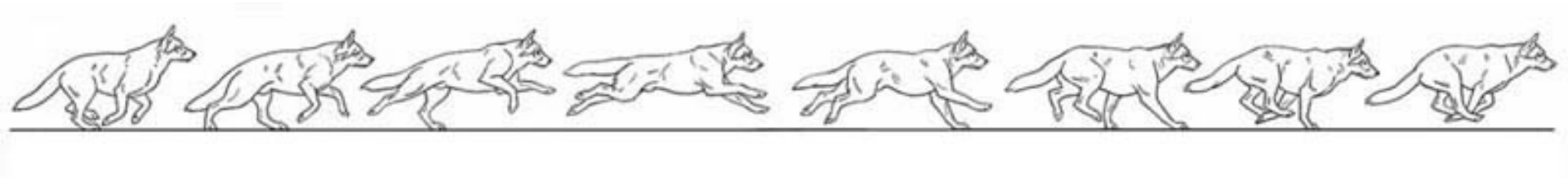




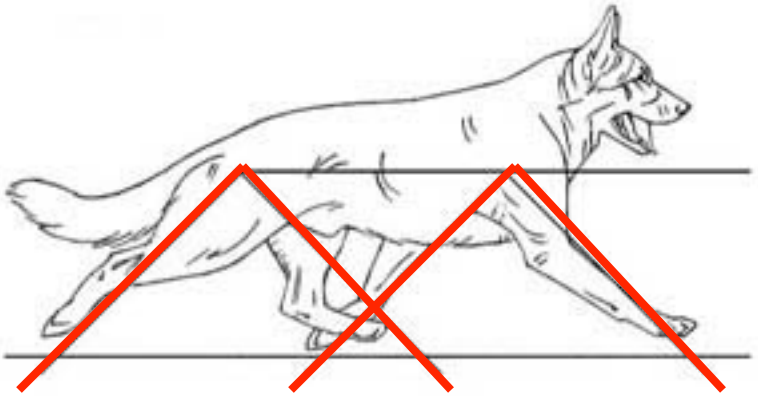
1878 – Eadweard Muybridge, hired by railroad baron Leland Stanford to understand horse locomotion and gait, simultaneously invents gait analysis and the technological basis of motion pictures.

GALLOP - In lightly built (usually carnivores) mammals such as dogs, the gallop is a four-beat gait.

In the example below: right hind, left hind, (extended suspension), left front, right front, (gathered suspension).



GALLOP compared to a TROT



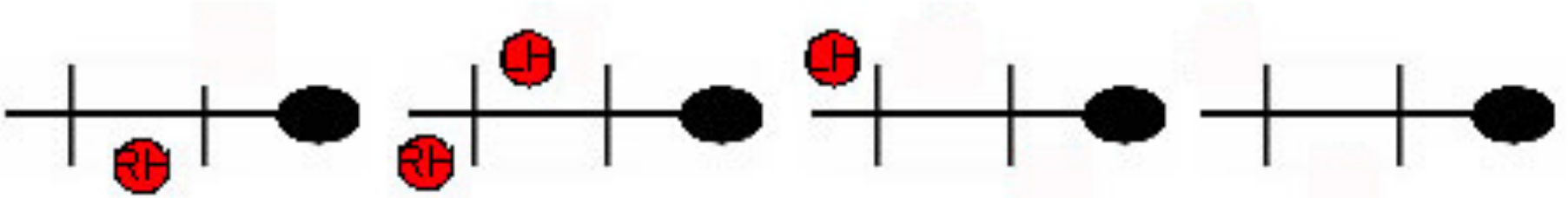
Note that in a trot, the fore- and hind limbs appear as complimentary angles.

Whereas in a gallop, the forelimbs are almost PARALLEL to the ground at some point.

