



Anatomy for Yogis

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Here is an amazement: once I was twenty years old and in every motion of my body there was a delicious ease, and in every motion of the green earth there was a hint of paradise, and now I am sixty years old, and it is the same.

- Mary Oliver

Introduction

The following is a 10 lesson (taking approximately 15 hours) anatomy course designed for aspiring yoga teachers going through their first 200-hr, as well as yoga practitioners looking for a deeper understanding of anatomy as it applies to their asana practices.

Each lesson is organized as follows:

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Let this course be the beginning of a lifetime of learning. The human body is as beautiful as it is complex, as much a miracle as it is impossible to fully understand. 10 lessons is very little compared to a multi-year physical therapy or medical program, and much shorter than many massage schools.

Use the knowledge gained here as a solid foundation for teaching yoga in a safe and anatomically informed manner, and continue your studies as you continue your practice.

Recommended reading:

- Andrew Biel, *Trail Guide to the Body: How to Locate Muscles, Bones and More*
- Blandine Calais-Germain, *The Anatomy of Movement*
- Elaine N. Marieb, *Anatomy and Physiology Coloring Workbook: A Complete Study Guide*
- H. David Coulter, *Anatomy of Hatha Yoga*
- Kelly Solloway, *The Yoga Anatomy Coloring Book* (Elizabeth J. Rochester also has another *Yoga Anatomy Coloring Book*)
- Leslie Kaminoff, *Yoga Anatomy*
- Ray Long, MD, *The Key Muscles of Yoga, The Key Poses of Yoga, The Yoga Mat Companion Series*
- Wynn Kapit, Lawrence M. Elson, *The Anatomy Coloring Book*

Online Resources:

- bandhayoga.com
- pranamaya.com
- teachmeanatomy.info
- yoganatomy.com

Anatomy Apps

- Complete Anatomy by 3D4Medical
- Visible Body

Lesson 1: Introduction, Planes of Motion, Basic Terms

Before we discuss anatomy, let us consider the fundamental question of **epistemology**: *how do we know what we know?*

Just as any spiritual path begins with a search for deeper truth and a questioning of conventional wisdom and potentially limiting beliefs, our discussion on the truth of our anatomy can begin by acknowledging the set of assumptions we are operating under.

Modern anatomy and modern medicine is primarily based on the method of **scientific reductionism**. Science, in this case, is an empirical practice based on the belief that hypotheses and theories must be tested against observations of the natural world. Any hypothesis must have a strong compendium of evidence to make it a theory and even then, it is continuously tested as new evidence and findings are uncovered.

Reductionism is one way of understanding complex phenomena and a common way to develop scientific models of the way the universe works. Reductionism attempts to describe a system by breaking it down into constituent or fundamental parts, which are then analyzed and understood in order to gain insight into how the system works as a whole.

Reductionism is like taking apart a clock or a watch into all of its individual functioning parts. By understanding each piece, you can begin to understand how the clock works as a whole.

When it comes to our understanding of anatomy, the extraordinarily beautiful and infinitely complex body is divided up into parts that we call **systems**. If you take the average anatomy book, for example, its chapters might be divided up as such:

1. The nervous system
2. The endocrine system
3. The cardiovascular system
4. The lymphatic system
5. The respiratory system
6. The digestive system
7. The urinary system
8. The reproductive systems

Each system tends to be a collection of organs and structures sharing a common function and/or the same fundamental properties.

These systems are then further broken down. For example, the skeletal system is divided into the **axial skeleton** (head, rib cage, vertebrae, and sacrum) and the **appendicular skeleton** (bones of the limbs, shoulder, and pelvic girdle). These skeletons are then further divided into the 206 bones of the body. The digestive system may be broken down organ by organ, layer by layer, and eventually, cell type by cell type.

While learning about the systems listed above are important to understanding how a body works, for the purpose of practicing and teaching yoga, we will primarily focus on one system: **the musculoskeletal system**. The musculoskeletal system includes all the bones, muscles, and connective tissues that make up the body, as well as the nervous system that controls them. These are the parts of the body that matter the most for a strong anatomical understanding of our asana practice.

Because the human brain is not an all-knowing entity, breaking down complex systems into their parts and understanding those parts allows us to learn in an easy and methodical way. But it is important to note that all of these systems are part of a whole body. You'll never see just a nervous system existing in the wild!

Also, learning the parts of a watch won't necessarily teach you how to know the time. That's why it is important to stay rooted in your yoga practice and maintain a holistic view of the body. As you learn about the different parts and systems of the body, think about how they make up and interact with the whole. Spirit teaches us that everything in this universe is connected. This is especially true for our bodies.

These lessons will not be mentioning anything about the **energetic body, light body, subtle bodies, seed body, auric bodies, koshas, bandhas**, nor their **constituent chakras, nadis, meridians, prana, vayus, or kundalini energy**. While countless sages, mystics, healers, and embodiment practitioners can speak to the subjective reality of such systems, we have yet to find any scientific or empirical evidence for their existence.

Perhaps in the future we will develop the tools to measure the energetic and the subtle. But for now, we will simply focus on **the physical body** made up of physical matter: on what can be seen, verified, and measured. Nevertheless, remember to keep your mind free and your heart open to the infinite everything that is possible beyond our limited conceptual understanding, and to the mystery of all that is.

Namaste.

Remember: the bones of the _____, linked together at the _____, are moved by the actions of the _____.

Basic terms

Directional terms used to describe **ORIENTATION** in the **ANATOMICAL POSITION**
(i.e. where is...?)

Front to back:

Anterior: toward the front of body

Posterior: toward the back of body

Left to right:

Medial: toward the midline

Lateral: away from the midline

Top to bottom:

Superior: toward the head

Inferior: away from head

Center to outer (for the legs and arms)

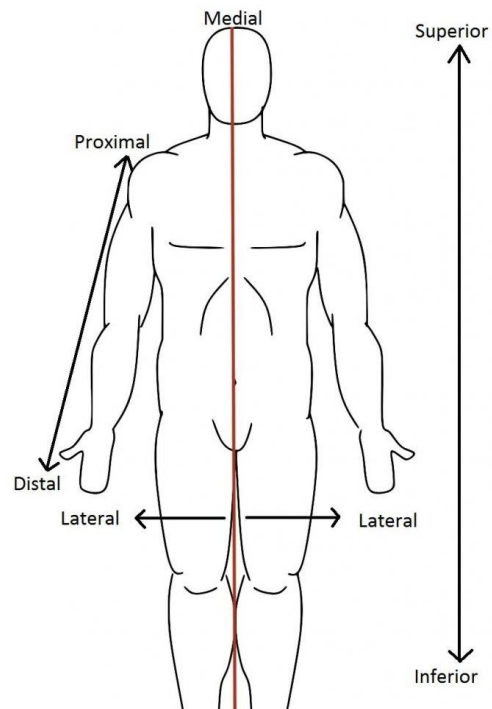
Distal: toward extremities

Proximal: toward center of body

Inside to outside:

Superficial: near the skin

Deep: deeper into the body



Examples:

- Pectoralis major lies **anterior** to pectoralis minor.
- The triceps are **posterior** to biceps brachii.
- The lungs are **superior** to the liver.
- The stomach is **inferior** to the heart.
- The wrist joint is **distal** to the elbow joint.
- The scaphoid lies in the **proximal** row of carpal bones.
- The cornea is on the **superficial** surface of the eye.
- The bones are **deep** to the skin.

Now, fill out an example for each one to help you remember:

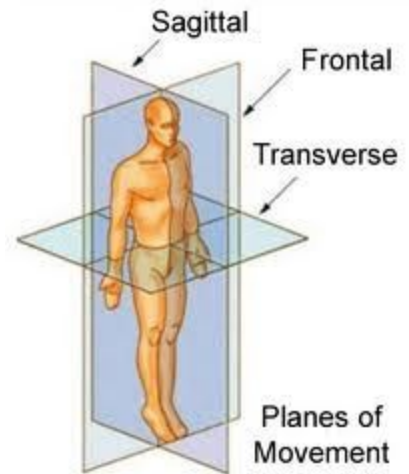
1. The _____ is/are **anterior** to the _____.
2. The _____ is/are **posterior** to the _____.
3. The _____ is/are **medial** to the _____.
4. The _____ is/are **lateral** to the _____.
5. The _____ is/are **superior** to the _____.
6. The _____ is/are **inferior** to the _____.
7. The _____ is/are **distal** to the _____.
8. The _____ is/are **proximal** to the _____.
9. The _____ is/are **superficial** to the _____.
10. The _____ is/are **deep** to the _____.

Terms used to describe **MOVEMENT** from the **ANATOMICAL POSITION**

The Three Cardinal Planes of Motion:

Sagittal: vertical plane, runs anterior-posterior (forward-back), divides the body into left and right sides

Frontal (Coronal): vertical plane, runs side to side, divides the body into forward and back (anterior-posterior)



Transverse: horizontal plane, any movement along a central axis

List at least 5 yoga poses that are primarily in one plane of motion:

Sagittal:

Frontal:

Transverse:

How might we use this knowledge to increase the quality of our yoga classes?

Joint Motions

In *Sagittal* Plane:

Flexion: bones move *toward* each other (the angle *decreases*, bending the knee or elbow)

OR anterior (like reaching the arm or leg forward)

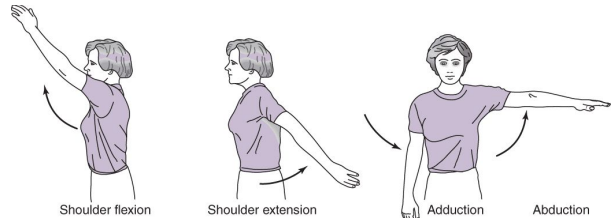
Extension: bones move *away* from each other (the angle *increases*, like *hyperextension*)

OR posterior (like reaching the arm or leg backward)

In *Frontal* Plane:

Abduction: bones move away from midline

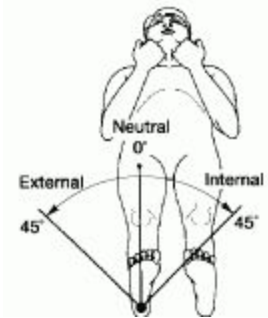
Adduction: bones move toward midline



In *Transverse* Plane:

Internal/medial rotation: rotation in

External/lateral rotation: rotation out



Circumduction: Movement in two or three planes of motion

Special Joint motions

Ankle Joint:

Plantar flexion: standing on toes, heels lifted (*pointing* foot)

Dorsiflexion: standing on heels, toes and ball of foot lifted (*flexing* foot)

Pronation: rotation foot inward and downward (outer arch up, inner arch flattens)

Supination: the outward roll of the foot (inner arch up)

Elbow joint (these are sometimes referred to as *forearm* motions):

Supination: palm up (palm is anterior, sometimes called *external rotation* by yogis)

Pronation: palm down (palm is posterior, sometimes called *internal rotation* by yogis)

Shoulder joint:

Elevation: shoulders up

Depression: shoulders down

Protraction: shoulder blades move away from the spine

Retraction: shoulder blades move toward spine



Pose Analysis

Now, analyze a yoga pose and specify **what joint motions from the anatomical position** are required to get into the pose.

Specify the plane(s) of motion (sagittal, frontal, transverse) and joint motions (abduction, adduction, flexion, extension, medial rotation, lateral rotation, etc.) for the ankle, knee, hip, spine, shoulder, elbow, and wrist.

Suggested poses include: Chair, Warrior III, High Lunge, Bow, Triangle, Forward Fold, Downward Dog, Warrior II, Sphinx, Cross Legged). *Note: many answers will be blank.*

Yoga pose: _____

Plane(s) of motion: _____

Specify the joint motion for: Ankle: _____

Knee: _____ Hip: _____

Spine: _____ Shoulder: _____

Elbow: _____ Wrist: _____

Yoga pose: _____

Plane(s) of motion: _____

Specify the joint motion for: Ankle: _____

Knee: _____ Hip: _____

Spine: _____ Shoulder: _____

Elbow: _____ Wrist: _____

Yoga pose: _____

Plane(s) of motion: _____

Specify the joint motion for: Ankle: _____

Knee: _____ Hip: _____

Spine: _____ Shoulder: _____

Elbow: _____ Wrist: _____

Yoga pose: _____

Plane(s) of motion: _____

Specify the joint motion for: Ankle: _____

Knee: _____ Hip: _____

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Yoga pose: _____

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Knee: _____ Hip: _____

Spine: _____ Shoulder: _____

Elbow: _____ Wrist: _____

Yoga pose: _____

Plane(s) of motion: _____

Specify the joint motion for: Ankle: _____

Knee: _____ Hip: _____

Spine: _____ Shoulder: _____

Elbow: _____ Wrist: _____

Yoga pose: _____

Plane(s) of motion: _____

Specify the joint motion for: Ankle: _____

Knee: _____ Hip: _____

Spine: _____ Shoulder: _____

Elbow: _____ Wrist: _____

Lesson 2: Bones, Spine, Movement of the Spine, Posture

The **musculoskeletal system** provides the body with support and movement. It consists of bones, joints, and soft tissues, which include muscles, tendons, ligaments, and fascia.

