

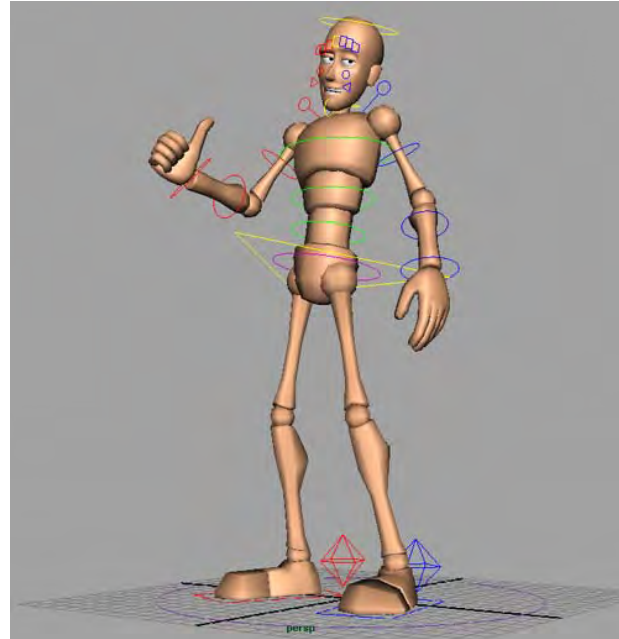
Joints



National Science Foundation
WHERE DISCOVERIES BEGIN

Articulated Figures

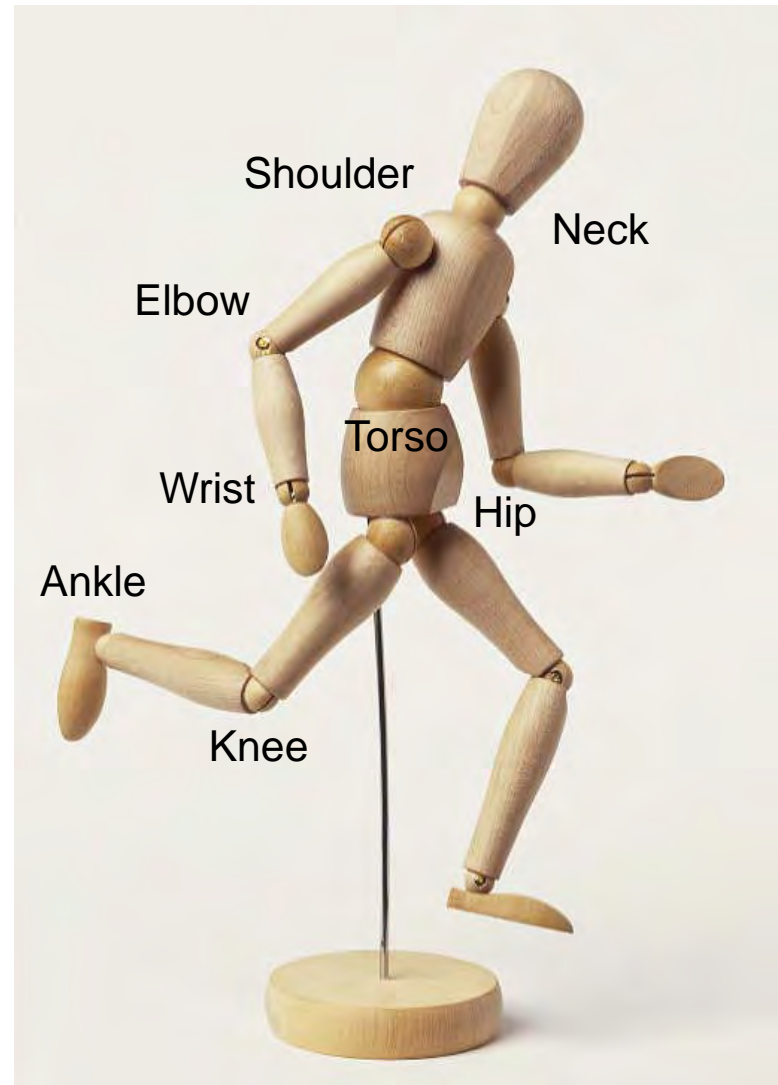
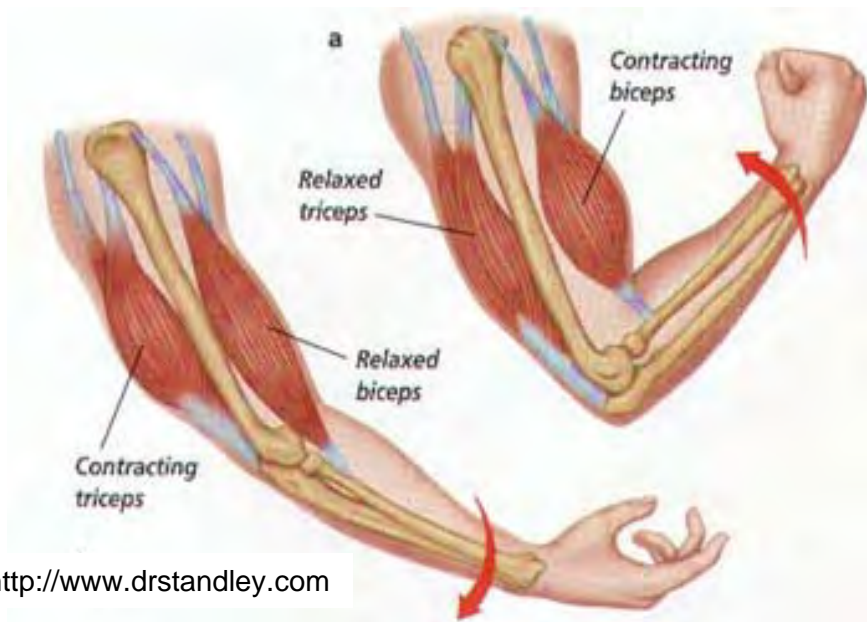
In computer animation characters are articulated figures, like marionette puppets.