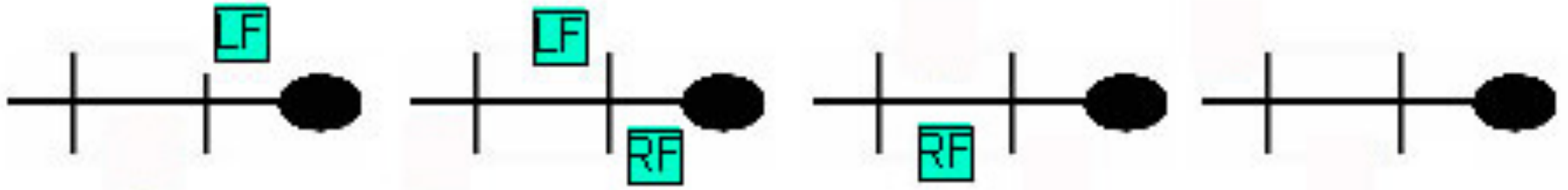
(ROTATORY) GALLOP

•In carnivores, the gallop usually has a double suspension, or a floating phase with the limbs both gathered underneath as well as extended forward and back.

•The footfall sequence tends to be: right hind, left hind, left, front, right front. (Or left hind, right hind, right front, left front.)

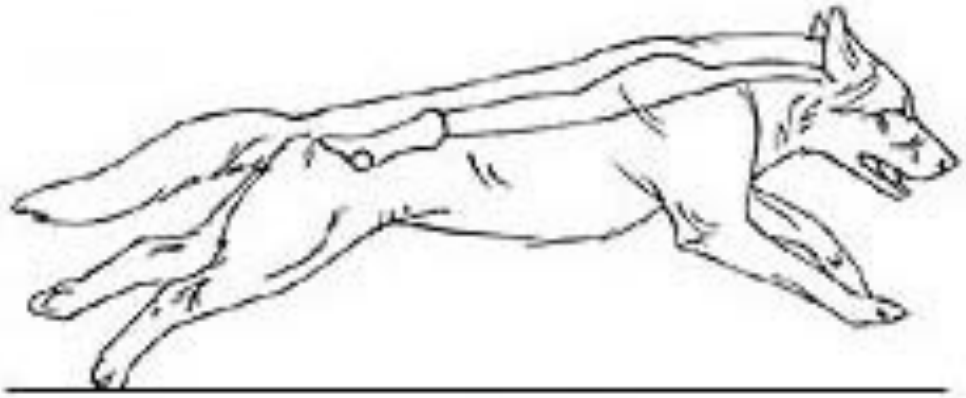