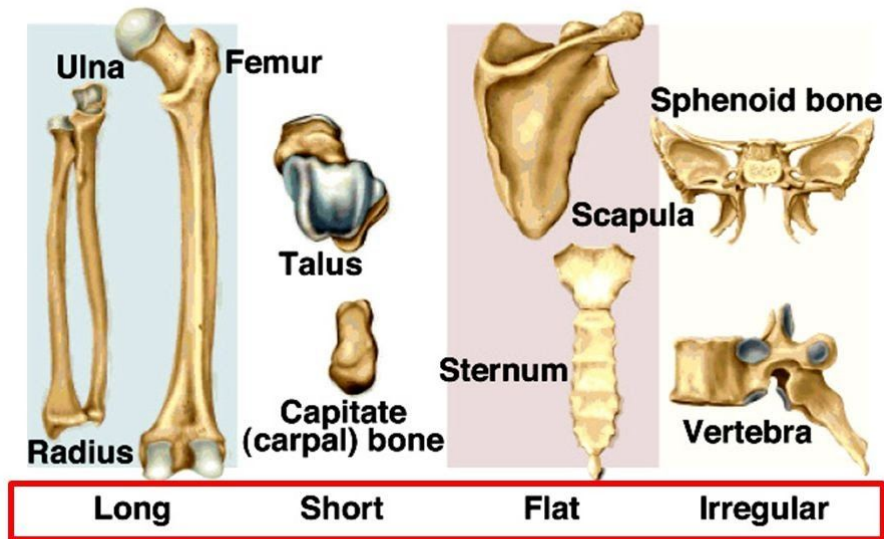
Bones and Joints Basics

Bones are **living, growing tissue** made mostly of **collagen**. Collagen is a protein that provides a soft framework, and calcium phosphate is a mineral that adds strength and hardens that framework. This combination of collagen and calcium makes bone strong and flexible enough to withstand stress.

Human beings have 270 bones at birth, some of which eventually fuse together, and we have 206 bones by adulthood. Our skeletal system serves five primary functions:

1. _____
2. _____
3. _____
4. _____
5. _____

There are four main types of bones: **long** (femur), **flat** (scapula, cranium, ribs), **short** (talus, carpal, tarsal) and **irregular** (vertebra). (Note: some textbooks will include a fifth type of bone, **sesamoid**, like the patella).

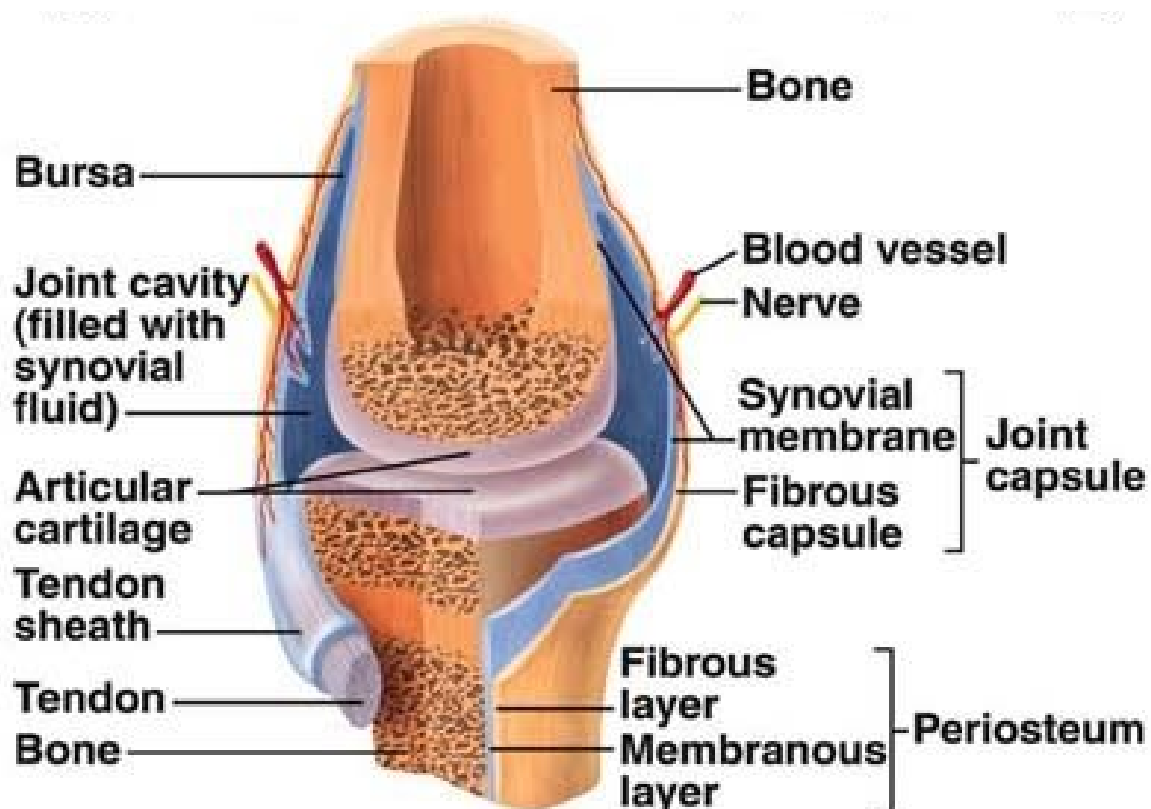


A joint is a point where any two or more bones meet. There are three main types of joints: **fibrous** (immovable), **cartilaginous** (partially movable) and **synovial** (freely movable) joint.

Fibrous (synarthrodial) joints: This type of joint is held together only by ligaments. They have no joint cavity and do not move. All 22 bones of the skull except for the mandible connect at fibrous joints.

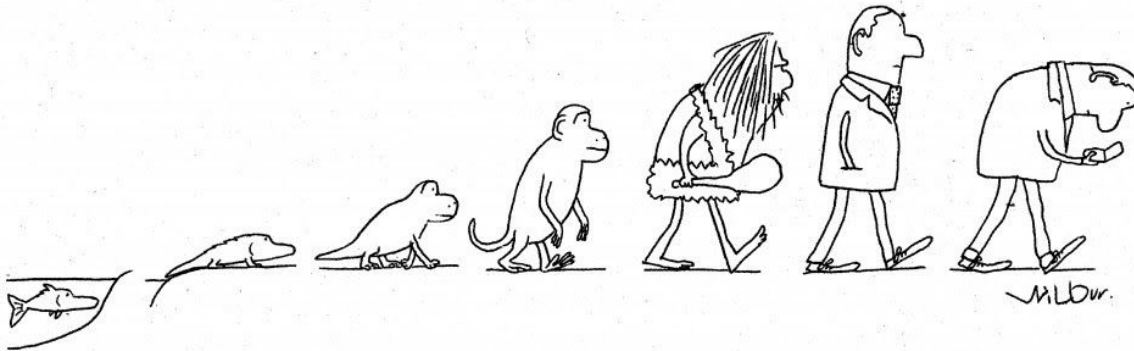
Cartilaginous (synchondrosis and symphysis) joints: These joints occur where the connection between the articulating bones is made up of cartilage. Examples of cartilaginous joints include the intervertebral discs in the spine, the ribs to the sternum, the pubic symphysis, and the manubriosternal joint (between the manubrium and the sternum). These are “semi-movable.”

Synovial (diarthrosis) joints: These joints are by far the most common classification of joint within the human body and will be our primary concern when it comes to yoga, since synovial joints are where most of our movement happens. All synovial joints have a **synovial capsule** (collagenous structure) surrounding the entire joint, a **synovial membrane** (the inner layer of the capsule) which secretes synovial fluid (a lubricating liquid), and cartilage known as **hyaline cartilage** which pads the ends of the articulating bones (think of the white/glossy part at the end of a chicken bone). The structure of the synovial joint can be seen below:



The Spine

In yoga there is a saying: *you are as young as your spine*. Whether or not that is literally true, our spine is our literal backbone and the center of all of our movement. Before we build the rest of our skeleton, let us discuss and get to know our spine.



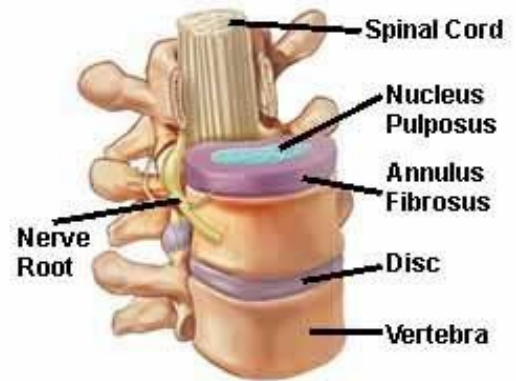
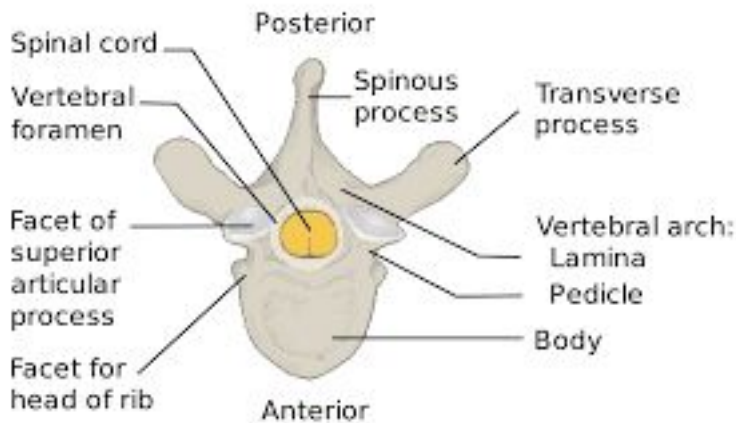
Written into our spine is the evolution of our species. From fish who moved side to side with their head but never had to consider the force of gravity, to reptiles who developed a “primary curve” or arch to carry their weight, to mammals who then lifted their heads up to bring a new curve to the neck, and finally humans being the only species that mainly walks on two feet, a third curve was introduced.

We now refer to these arches as **thoracic** (ribs), **cervical** (neck), and **lumbar** (lower back) curves.

Patanjali writes in the yoga sutras: *sthira sukham asanam*. This sutra is most commonly translated as: *seated posture should be steady and comfortable*. We see this delicate balance of **sthira**, meaning weight bearing, strong, passive, or stable, and **sukham**, meaning easy, agreeable, flexible, active, or moving, in every living thing.

An organism must be flexible enough to move around its environment, but not so flexible that it falls apart at the least amount of stress. A tree, for example, must be strong enough to withstand intense winds, but not so rigid that it snaps in half at the slightest stress. A bacterium must be rigid enough to separate itself from its environment, while also being able to move and be permeable enough for nutrients to come in and waste to come out.

Our spine balances the necessity of stability with strong **vertebrae**, along with the necessity of flexibility with spongy, **intervertebral discs**. The structure of our spine is as follows:

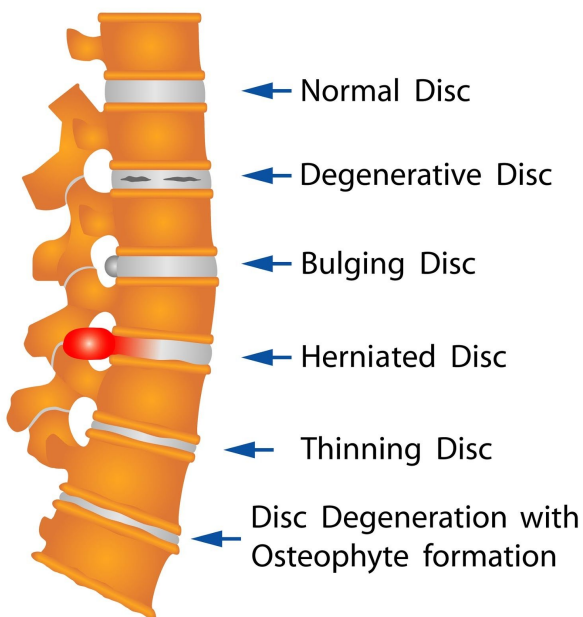


While every vertebrae is different, and every body is different from another, there are some similar structures across all vertebrae, as shown in the picture on the left.

In the picture on the right, we can see the **nucleus pulposus**, which covers 15% of the disc space and consists of a gelatinous material made up of water and collagen fibers.

The **annulus fibrosus** surrounding the nucleus is made up of concentric rings of fibrous cartilage. Notice also how the spinal cord is heavily protected, as it runs through the tunnel known as the **vertebral foramen**.