The challenge for animators is to move all the elements (arms, legs, hands, etc.) believably from frame to frame.

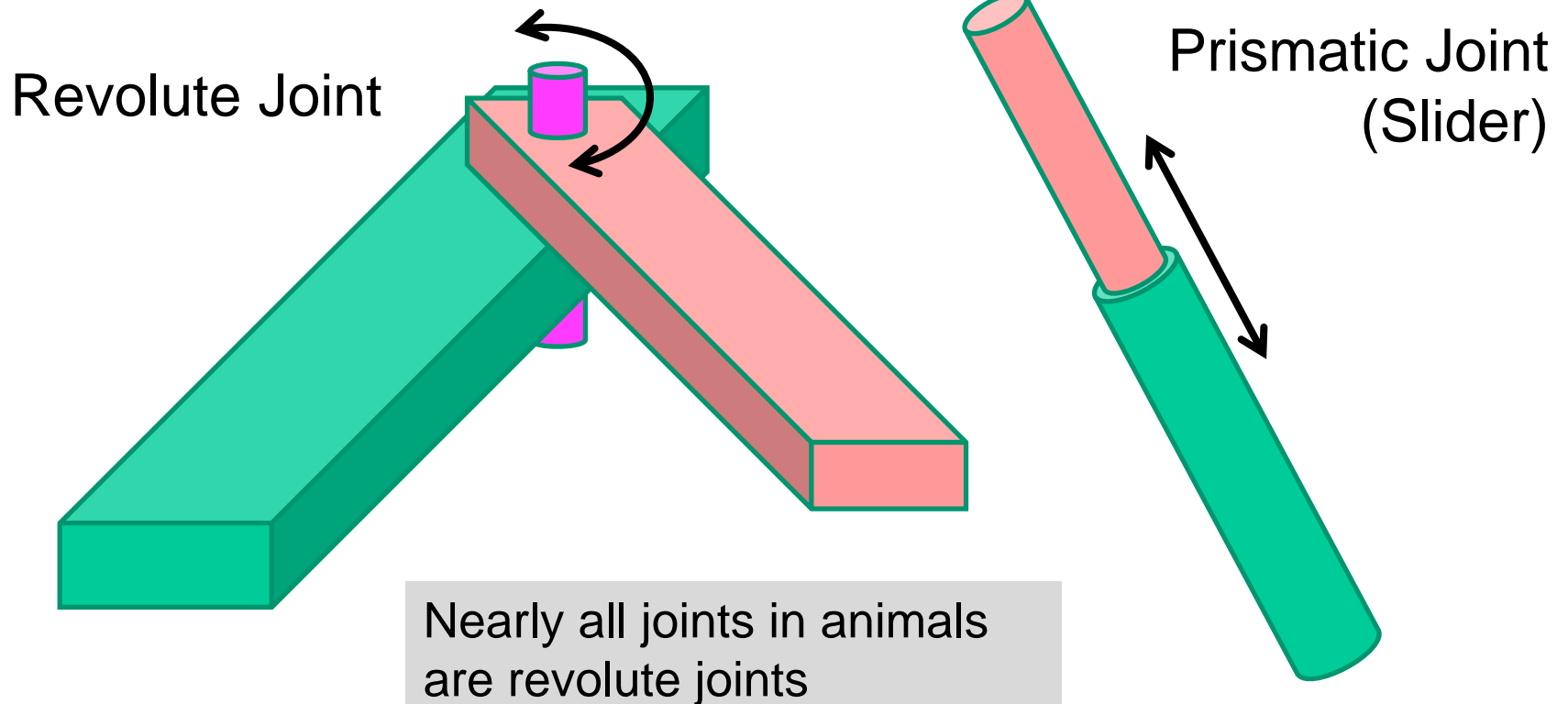
Human Joints

Human joints are very familiar; they rotate by contraction of muscles.



Mechanical Joints

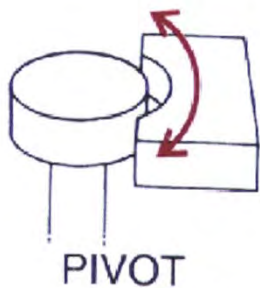
Two kinds of joints: Revolute (rotation) and Prismatic (extension/contraction).



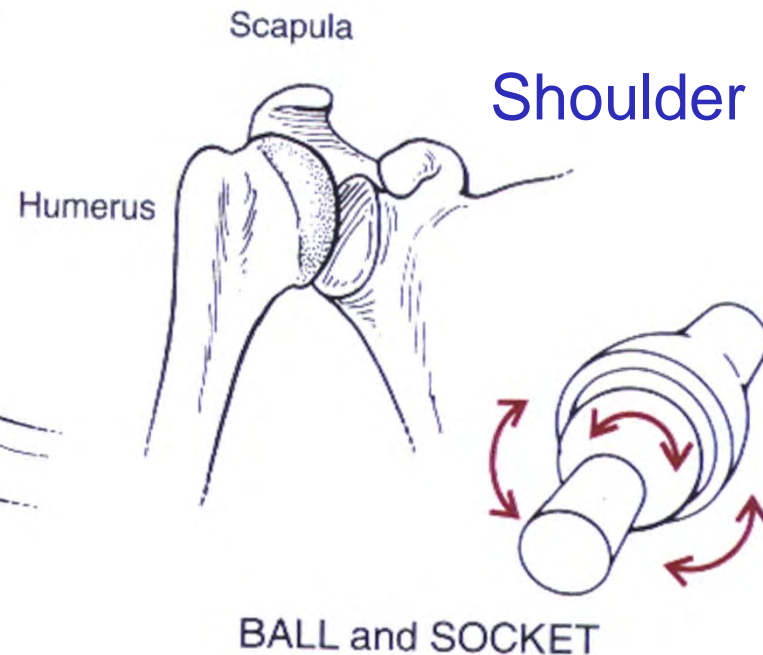
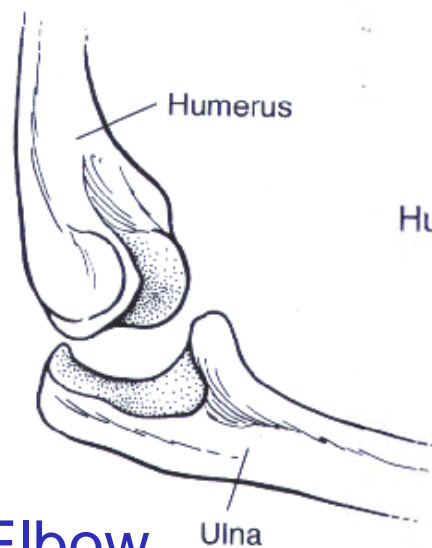
Revolute Joints

Revolute joints may have a single axis of rotation, like hinge joints and pivot joints, or a variable axis, such as the ball and socket joint.