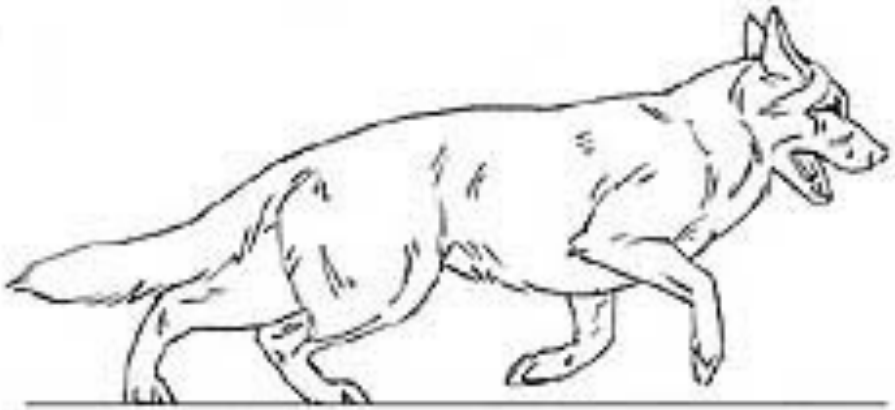
extended suspension

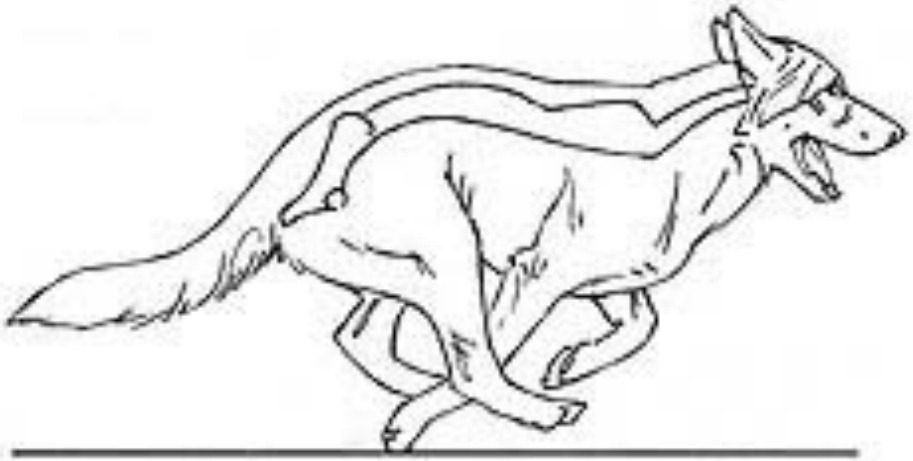


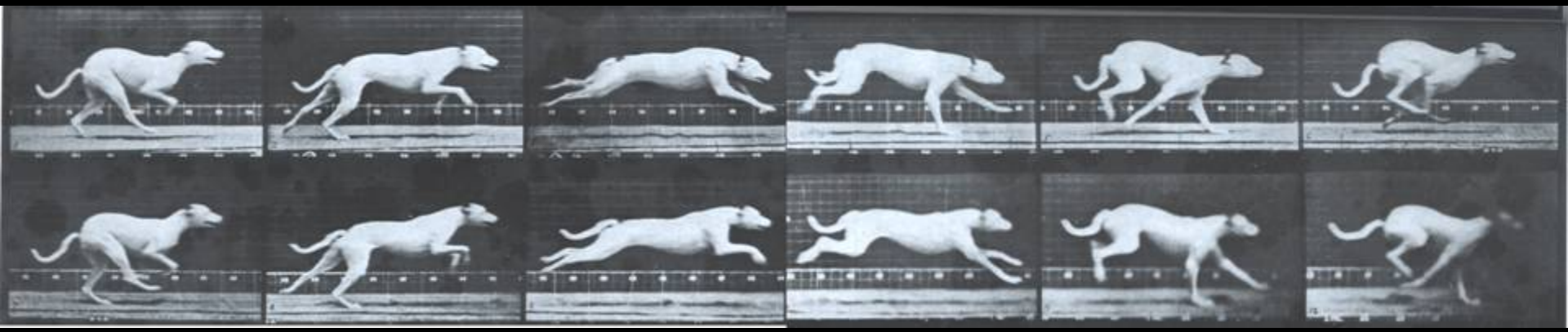
gathered suspension

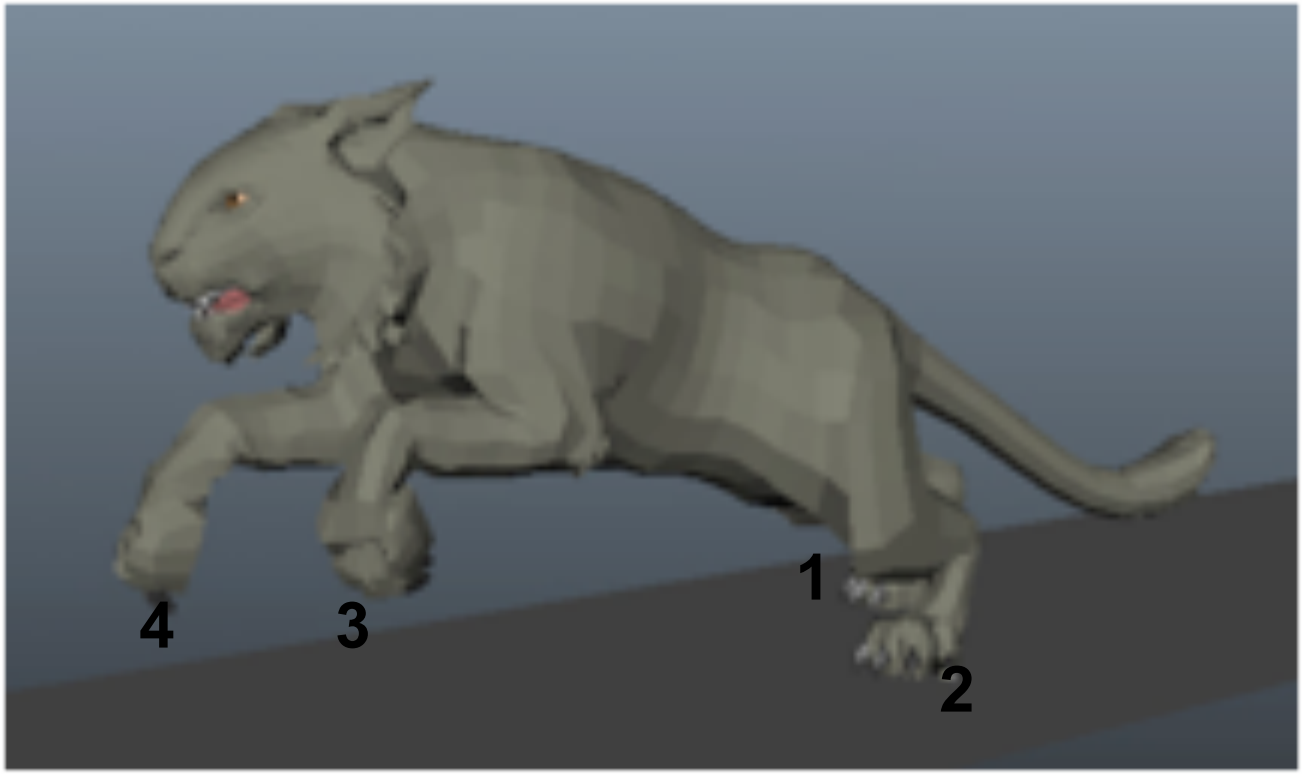
Gallop