Things can also go wrong with these discs, as shown below:

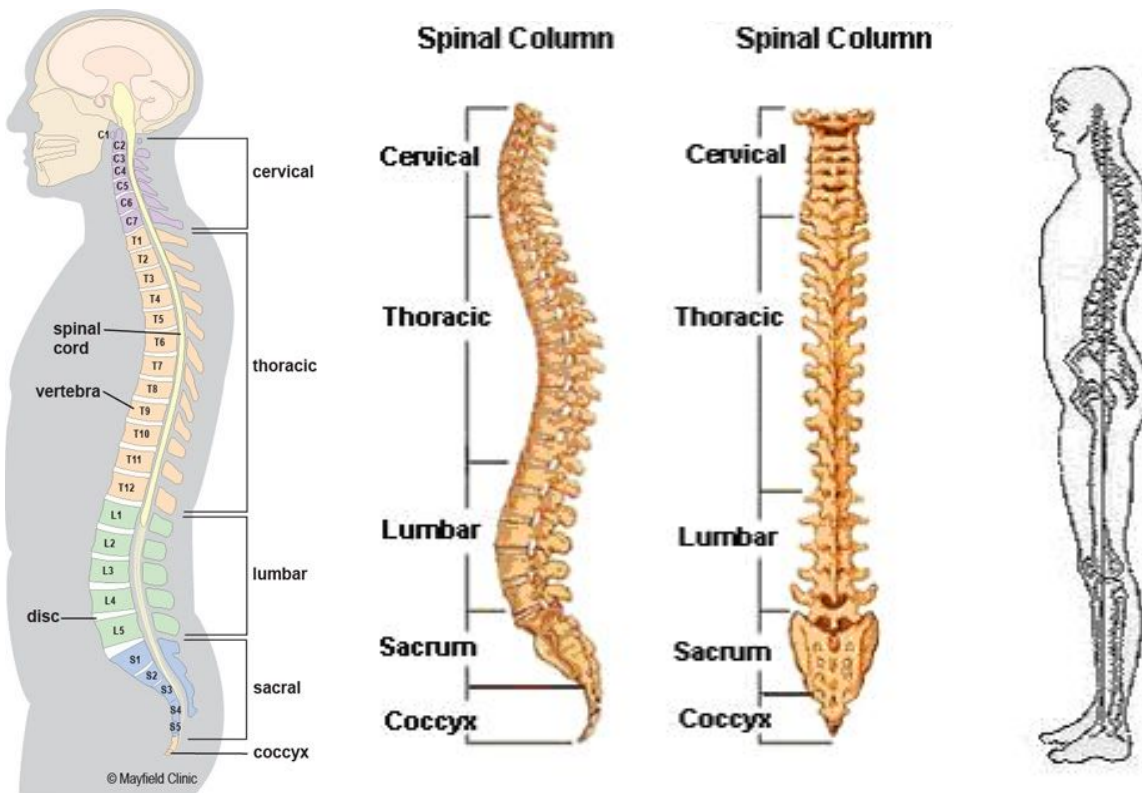


An estimated 80% of people will experience some form of debilitating back pain in their lives.

This is why it becomes so important to maintain a healthy spine throughout one's entire life, which yoga can greatly help with. Since there is no blood flow in the discs, a spine must move to stay healthy.

Some people and even professionals will use the term "**slipped disc**," but this term is a misnomer, and is usually referring to a herniated disc.

Now, let us look at the structure of the entire spine, which consists of **24 vertebrae**, with discs in between each one:



There are 4 types of spinal movement, each with a general range of motion, as shown in the table below (note: some yogic textbooks will include a 5th type of movement, **axial extension**, for straightening the spine, like in *tadasana*, mountain pose, or *navasana*, boat pose).

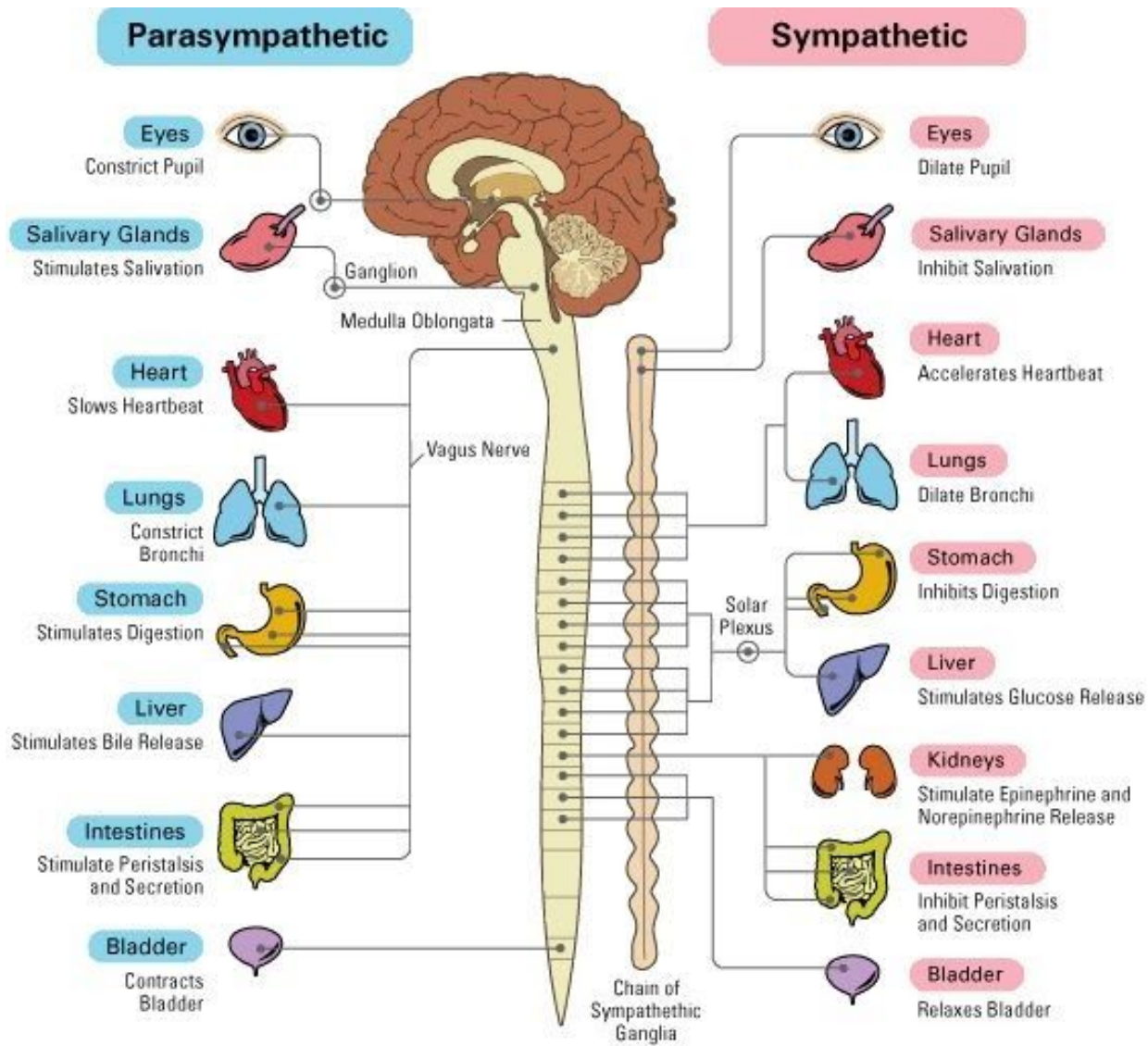
<u>Movement</u>	<u>Breath</u>	<u>Yoga</u>	<u>Plane of motion</u>	<u>Cervical</u>	<u>Thoracic</u>	<u>Lumbar</u>	<u>Total</u>
Flexion	Exhale	cat	Sagittal	40°	45°	60°	145°
Extension	Inhale	cow	Sagittal	75°	25°	35°	135°
Axial rotation	Exhale	twist	Transverse	50°	35°	5°	90°
Lateral flexion	Exhale	side-stretch	Frontal	35°	20°	20°	75°

Looking at the above table,

1. Where would you adjust a twist?
2. Which parts of the spine are the most and least movable? Why do you think that is?
3. Why have many studios stopped teaching shoulderstand?

The spinal cord runs down the posterior to the vertebral body and branches out to specific areas of the body along the way. A break in the spinal cord will result in paralysis in all the areas inferior to the break.

The **autonomic nervous system** has two branches: the **sympathetic nervous system** (*fight, flight, freeze*) and the **parasympathetic nervous system** (*rest and digest, or feed and breed*). Some textbooks will also include a third branch: the enteric nervous system.



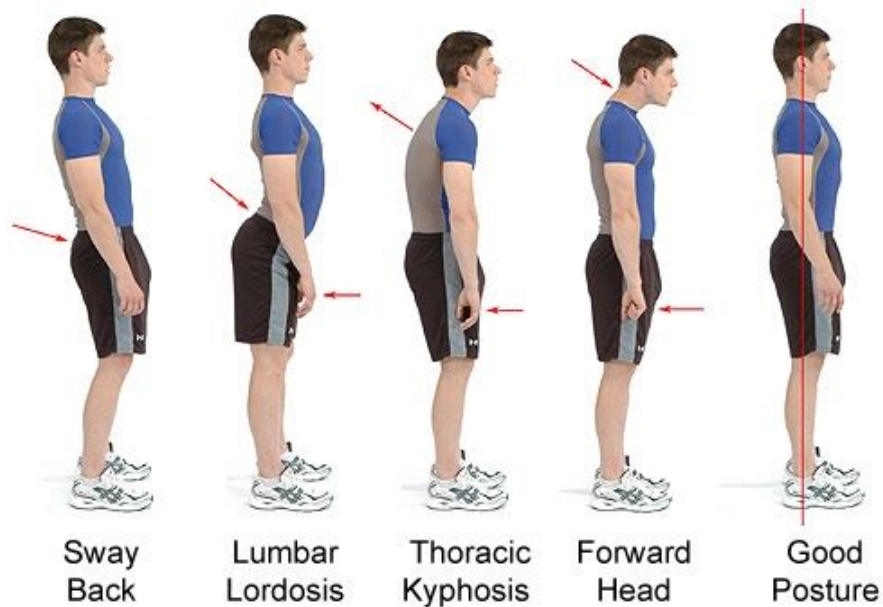
The **vagus nerve** is of considerable interest to yogis and scientists alike, as it represents the physiological connection between the mind and the heart. This nerve, the longest cranial nerve, regulates our heart rate, lungs, and digestive tract. It also modulates inflammation levels within the body and is a marker of our overall state of health. High **vagal tone** is found in yogis, meditators, and people that show a concern for the well-being of others.

When abnormalities occur in the spine, it may be evident by looking at that person's posture.

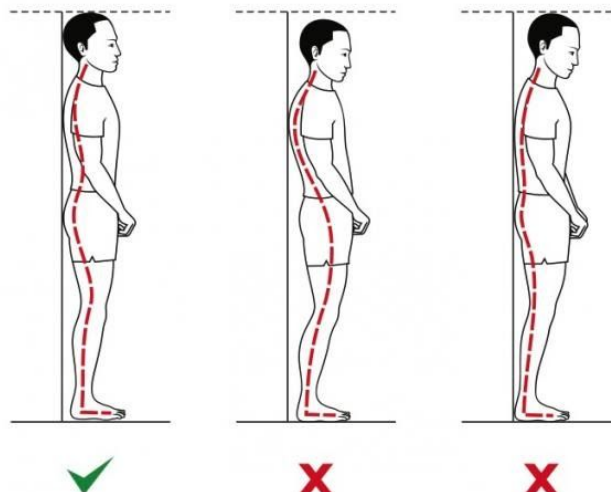
In latin, the prefix *kyph* means bent, and the thoracic curve is sometimes referred to as a *kyphotic* curve. *Lord* means bent backwards, and the term *lordotic* is sometimes used to describe both the cervical and lumbar curves (think of bending a metal bar towards you).

The suffix *-osis* means abnormal. Combining these words together, we see the spine can have the following abnormalities:

1. **Lumbar kyphosis** - swayback, posterior tilt so the lumbar curve disappears
2. **Lumbar lordosis** - butt out, belly forward, large anterior tilt
3. **Thoracic kyphosis** - humpback, an abnormally rounded back
4. **Scoliosis** - abnormal lateral curvature of the spine.