Forearm

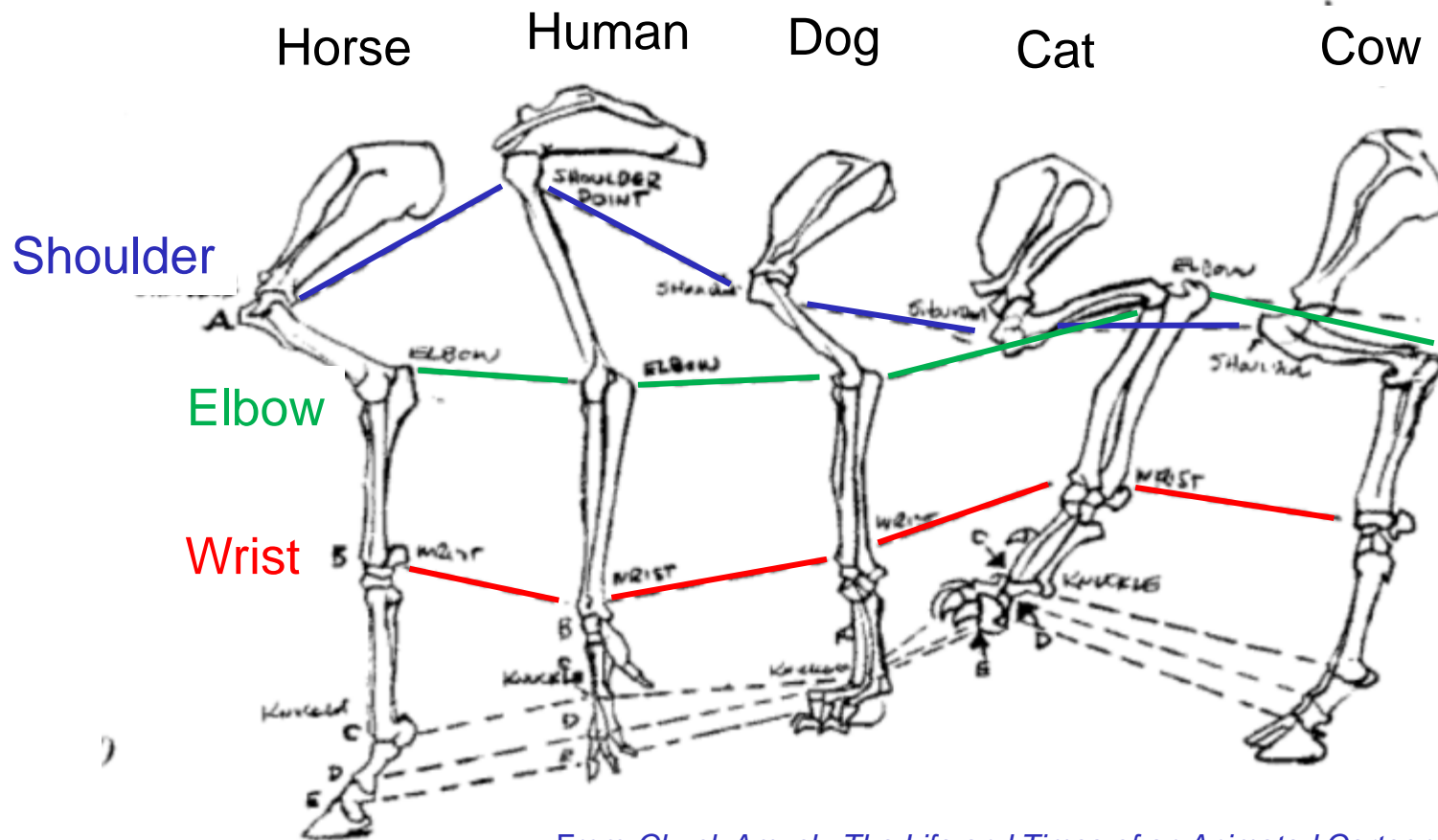


Elbow



Joints in Mammals

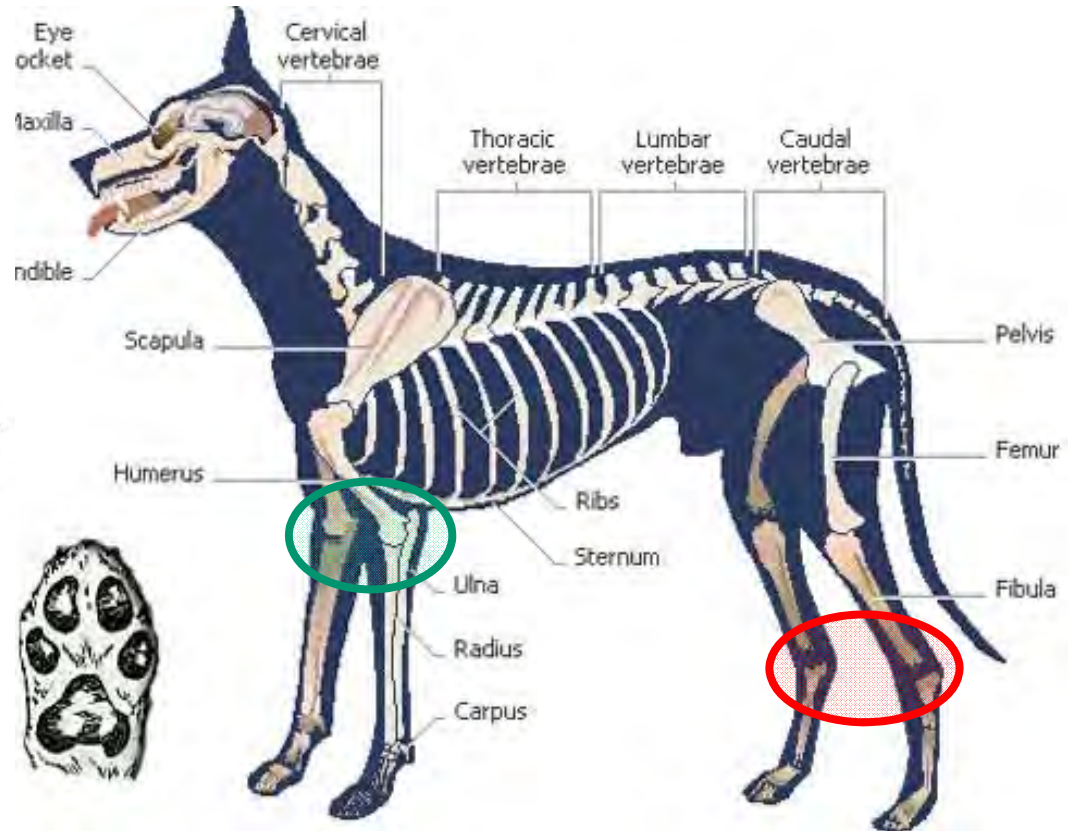