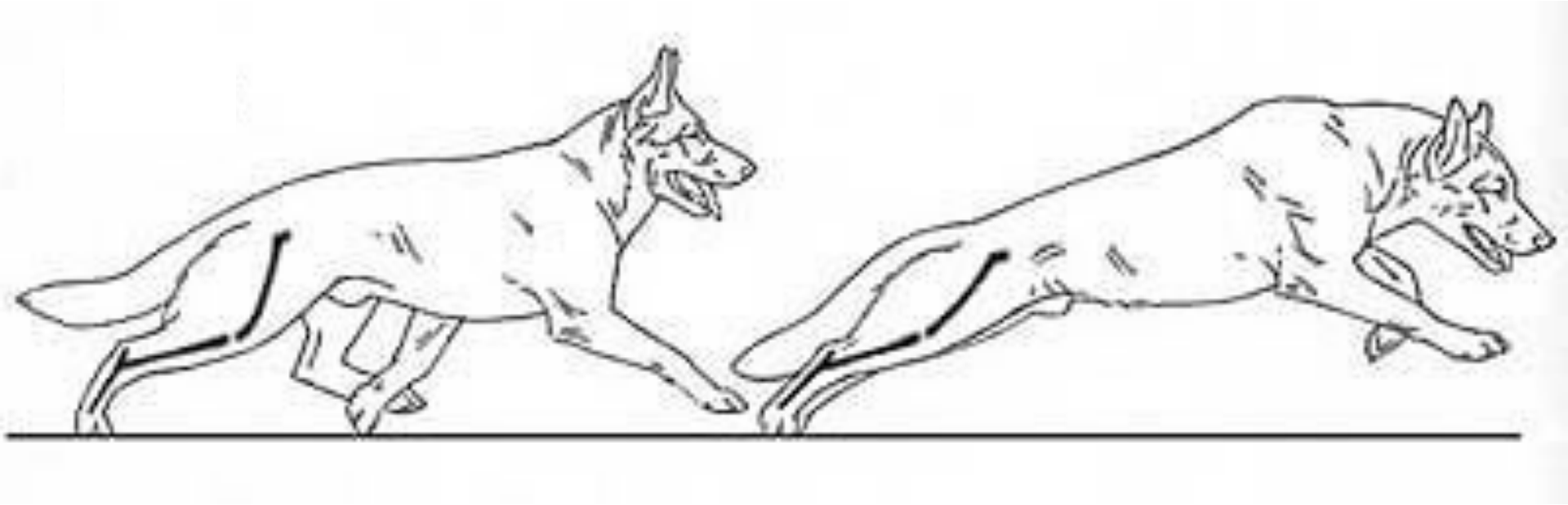






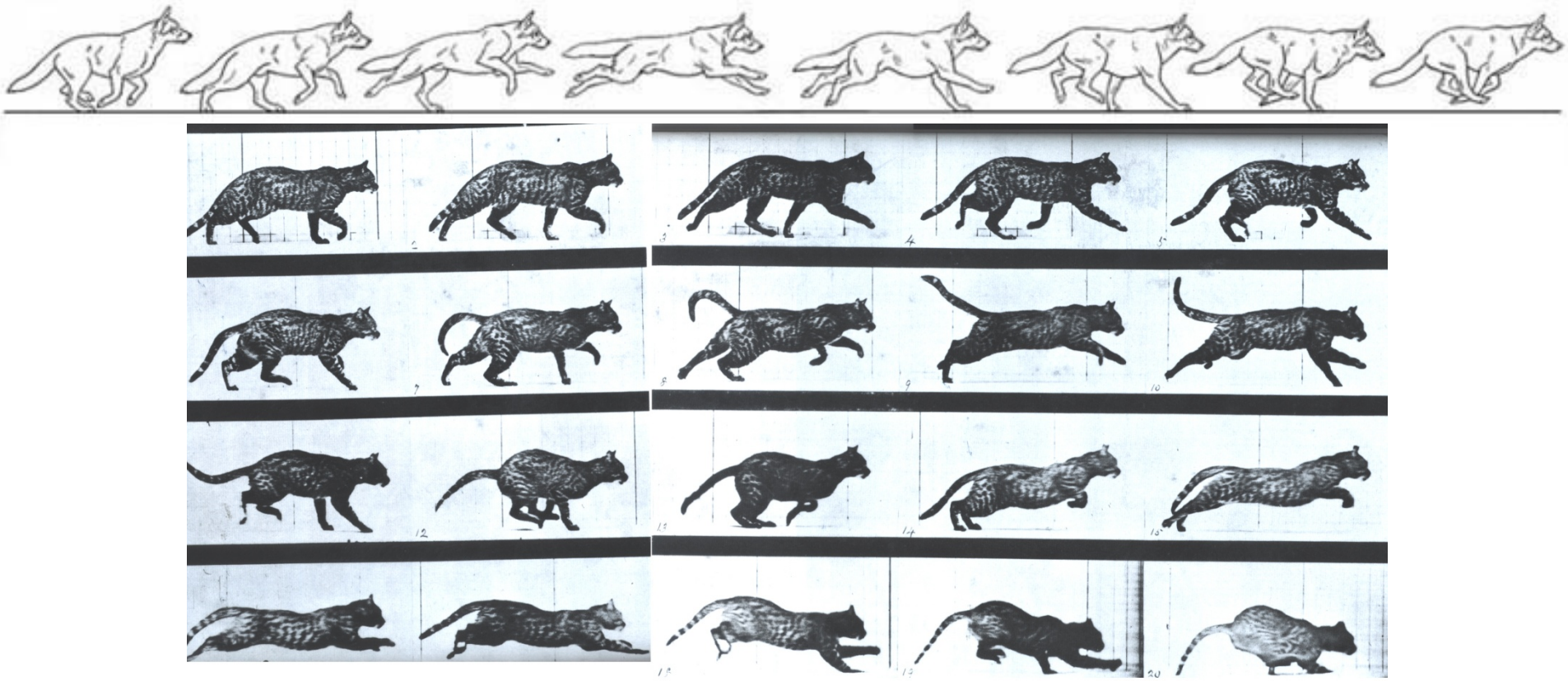
This animal is in the initial stage of a gallop. The proper subsequent footfall sequence is labeled next to each foot.