Exercise: Posture test



Lesson 3: Soft Tissues, Muscles 101

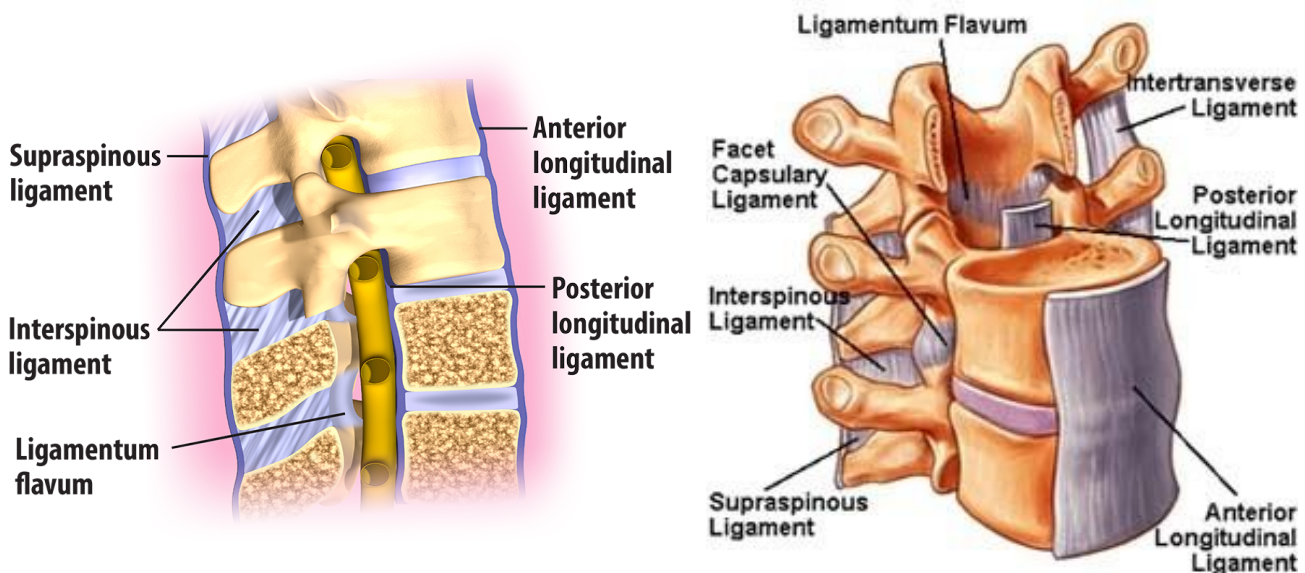
Now that we know what bones are and how they are structured, we can add literal flesh to our skeleton with the four soft tissue types.

Soft Tissue Types

- **Ligament:** Fibrous tissue, joins bone to bone. Helps stabilize joint, and allows movement. Mostly collagen.
- **Tendon:** Fibrous tissue, joins muscle to bone. Mostly collagen.
- **Fascia:** Fibrous tissue that lifts, connects, attaches everything to everything else. May be microscopic or form large bands. More elastin than collagen, allows muscles to “snap back” after stretching.
- **Muscle:** Contractile tissue that moves, stabilizes and supports bones.

A **sprain** is a stretched, strained or torn ligament. Most common sprains are in the ankles, wrists, and thumbs. Anyone who has torn their **ACL (Anterior Cruciate Ligament)** knows the important roles that ligaments play in our joint stability. A **strain** is a stretched or torn muscle or tendon. When this occurs, scar tissue is formed upon healing. To prevent these injuries from happening, it helps for the body to be warm before any physical activity which softens the connective tissues. Lastly, fascia can get inflamed, as in the case of **plantar fasciitis** and **iliotibial band syndrome (ITBS or IT band syndrome)**.

We have a number of ligaments running up and down the spine as well, which help to stabilize the spine while still allowing for enough range of motion:



Connective tissue test

Give yourself a point if you can:

1. Bring a finger past 90° _____
2. Hyperextend your knees _____
3. Hyperextend your elbows _____
4. Get your palms to the ground in a forward fold _____
5. Touch your thumb to your forearm _____
6. Bring your chin to chest with less than two fingers between _____
7. Get your knee to the wall when toes are one-hand-length away from the wall _____

Total = _____

If you got a high score (more than 4), don't celebrate too quickly. While a high number means it will often be easier for you to get into deeper expressions of yoga pose, it also means you will have to work to stabilize poses with muscles because the ligaments/tendons can get easily overstretched.

Muscles 101

The human body has at least **400 muscles**, sometimes counted as more than 600 depending on what is referred to as a muscle. Muscles take up 40-45% of the average human's body weight, and are responsible for all of our actions. From breathing to walking to speaking, none of what we do in this world could be accomplished without the actions of our muscles. There are three main types of muscles:

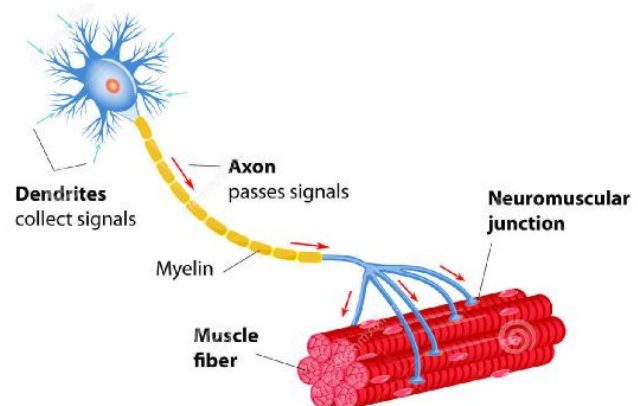
Smooth: Involuntary muscle, stretch and maintain tension found in the digestive system, airways, walls of internal organs

Cardiac: Located in the heart, good for consistency and automaticity

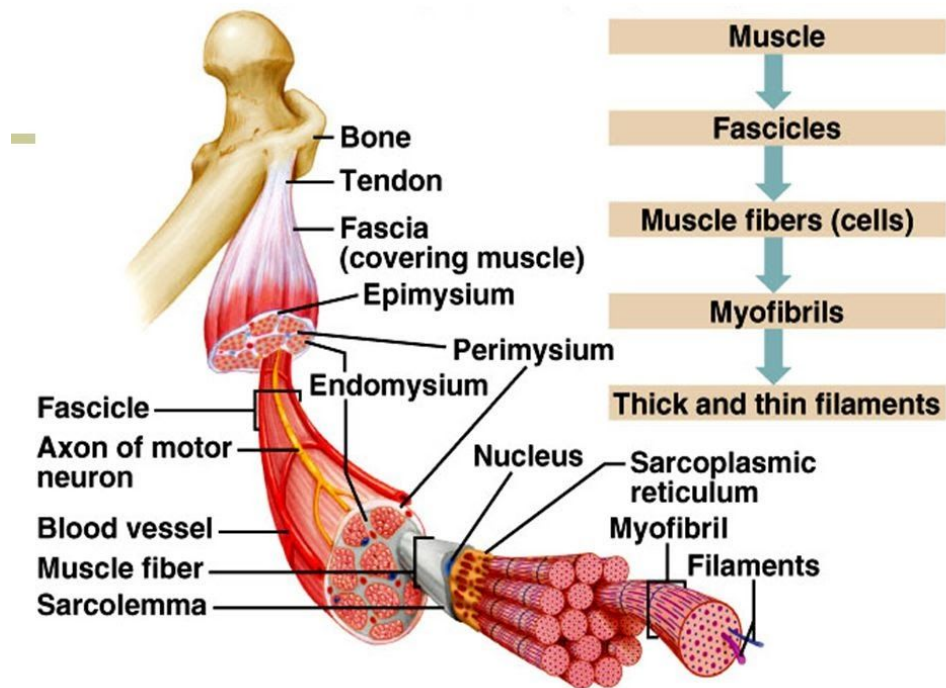
Skeletal: What we can see and feel, responsible for locomotion, breathing, posture and heat.

Skeletal muscle is our primary interest when it comes to yoga practice, because our skeletal muscles are what play a role in our movement and fitness.

For our brain to move our bodies, it has to convert the electrical signals of the brain into physical movement of the muscles. This happens through our **motor neurons**, as the signals from our dendrites pass along our nerves and across the neuromuscular junction.



Once the signal successfully reaches the muscle, the muscle structure as bundles upon bundles upon bundles. You can have more than 100,000 fibers in your bicep alone.



1. Muscles have the following characteristics: **contractibility**, **extensibility**, **excitability**, and **elasticity**. This means:
 - a. Muscles only generate force by contracting.
 - b. Myofibrils can relax, elongate, and change length over time
 - c. Signal is synchronized over entire muscle fiber, triggered by electrical impulses via the **motor neurons**.
2. To get stronger:
 - a. **Muscle hypertrophy** - bigger muscle fibers
 - i. Damage myofibrils through stress
 - ii. Repair, create more, and thicken
 - iii. Body-builders, weight trainers
 - iv. Muscles shorten in this process (they also shorten when chronically contracted)
 - b. **Muscle hyperplasia** - more muscle fibers
 - i. Rock climbers, gymnasts, ninjas, and yogis
 - c. **Change recruitment patterns** - increase efficiency
 - i. Recruit more fibers in the right way, release other ones
 - ii. This is why technique and form (aka *alignment*) is so important!

IMPORTANT MUSCLE TERMS

Muscle identifiers:

Origin: Attachment which is less moveable or proximal bone

Insertion: Attachment which is more moveable or distal bone

Action: what a muscle does

Types of muscle contraction:

Concentric: shortening contraction (bicep curl or doing a pull-up)

Isometric: muscle is working but doesn't change length (holding plank pose)

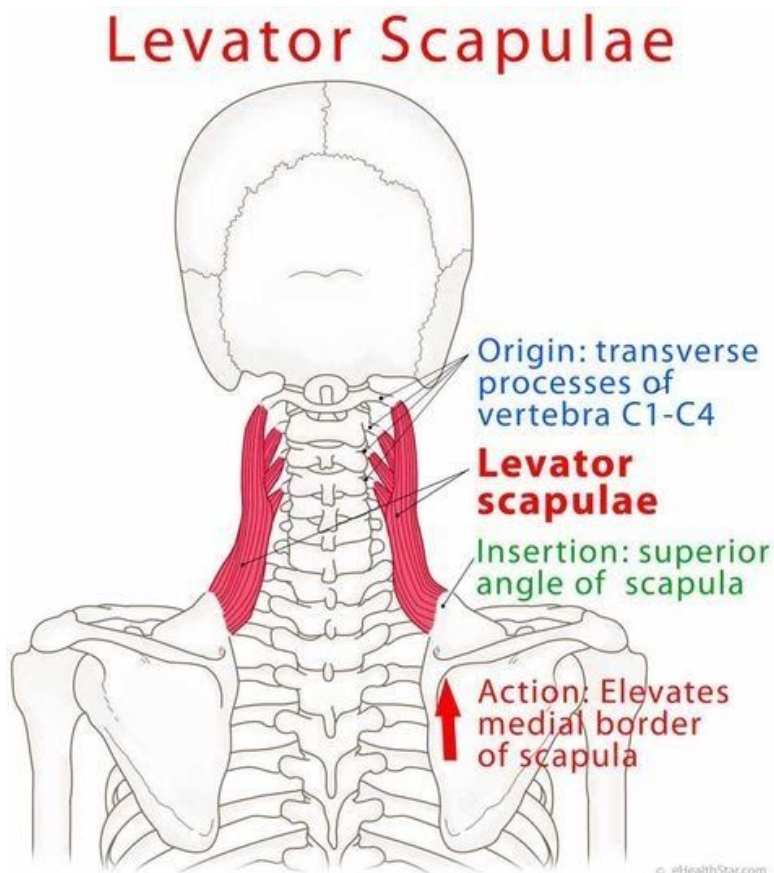
Eccentric: lengthening contraction (lowering down from a pull-up, folding forward)

Muscle movements:

Agonists/Prime mover: main muscle(s) doing a given action

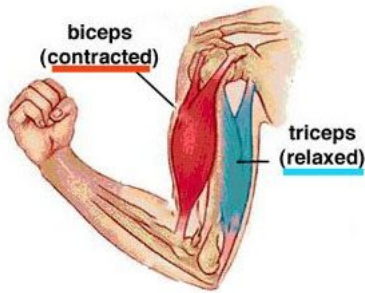
Synergists: muscles that work as a team to perform a given action

Antagonist: muscle doing opposite action to a given muscle

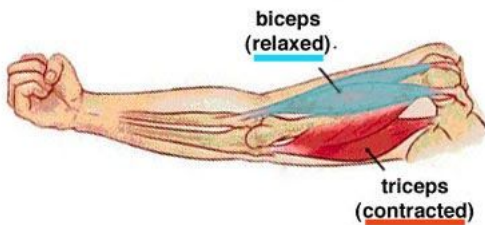


Case study: Elbow Flexion and Chaturanga Dandasana

Antagonist and agonist muscles often occur in pairs, called antagonistic pairs. As one muscle contracts, the other relaxes. An example of an antagonistic pair is the **biceps** and **triceps**.