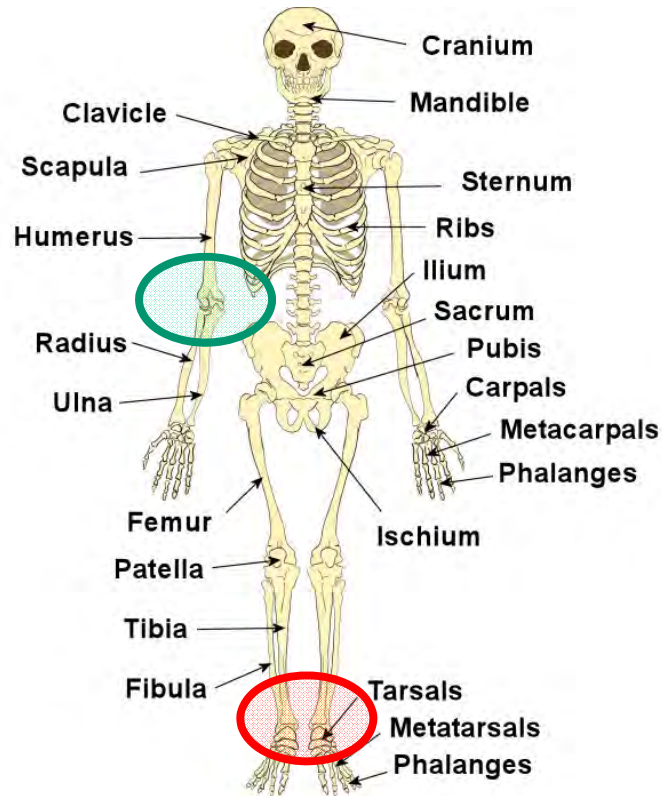
Front legs of mammals have the same joints and bones as our arms but with varying lengths.