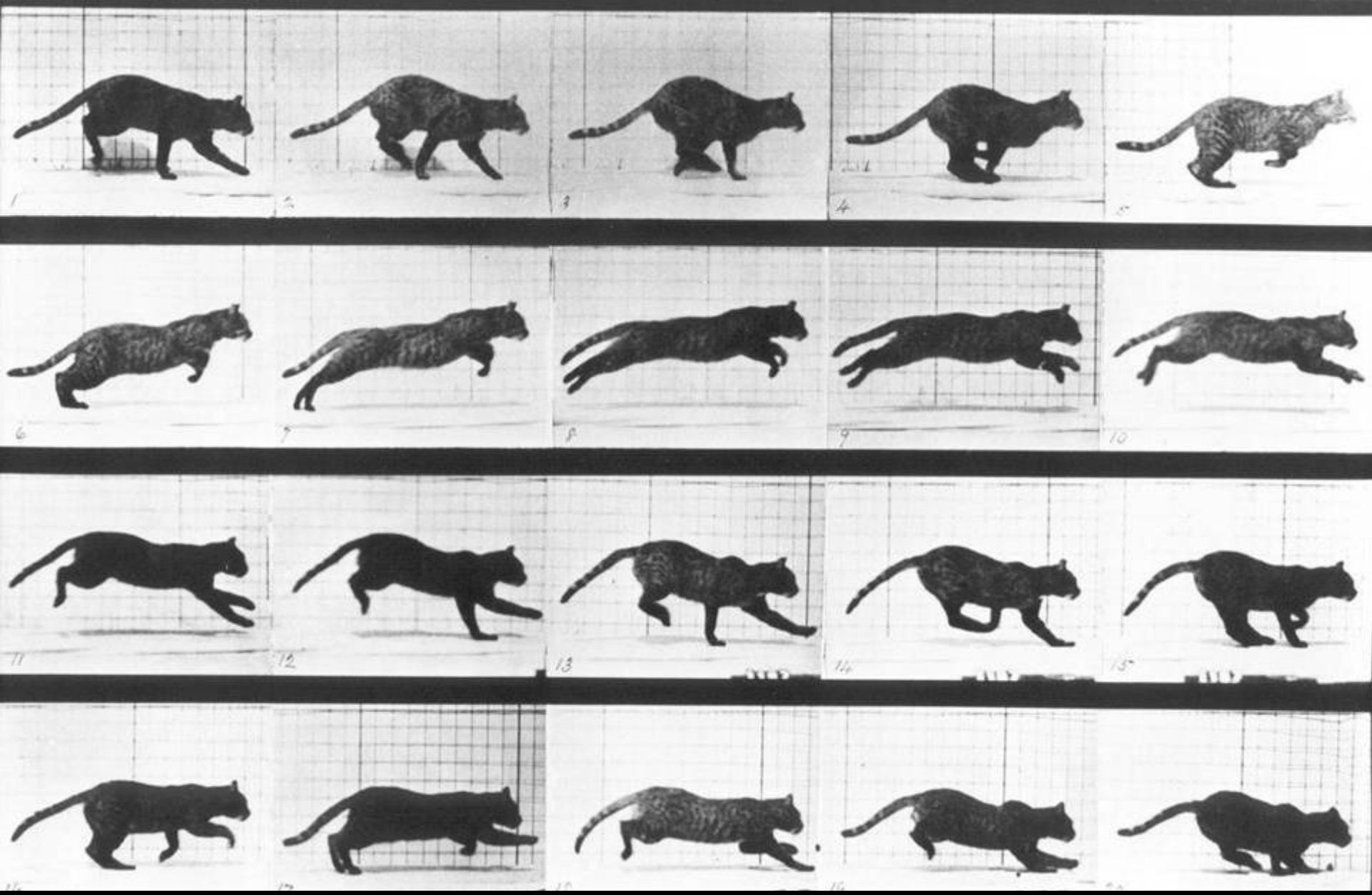
At pushoff, the hind limb is almost straight.



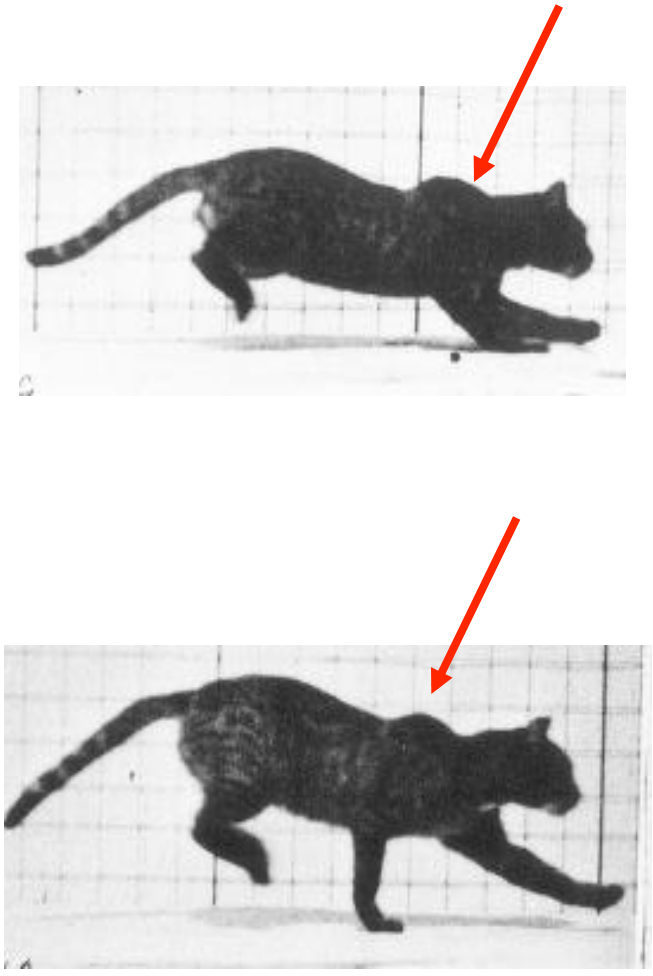
GALLOP - In lightly built (usually carnivores) mammals such as dogs, the gallop is a four-beat gait.