Muscle pair during a grab or pull



Muscle pair during a punch



Biceps:

Origin: Scapula
 Insertion: Radius
 Action: pronate and flex the arm

Triceps:

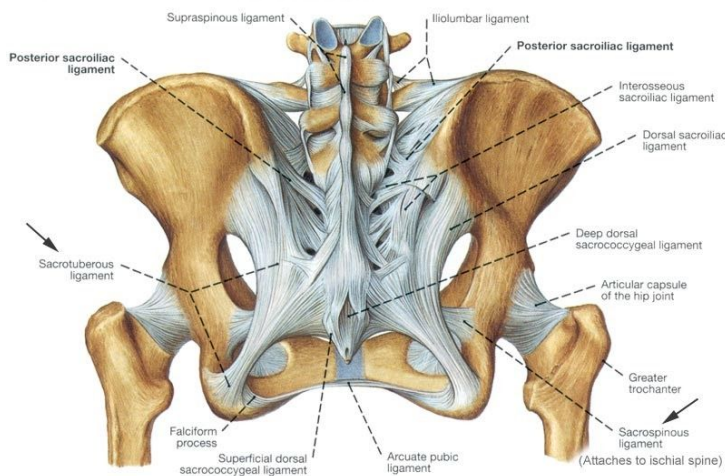
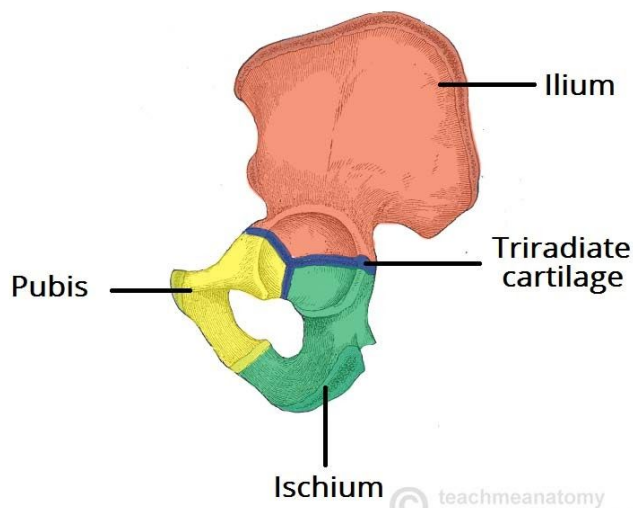
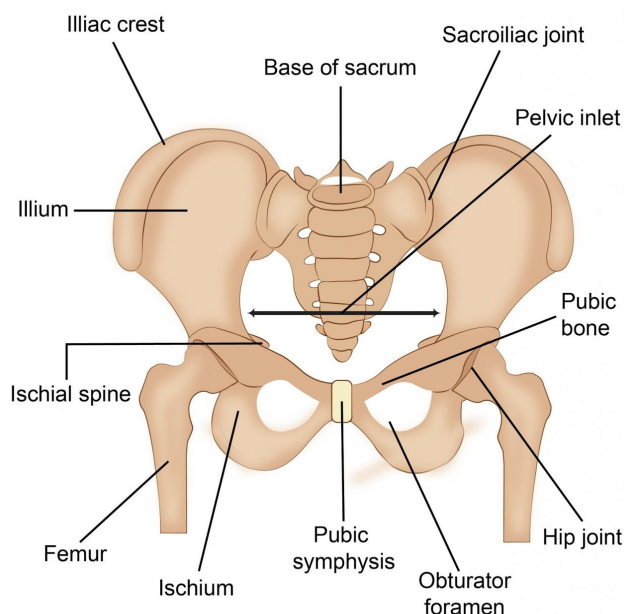
Origin:
 Scapula near shoulder joint
 Upper lateral and posterior sites of humerus
 Posterior surface of humerus
 Insertion: Back of olecranon process of ulna
 Action: Straighten (extend) the arm

Lesson 4: Pelvic Bowl, Hamstring and Psoas, Ribs and Breathing

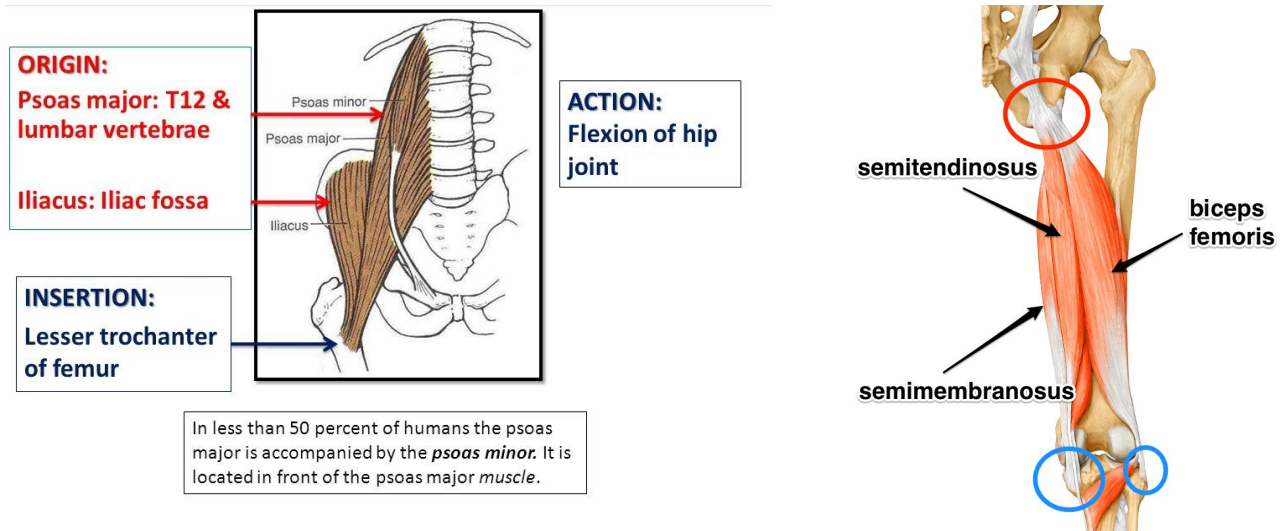
Now that we have learned the structure of the spine, and we know the properties of our soft and connective tissues, we can continue to build our body by adding some more bones and muscles.

The pelvic bowl consists of three sections on each side: the **ilium**, **pubis** and the **ischium**. In babies these are separate bones that become fused early on in life, and all connect to form the hip socket, **the acetabulum**. The **ischial tuberosities** are what yogis call the sit (or sitz) bones, and when people say hip points or hip bones, they most likely mean the **anterior-superior-iliac-spine**, or AS-IS bones.

The ilium connects to the sacrum at the **sacroiliac, or SI, joint**. There is a dense network of sacroiliac ligaments that keep this joint in place. This joint can become inflamed and those who have lower back problems may need to work on stabilizing (or to stop de-stabilizing) their SI joint.



Case study: Hip flexion and extension



Consider what roles the iliopsoas (hip flexors) and hamstring (hip extensors) play in:

1. One legged and two legged leg lifts
2. Sitting
3. Correct Posture
4. Sitting and standing head to knee
5. Standing Forward fold
6. High lunge, Warrior I, and King Arthur's pose

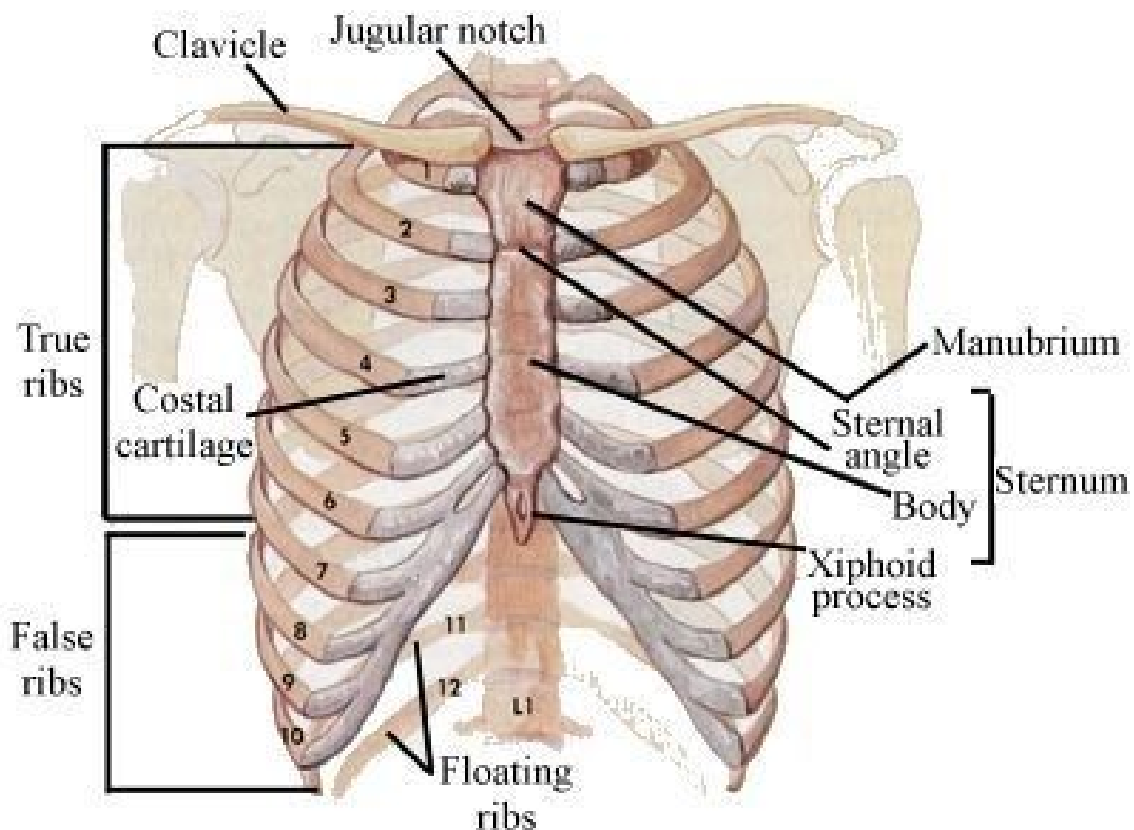
Remember: A muscle that does an action in one direction will often inhibit movement in the opposite direction. Similarly, to strengthen a muscle, perform its action. To stretch the same muscle, perform the opposite action.

Breathing Anatomy

To begin our discussion on breathing anatomy, let us first discuss the rib cage. The ribs partially enclose and protect the chest cavity, where many vital organs (including the heart and the lungs) are located. The rib cage is collectively made up of long, curved individual bones with joint-connections to the spinal vertebrae.

At the chest, many rib bones connect to the sternum via the **costal cartilage**, segments of hyaline cartilage that allow the rib cage to expand during respiration. Although fixed into place, these ribs do allow for some outward movement, and this helps stabilize the chest during inhalation and exhalation.

The rib cage is made up of **12 paired rib bones**; each are symmetrically paired on a right and left side. Of all 24 ribs, the first seven pairs are often labeled as **true ribs**. These bones are connected to the costal cartilage, while the five pairs of **false ribs** are not. Three of those connect to non-costal cartilage, and two pairs are deemed to be **floating ribs**, which means they only connect to the spine.

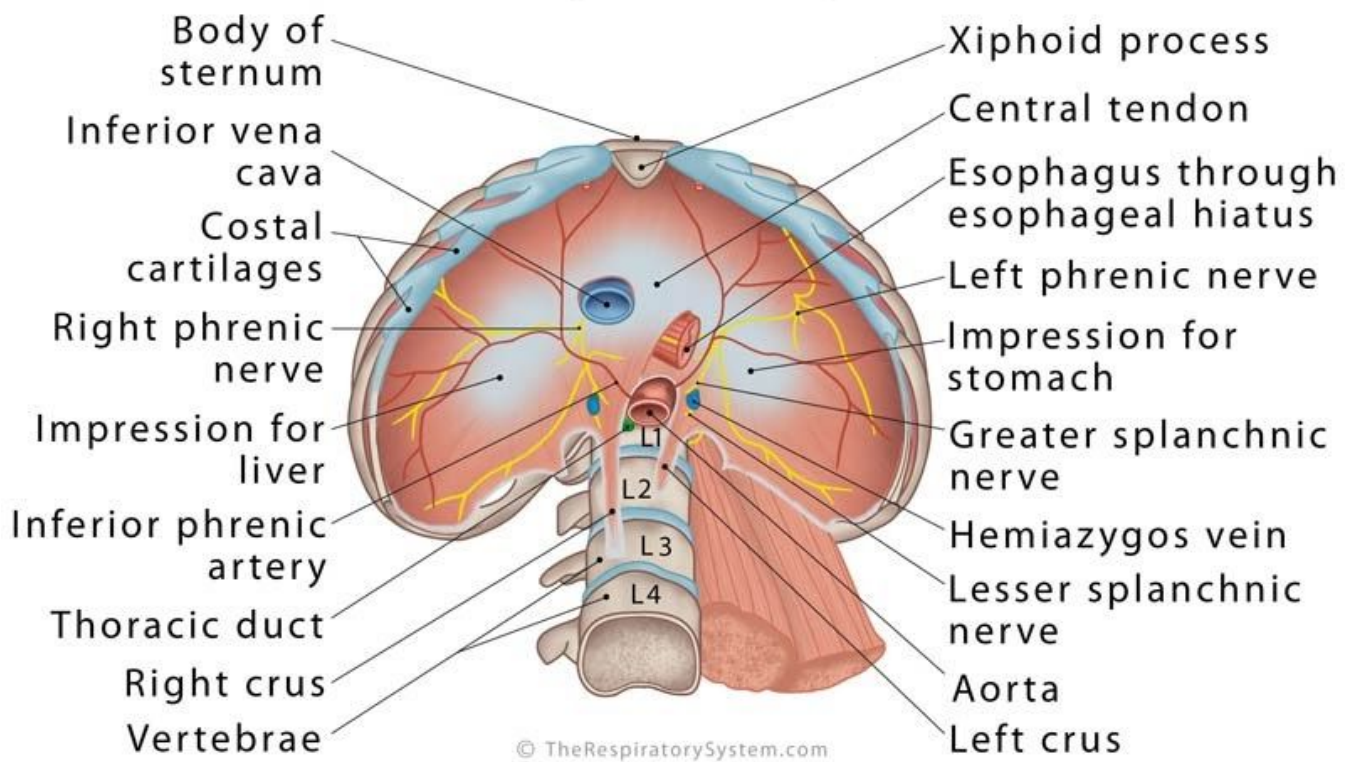


While there are some cases of minor anatomical variation, men and women generally have the same amount of ribs. A differing rib count between the genders is largely a medical myth.