From *Chuck Amuck: The Life and Times of an Animated Cartoonist* By Chuck Jones

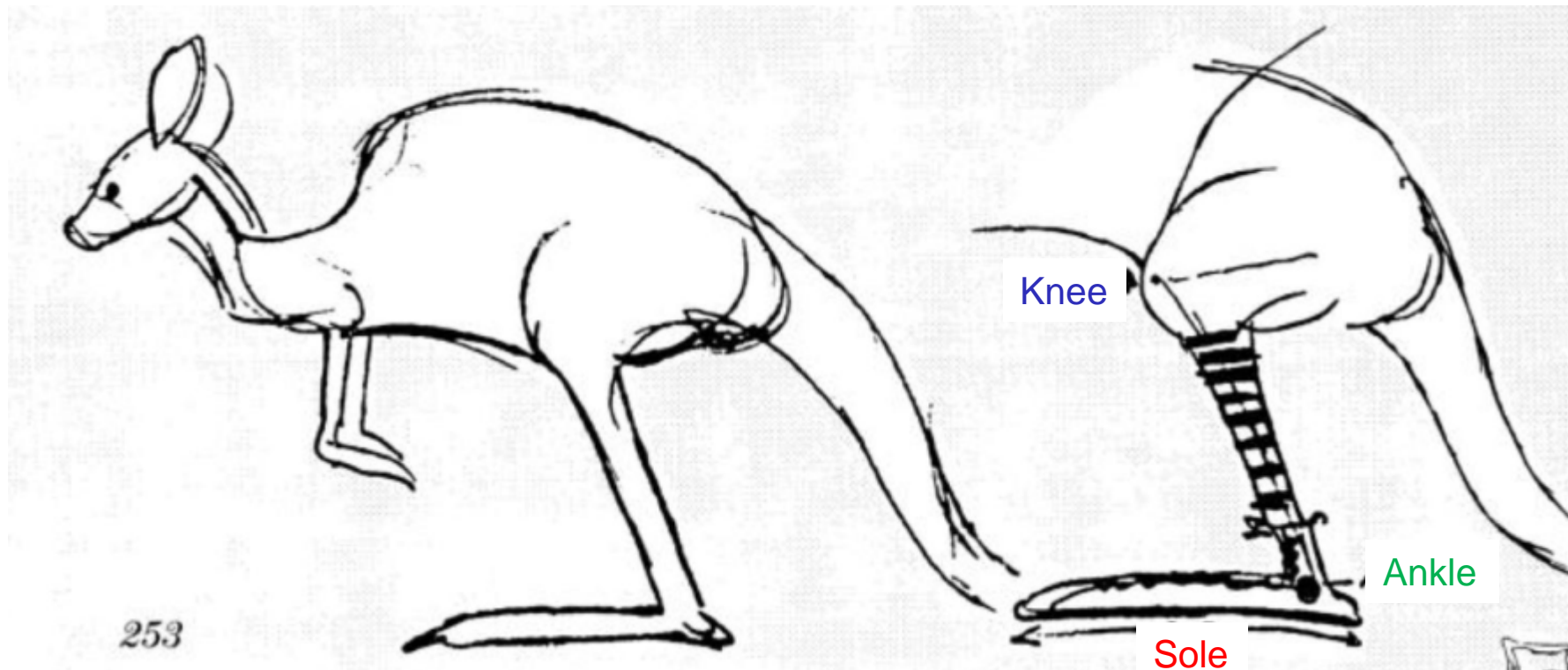
Quadruped Leg Joints

The joints that look like the “knees” on a dog are actually the elbows and ankles.



Tennis Shoes & Stripped Socks

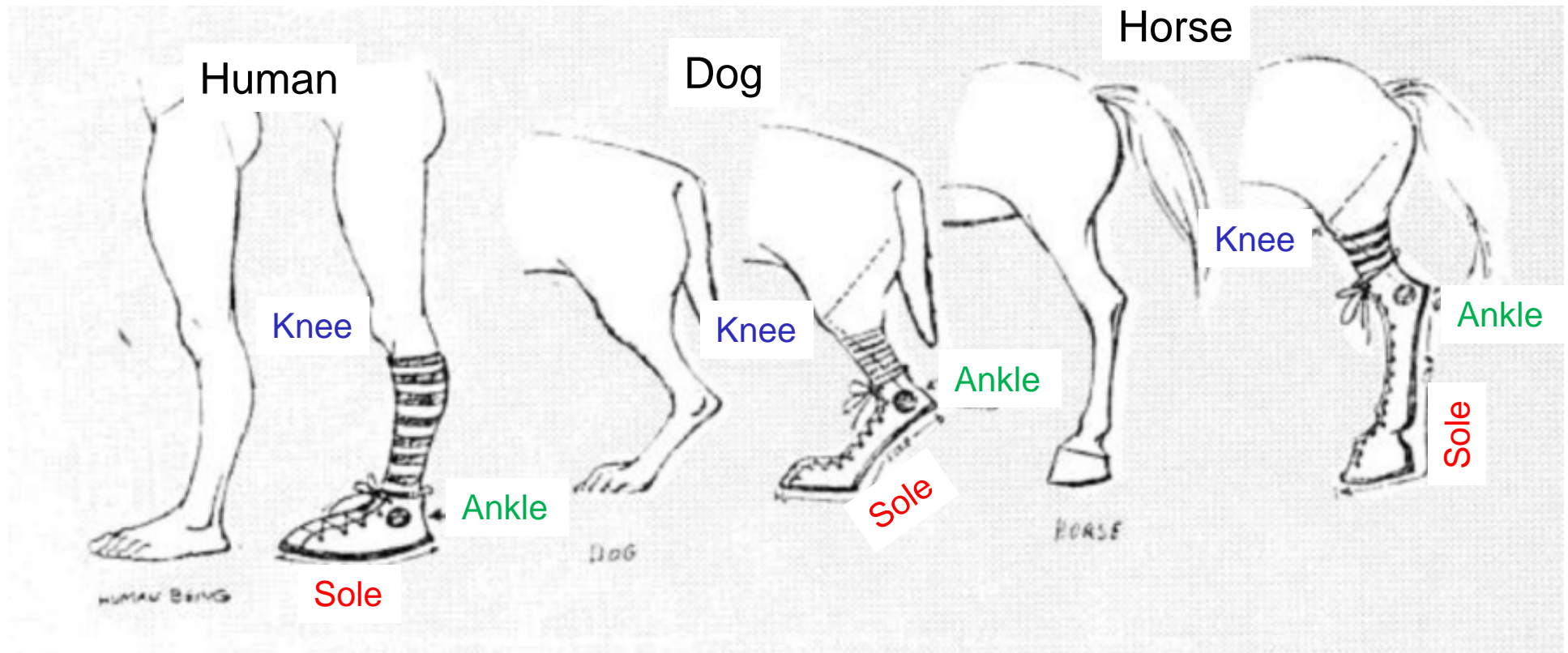
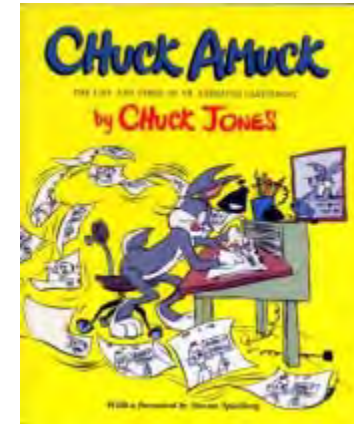
Chuck Jones presents a good way to remember animal anatomy: Tennis shoes & Stripped socks.