Although both of them show flexibility of backbone, flexibility is greater in cat.

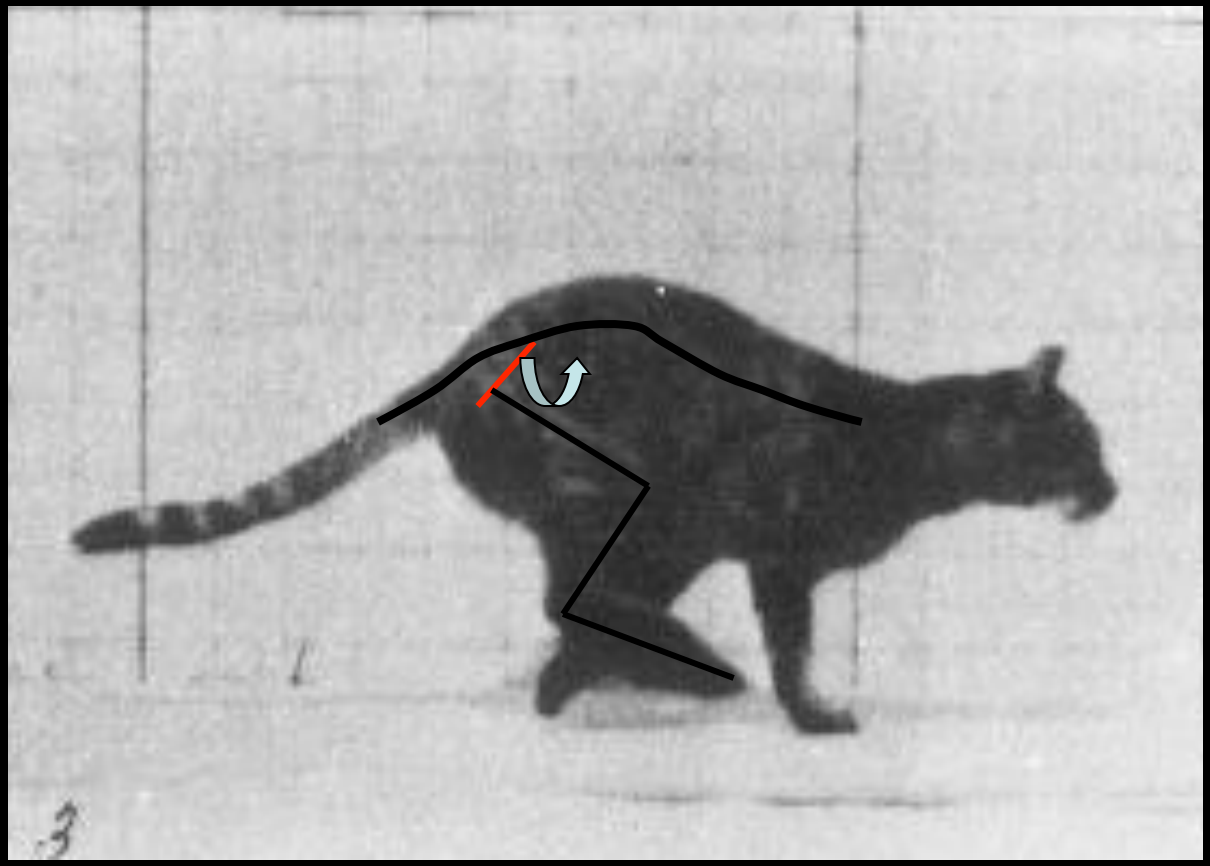




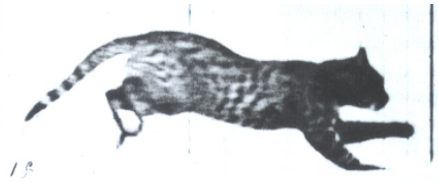
Cats often have greater duty-factor than dogs while running.

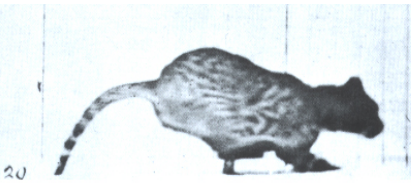


Cat scapula will show prominently, especially when weight is placed on the forelimb. This happens in all gaits, but is particularly prominent when galloping.



Cat hips will bend somewhat relative to the vertebral column, whereas those of a dog will not.





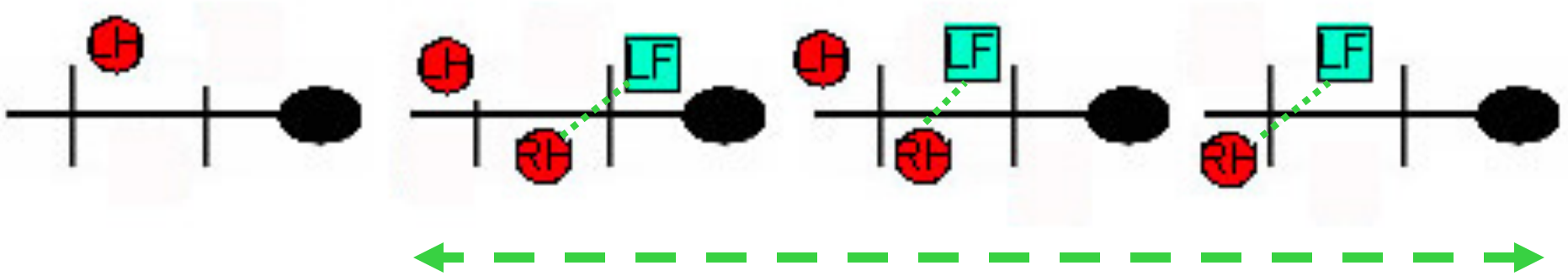
CANTER

•The canter is a 3 beat gait. The beat sequence begins with a rear leg, moves to the paired diagonals and then finally the front leg diagonal to the hind leg in the first beat. The animal is then briefly suspended before the sequence is repeated.