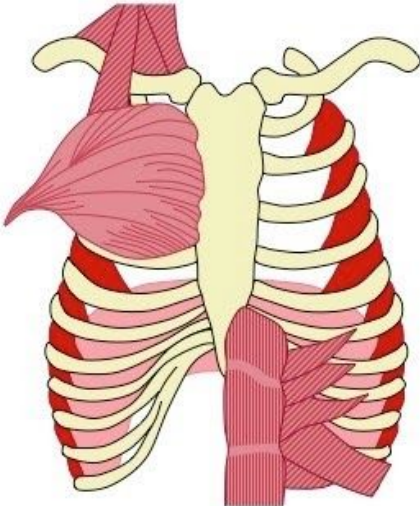
The main breathing muscle is the **diaphragm**, a dome/umbrella/jellyfish shaped muscle that lies between the thoracic and abdominal cavities. It originates along the low ribs, xiphoid process, side bodies of the lower lumbar, and the 5 arcuate ligaments, and connects to the cloverleaf shaped central tendon. The central tendon also leaves openings for the inferior **vena cava**, **esophagus**, and **aorta**.

The thoracic cavity contains the lungs and the heart. It is compressible, like an accordion or empty plastic coke bottle. The abdominal cavity contains our digestive organs. It is liquid filled and changes shape, but not volume. Therefore, for us to breathe more deeply, we must allow the belly to draw out, or the ribs to expand and draw up.

Diaphragm



There are also a few muscles beyond that diaphragm that can help us breathe more deeply, or to force more rapid breathing.

<p>Muscles of Inspiration</p> <p>Core Muscles</p> <ul style="list-style-type: none">• External intercostals <i>(contracts to elevate ribs)</i>• Diaphragm <i>(contracts to expand thoracic cavity)</i> <p>Accessory Muscles</p> <ul style="list-style-type: none">• Sternocleidomastoid <i>(contracts to elevate sternum)</i>• Pectoralis minor <i>(contracts to pull ribs outwards)</i>		<p>Muscles of Expiration</p> <p>Core Muscles</p> <ul style="list-style-type: none">• Internal intercostals <i>(contracts to pull ribs down)</i>• Diaphragm <i>(relaxes to reduce thoracic cavity)</i> <p>Accessory Muscles</p> <ul style="list-style-type: none">• Abdominals <i>(contracts to compress abdomen)</i>• Quadratus lumborum <i>(contracts to pull ribs down)</i>
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Consider:

What is happening in three-part yogic breath?

What is happening with more active pranayama like shining skull, fire's breath, breath of joy?

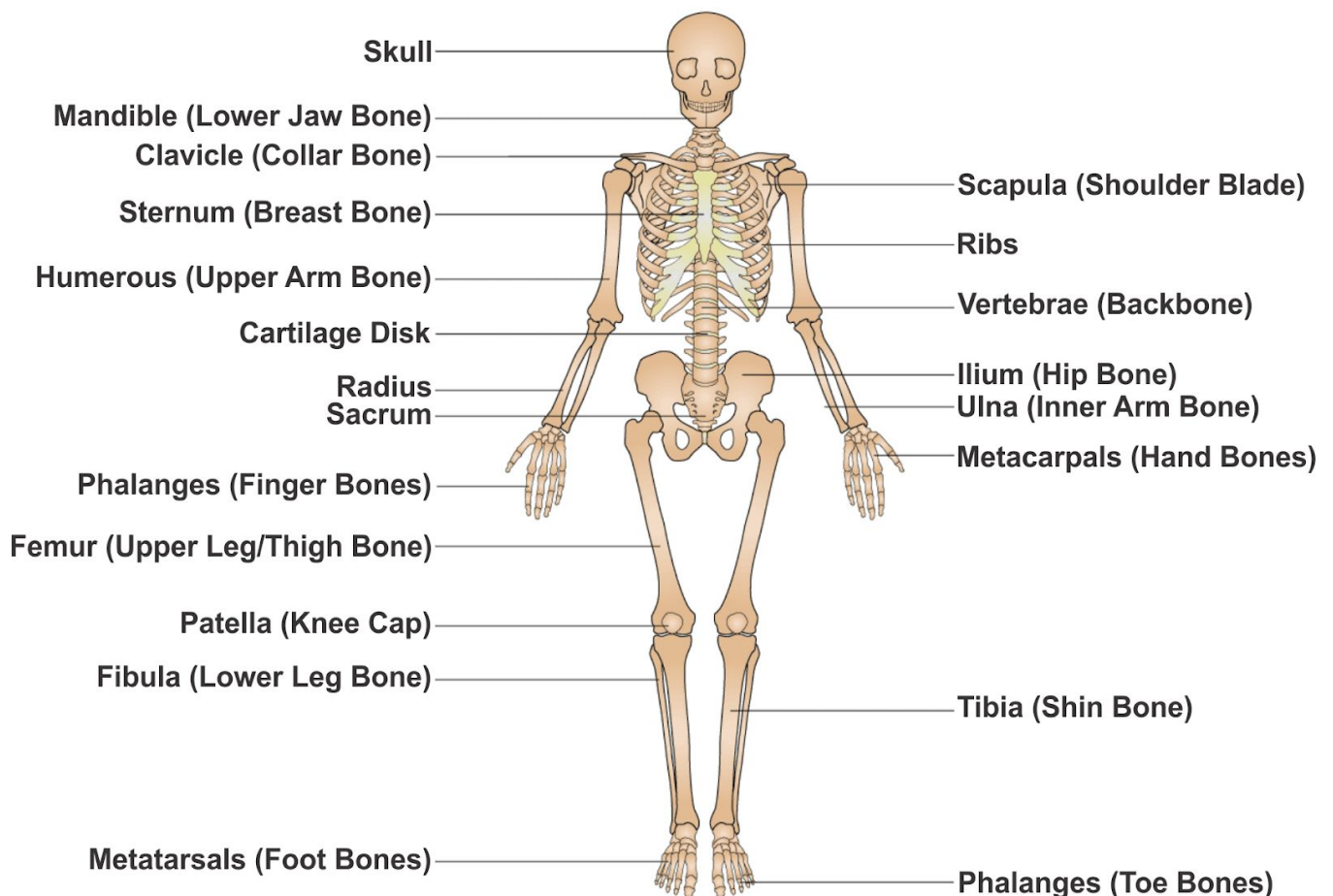
How do babies breathe? How do many adults breathe? What can we do to improve our breath?

Lesson 5: Skeletal System, Gross Muscles, and Muscle Movements

All together, a human adult has 206 bones. This can seem like a lot to memorize. Fortunately, we can group many of these bones into helpful categories.

More than half of the bones in our bodies are located in the hands, feet, and head. We have 27 bones in each hand, 26 bones in each foot, and 22 bones that are cranial and facial bones. Another 24 of our bones are our ribs, with 12 on each side (contrary to popular belief, both men and women have the same number of ribs), and another 24 bones are the vertebrae in the spine.

When it comes to gross movements of the body, there are only a handful of bones we can focus on learning now (note: more advanced anatomy and most 500-hr trainings will go more in depth into bone structure, particularly in the ankle and foot). These are pictured below:



Next, we can add in the main muscles of movement and their primary functions, including the associated antagonists.

Remember:

Agonist / prime mover – muscle *directly responsible* for the movement at a joint.

Antagonist – muscle that is relaxing and has the *opposite action* to the agonist.

MOVEMENT	AGONIST (prime mover)	ANTAGONIST (relaxed)
Wrist flexion	Flexor Digitorum	Extensor Digitorum
Wrist extension	Extensor Digitorum	Flexor Digitorum
Elbow flexion	Biceps Brachii	Triceps Brachii
Elbow extension	Triceps Brachii	Biceps Brachii
Shoulder flexion	<u>Anterior Deltoid</u> Pectoralis Major Biceps Brachii	<u>Posterior Deltoid</u> Latissimus Dorsi Triceps Brachii
Shoulder extension	<u>Posterior deltoid</u> Latissimus Dorsi	<u>Anterior deltoid</u> Pectoralis Major
Shoulder adduction	<u>Latissimus Dorsi</u> Pectoralis major	Deltoid (middle)
Shoulder abduction	<u>Deltoid (middle)</u>	<u>Latissimus Dorsi</u> Pectoralis major
Spine/ Trunk flexion	Rectus Abdominis	Erector Spinae
Spine/ Trunk extension	Erector Spinae	Rectus Abdominis
Hip flexion	<u>Iliopsoas</u> Quadriceps	<u>Gluteus Maximus</u> Hamstrings
Hip extension	<u>Gluteus Maximus</u> Hamstrings	<u>Iliopsoas</u> Quadriceps
Knee flexion	Hamstrings	Quadriceps
Knee extension	Quadriceps	Hamstrings
Dorsiflexion	Tibialis Anterior	Gastrocnemius Soleus
Plantar Flexion	Gastrocnemius Soleus	Tibialis Anterior

Let us add the rest of the muscles to the body. While this is not an exhaustive list of every muscle in the body and everything that they do, this list is a good reference guide for the main muscles of yoga and movement.

Gross Muscle Identification List

Muscles of mastication

- Masseter – elevates mandible
- Temporalis – elevates and retracts mandible
- Buccinator - compresses cheek

Neck muscles

- Sternocleidomastoid – prime mover of head and neck flexion

Abdominal and spinal muscles

- Rectus abdominis – flex and rotate lumbar region of spinal cord
- External oblique - aids rectus abdominis to increase intra-abdominal pressure, flex the spinal cord, rotate spine
- Internal oblique – same as external
- Transversus abdominis – compresses abdominal contents
- Erector spinae group – prime mover of back extension

Respiratory muscles

- Diaphragm – prime mover of inspiration
- External intercostals – elevate rib cage to aid in inspiration
- Internal intercostals – depress rib cage and aid in forced expiration

Muscles that move the pectoral girdle

- Pectoralis minor– moves scapula forward and down or rib cage superiorly
- Serratus anterior – important role in abduction and raising of arm movement “boxers muscle”
- Trapezius – adduct or elevate scapula as in shrugging shoulders
- Rhomboid – retract scapula “squaring shoulders”

Muscles that move the arm

- Pectoralis major– prime mover of arm flexion or pulls rib cage up
- Latissimus dorsi – prime mover of arm extension (arm power stroke)
- Deltoid – prime mover of arm abduction antagonist of pectoralis major and latissimus dorsi
- Subscapularis – medial rotator of humerus / stabilizes shoulder
- Supraspinatus – shoulder stabilization prevents downward dislocation of humerus
- Infraspinatus – stabilizes the shoulder / rotates humerus laterally
- Teres major - synergist of latissimus dorsi to medially rotate and adduct humerus
- Teres minor– same as infraspinatus to adduct arm

Muscles that move the forearm

- Biceps brachii – flexes elbow and supinates forearm
- Triceps brachii – forearm extensor / antagonist of flexors
- Brachialis – major forearm flexor

Muscles that move the wrist

Anterior compartment

- Pronator teres – pronates forearm
- Flexor carpi radialis – wrist flexor / abducts hand
- Palmaris longus – tenses skin and fascia of palm during hand movement

Flexor carpi ulnaris – wrist flexor / adducts hand
Brachioradialis – synergist in forearm flexion / stabilizes elbow

Posterior compartment

Extensor carpi radialis longus – extends wrist synergist with extensor carpi ulnaris
Extensor carpi radialis brevis – extends and abducts wrist with extensor carpi radialis longus
Extensor digitorum – prime mover of finger extension
Extensor carpi ulnaris – extends wrist with extensor carpi radialis

Muscles that move the thigh

Iliopsoas

Iliacus – prime mover for flexing thigh
Psoas major – flexes thigh and important in posture

Gluteus maximus – major extensor of thigh

Gluteus medius – major abductor of thigh, also medially rotates

Sartorius – flex, adduct, and laterally rotates thigh

Tensor fasciae latae – flex and abducts thigh

Gracilis – adducts, flexes, and medially rotates thigh / flexes knee

Adductor magnus – anterior part adducts and medially rotates or flexes thigh/ posterior part synergist with hamstrings on thigh extension