From *Chuck Amuck: The Life and Times of an Animated Cartoonist* By Chuck Jones

Sole, Ankle, Knee

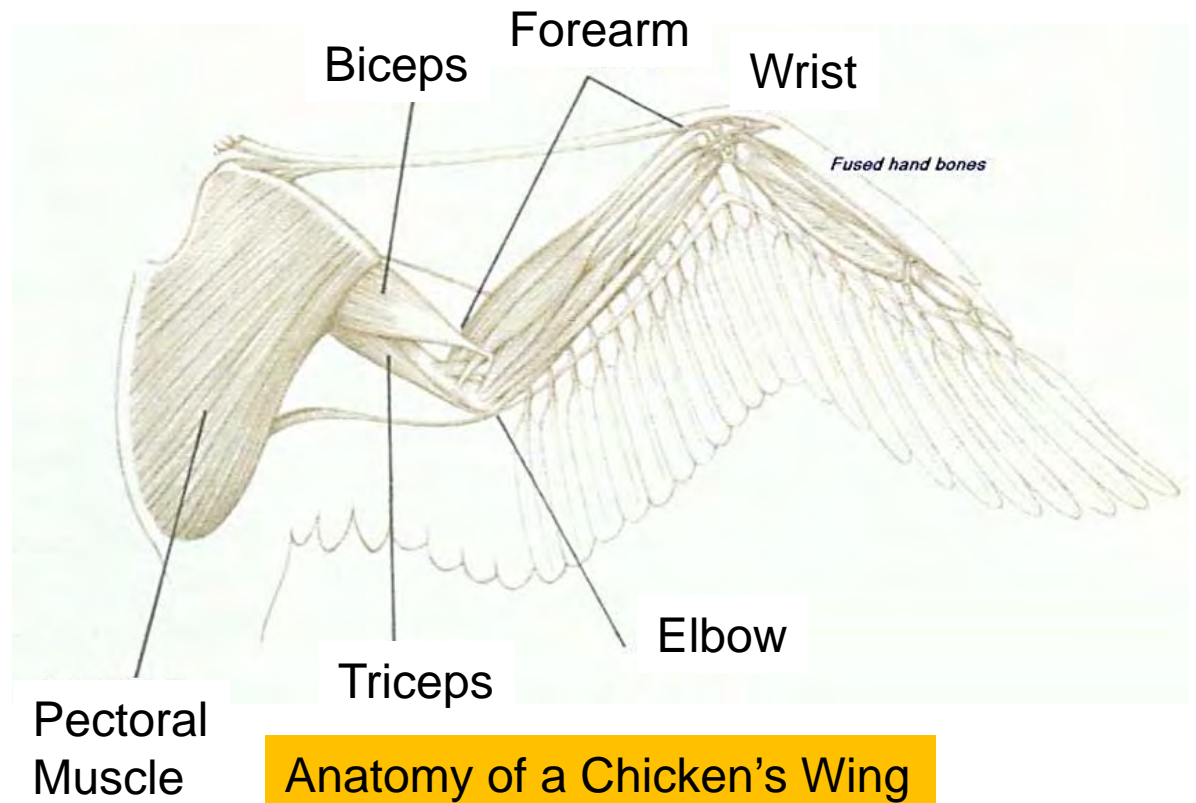
What you think is the “knee” on the animal’s hind leg is actually the ankle.



From *Chuck Amuck: The Life and Times of an Animated Cartoonist* By Chuck Jones

Anatomy of Vertebrates

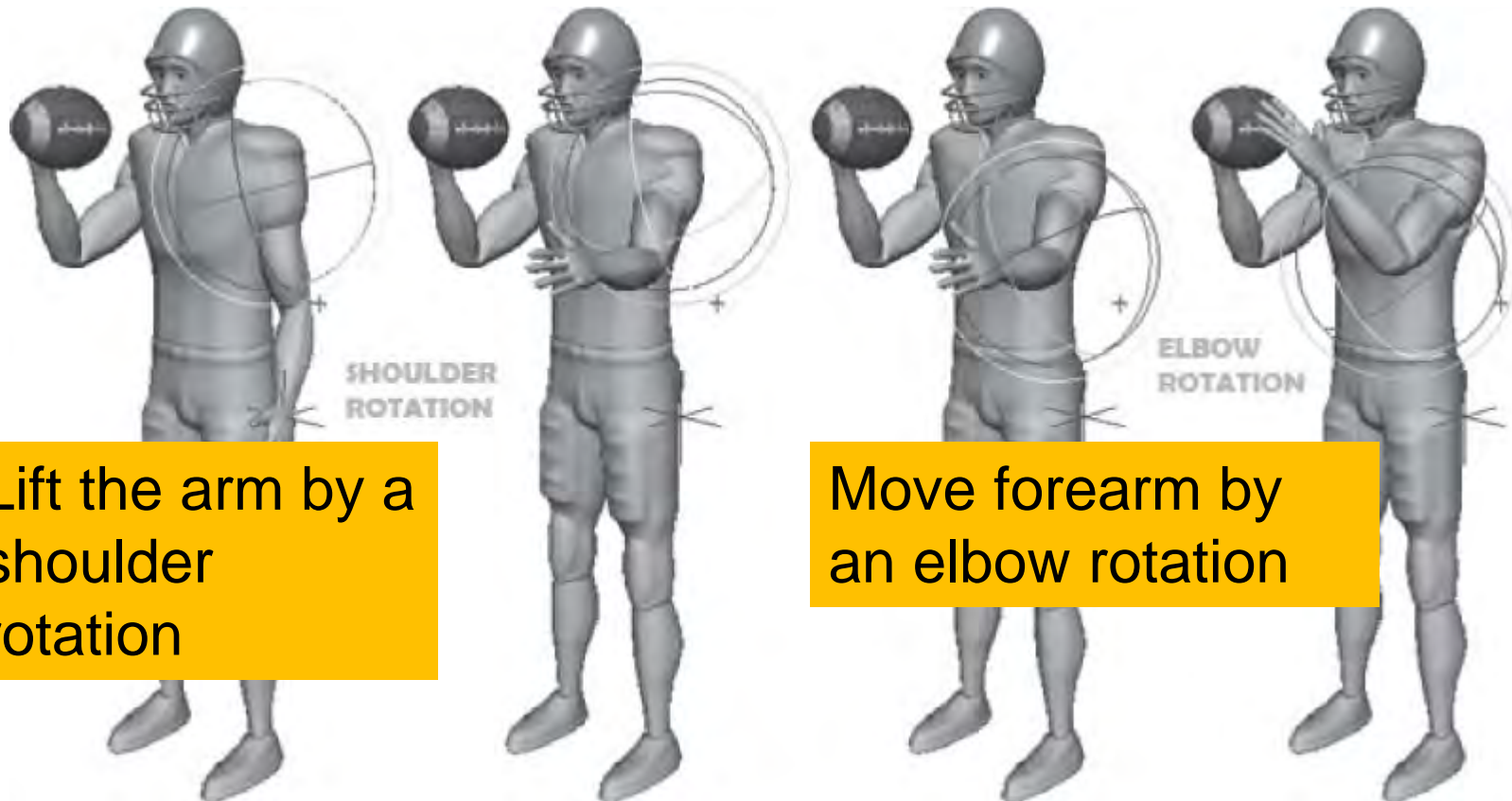
Vertebrates, such as frogs, lizards, and birds, have similar joints, muscles, and bones as mammals.