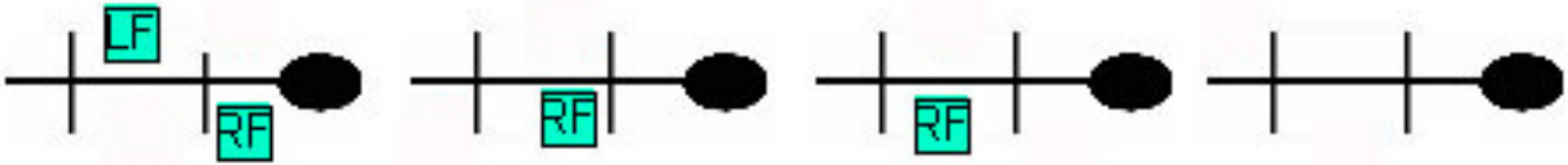
•If the right hind leg strikes the ground it is referred to as a left lead will if the left hind leg strikes the ground first it is a right lead.

•The canter is an infrequently used gait in dogs. When used it is often as a transition from the gallop as the animal is slowing down. It is also sometimes used when playing and the impression of speed is combined with interaction with other animals.

CANTER - The canter is a 3 beat gait. The beat sequence begins with a rear leg, moves to the paired diagonals and then finally the front leg diagonal to the hind leg in the first beat. The animal is then briefly suspended before the sequence is repeated.



Only one diagonal couplet



Body tilts forward