Adductor longus – adduct, flex, medially rotate thigh

Adductor brevis – adduct, medially rotates thigh

Muscles that move the leg

Quadriceps femoris

Rectus femoris – extends knee and flexes thigh at hip

Vastus lateralis – extends and stabilizes knee

Vastus medialis – extends knee and stabilizes patella

Hamstrings

Biceps femoris (lateral) – extends thigh and flexes knee

Semitendinosus (medial) – extends thigh at hip / flexes knee

Semimembranosus (medial) – extends thigh and flexes knee

Muscles that move the foot

Gastrocnemius – plantar flexes foot

Soleus – plantar flexes foot, important in walking and running

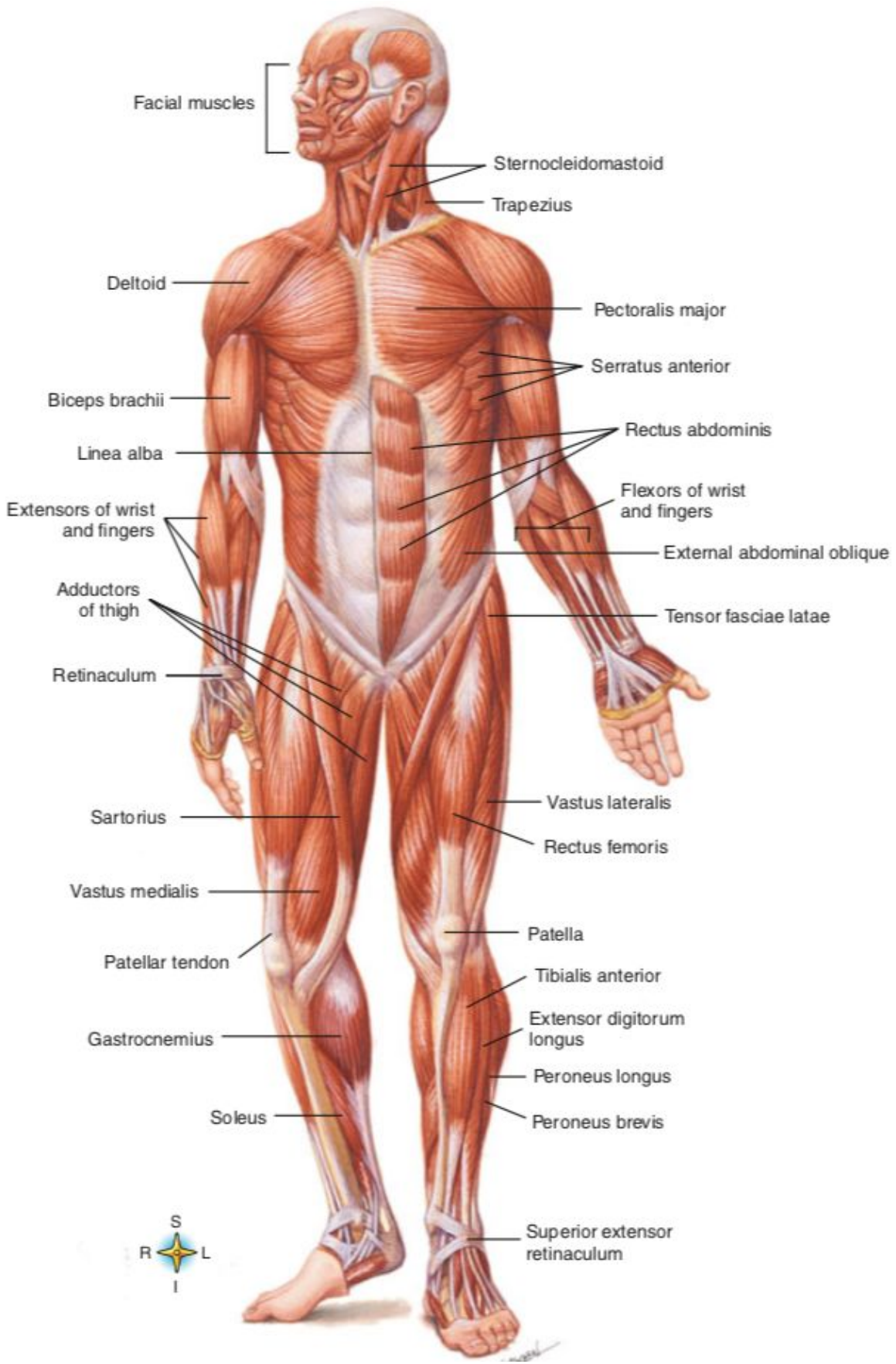
Tibialis anterior – prime mover of lifting the foot (dorsiflexion)

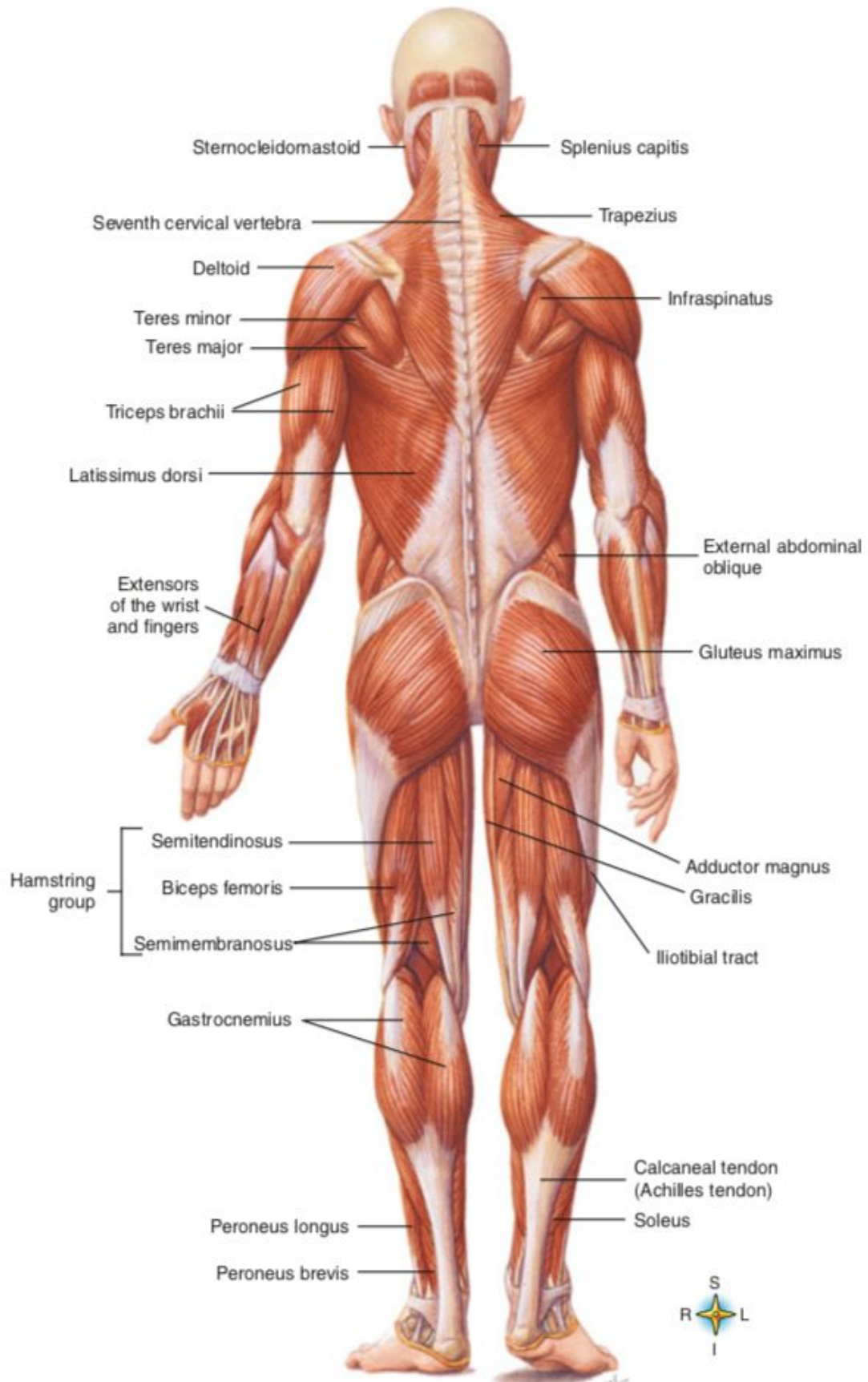
Extensor digitorum longus – prime mover of toe extension

Fibularis (peronius) longus – plantar flexes and everts foot

Fibularis (peronius) brevis – plantar flexes and everts foot

Flexor digitorum longus – plantar flexes and inverts foot

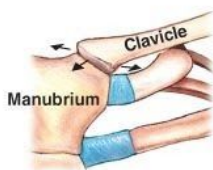
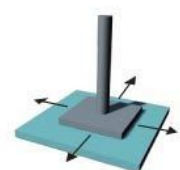

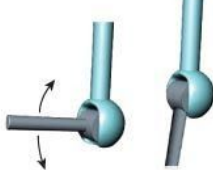
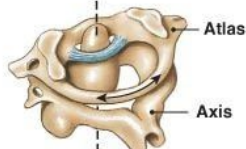
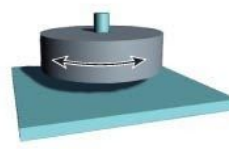


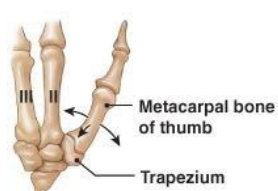
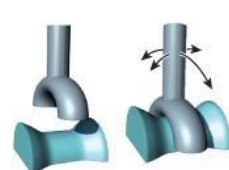
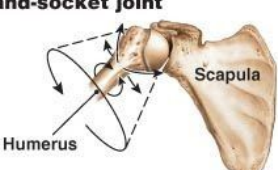





Lesson 6: Joint Types, The Hip Joint

Now that we have put together the entire skeleton and added the muscles, let's continue to break down how everything works together.

A joint is anywhere two bones meet. We have a nice round number of 360 joints in our bodies, each one roughly categorized as either a **gliding**, **hinge**, **pivot**, **ellipsoid**, **saddle**, or **ball-and-socket** joint, as shown below.

Types of Synovial Joints	Models of Joint Motion	Examples
Gliding joint 		<ul style="list-style-type: none"> • Acromioclavicular and sternoclavicular joints • Intercarpal and intertarsal joints • Vertebrocostal joints • Sacro-iliac joints
Hinge joint 		<ul style="list-style-type: none"> • Elbow joints • Knee joints • Ankle joints • Interphalangeal joints
Pivot joint 		<ul style="list-style-type: none"> • Atlas/axis • Proximal radio-ulnar joints
Ellipsoid joint 		<ul style="list-style-type: none"> • Radiocarpal joints • Metacarpophalangeal joints 2-5 • Metatarsophalangeal joints
Saddle joint 		<ul style="list-style-type: none"> • First carpometacarpal joints
Ball-and-socket joint 		<ul style="list-style-type: none"> • Shoulder joints • Hip joints

Although there are 360 joints in the body, and it is helpful for some professions to know every single one, as beginning yoga teachers, we can limit our focus to some of the most important ones: the **ankle, knee, hip, spine, shoulder, elbow, and wrist joints**. Let's start with the hip joint.