Anatomy of a Chicken's Wing

Forward Kinematics

With forward kinematics (FK) the animator has to specify the axis of rotation and the angle of rotation for each joint on a moving limb.

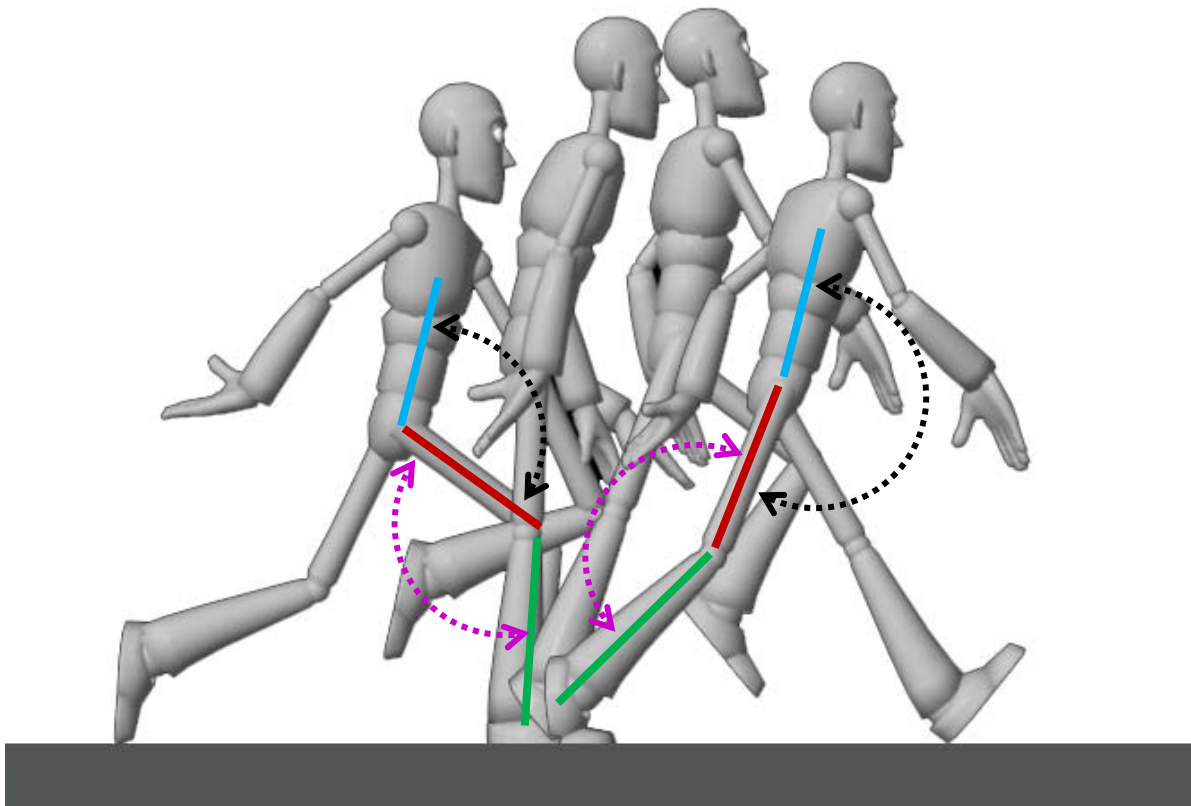


Lift the arm by a shoulder rotation

Move forearm by an elbow rotation

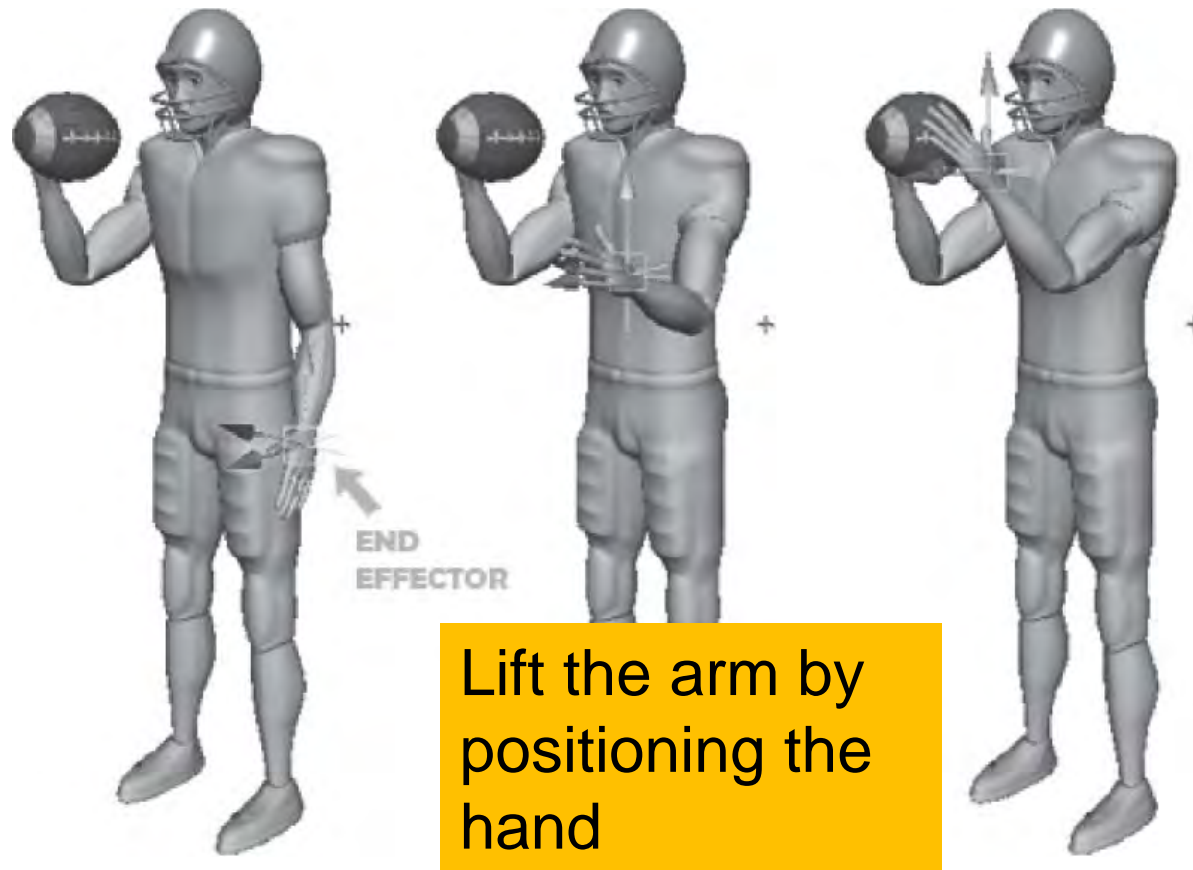
Forward Kinematics

Forward kinematics (FK) can be a tedious process for the animator and it is difficult to maintain certain constraints, such as the planted foot in a walk.



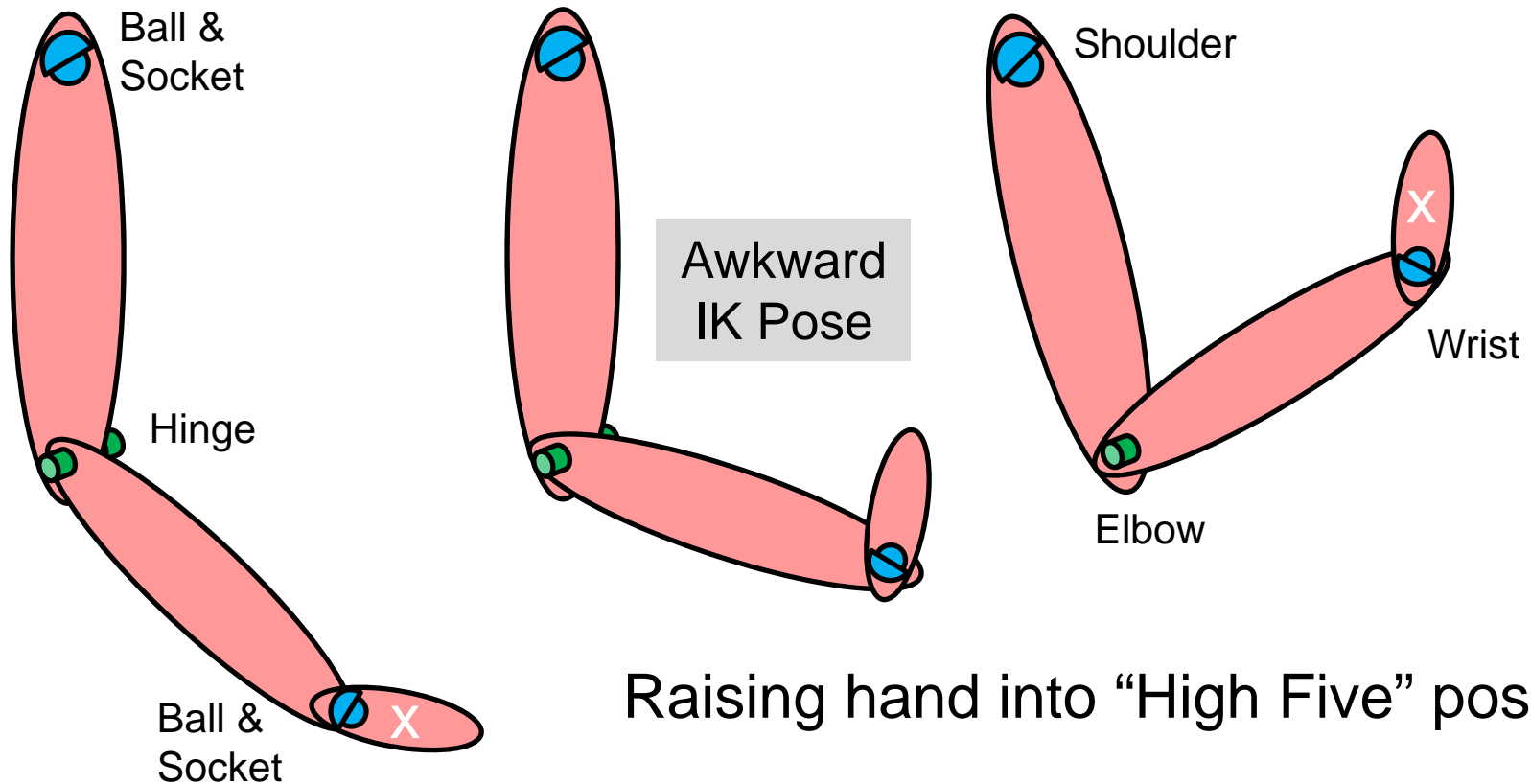
Inverse Kinematics

With inverse kinematics (IK) the animator positions the end effector, such as the hand, and the computer calculates the required joint rotations.



Inverse Kinematics

Rotations calculated by IK may not be natural poses and the timing of the motion may not be correct.



Summary

- In computer graphics characters are posed and animated by rotating the joints.
- Vertebrates have similar revolute joints that are pivot, hinge, or ball-and-socket.
- In Forward Kinematics (FK) a figure is posed by setting the joint angles.
- Inverse Kinematics (IK) calculates the joint angles from the position of an end effector, such as a hand or foot.