Case study: The Hip Joint

The Basics:

Ball and socket joint that connects the femur to the pelvis

Restrictions in range of motion (ROM) can affect lower back, knees, and feet

Difficult to feel and locate due to its depth and surrounding muscles

Strong bundle of ligaments bring stability to joint (people rarely dislocate their hips)

Movement:

Flexion - passive flexion is greater (it's easy to hug knee to chest)

Extension - less ROM than flexion

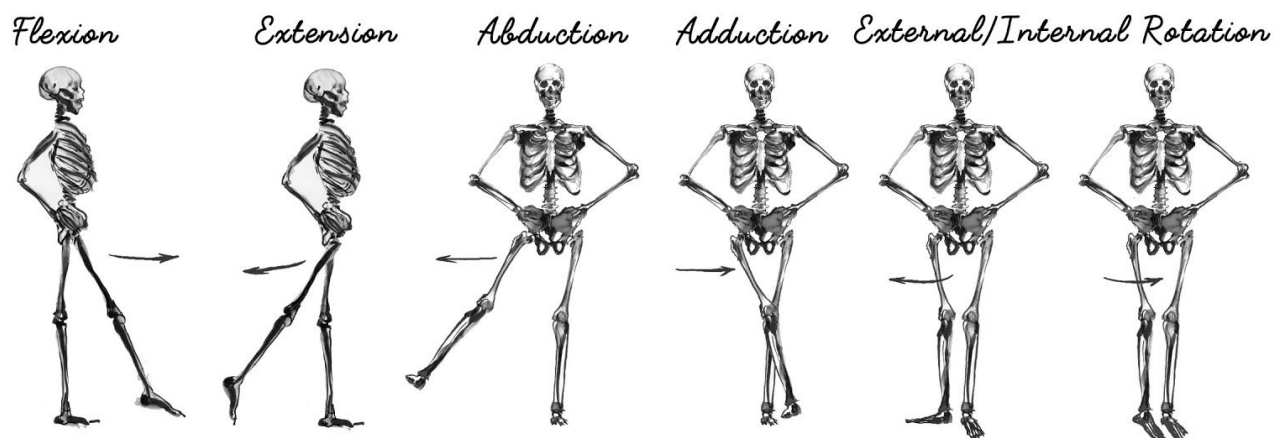
Internal/medial rotation - needed for hero's pose (even moreso with dorsiflexion)

External/lateral rotation - needed for lotus pose

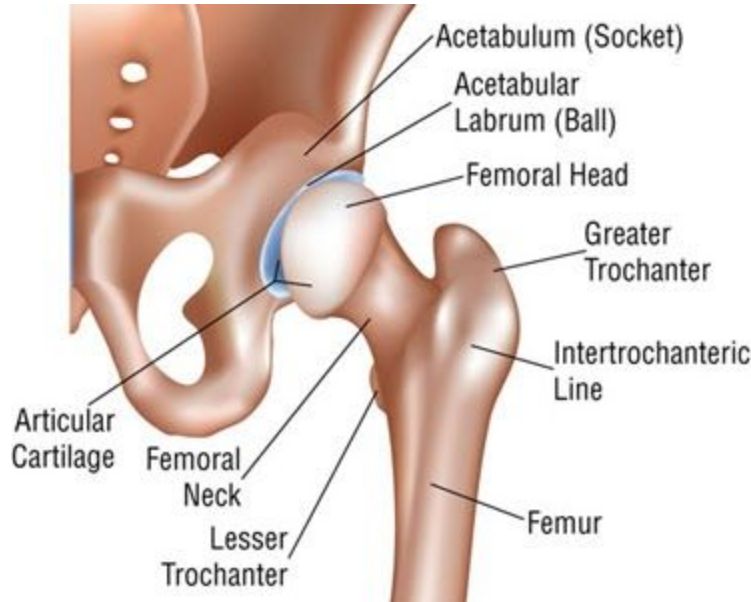
Adduction - need to flex or extend legs to get in this position

Abduction - limited to 40 degrees before superior femoral neck hits the acetabulum

Circumduction - movement through all three planes

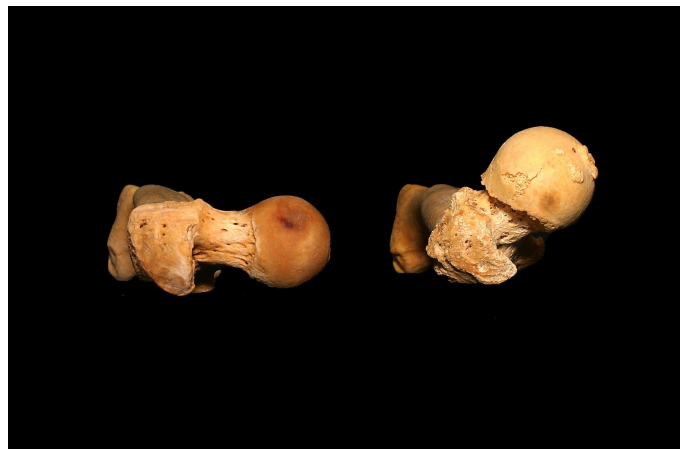


Bone Structure:



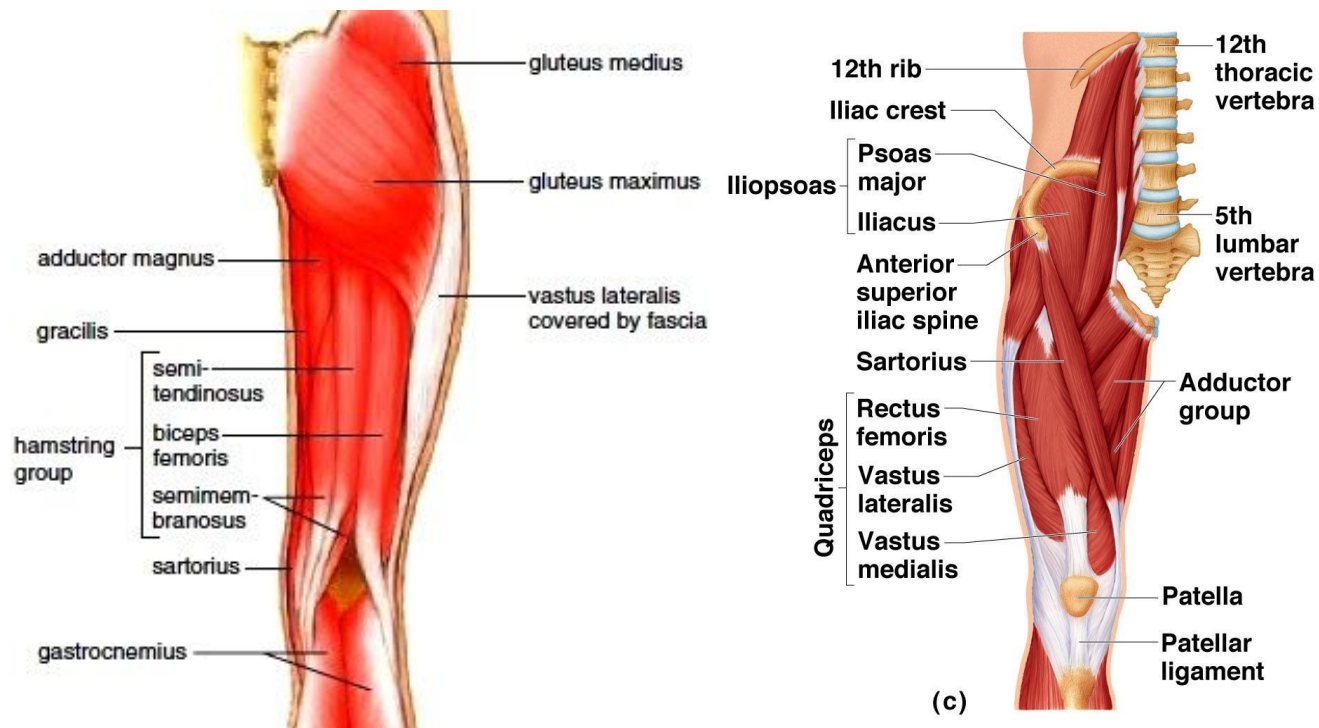
The **greater trochanter** is an important insertion point for a lot of important muscles, like the gluteus medius and piriformis. The **lesser trochanter** also serves as an important insertion point, such as for the iliopsoas.

It's important to know that the acetabulum is oriented **laterally**, **anteriorly**, and **inferiorly** (meaning it points to the side, down, and forward). While this orientation is universal, the specific angles the femur meets the acetabulum can greatly vary amongst individuals and with age. The angle the neck of the femur meets the shaft can greatly vary too. Some examples are shown below (photos from Paul Grilley):

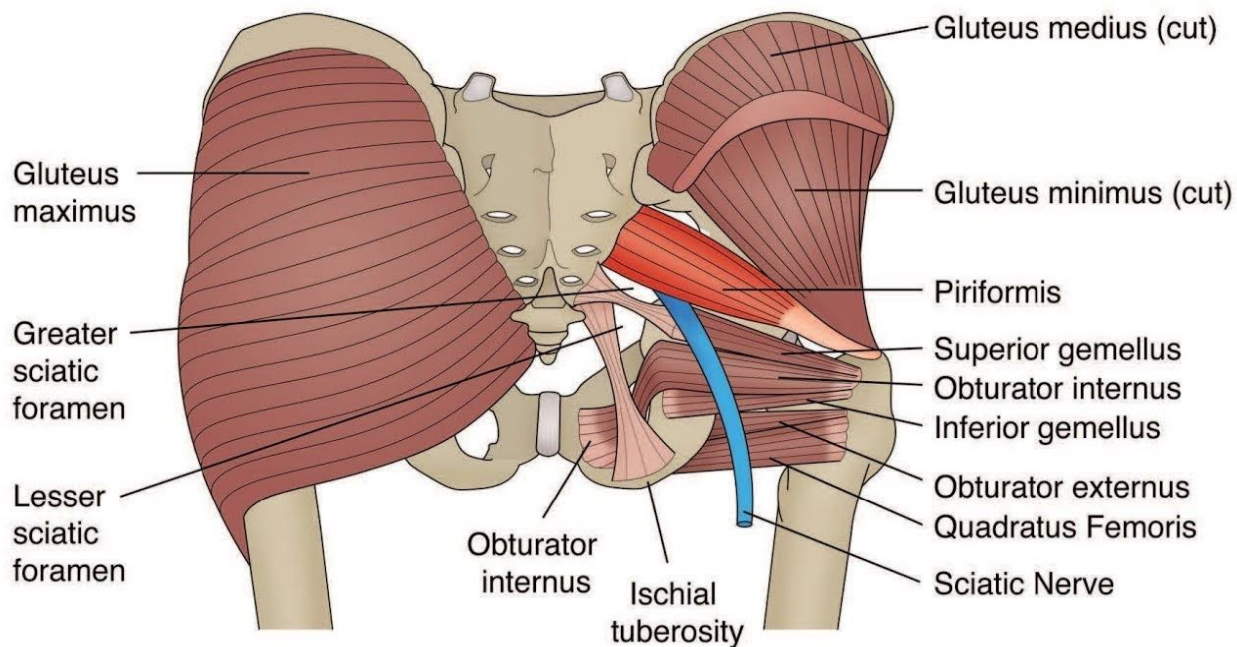


Superficial Muscles of the hip

There are over 30 muscles that give support hip movement and stability, and they are often categorized by either what they do or what group of muscles they are in, such as: the adductors, abductors, and flexors, or the hamstrings and quadriceps.



Deeper hip muscles



Around-the-hip joint yoga stretch sequence

Many people will say they have “tight hips,” but are often unclear or uncertain about what muscles are actually tight. If a student asks you to do hip openers in class, you might want to ask them if they mean the front, back, inside, or outside of the hip, or deeper in the pelvic bowl.

<u>To stretch the:</u>	<u>Bring the hip into</u>	<u>By coming into</u>
hip flexors (anterior thigh)	Extension	
abductors (lateral thigh)	Adduction	
hamstrings (posterior thigh)	Flexion	
adductors (medial thigh)	Abduction	
deep hip muscles	External Rotation	

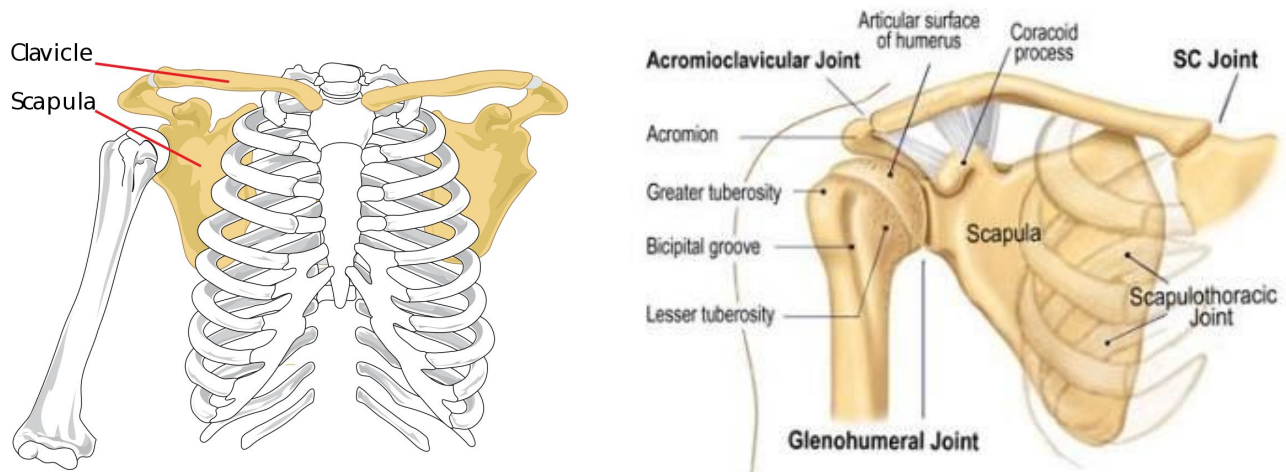
Teacher challenge: Design a yoga class around a peak pose that requires open hips.

Lesson 7: The Shoulder

There are two ball and socket joints in the body. We have already covered the hip joint, and now we can look at the shoulder, which is a structure consisting of three bones: the humerus (upper arm bone), clavicle (collarbone), and scapula (shoulder blade) all tied together with numerous muscles, tendons and ligaments.

The shoulder joint is more complex than the hip, because there are actually **three joints that interact** to create the movement of the shoulders. Those three joints are the:

- **glenohumeral joint**, where the humerus of the arm meets the scapula
- **acromioclavicular joint**, between the distal clavicle and acromion process of the scapula,
- **sternoclavicular joint**, between the medial clavicle and manubrium of the sternum, as shown below:

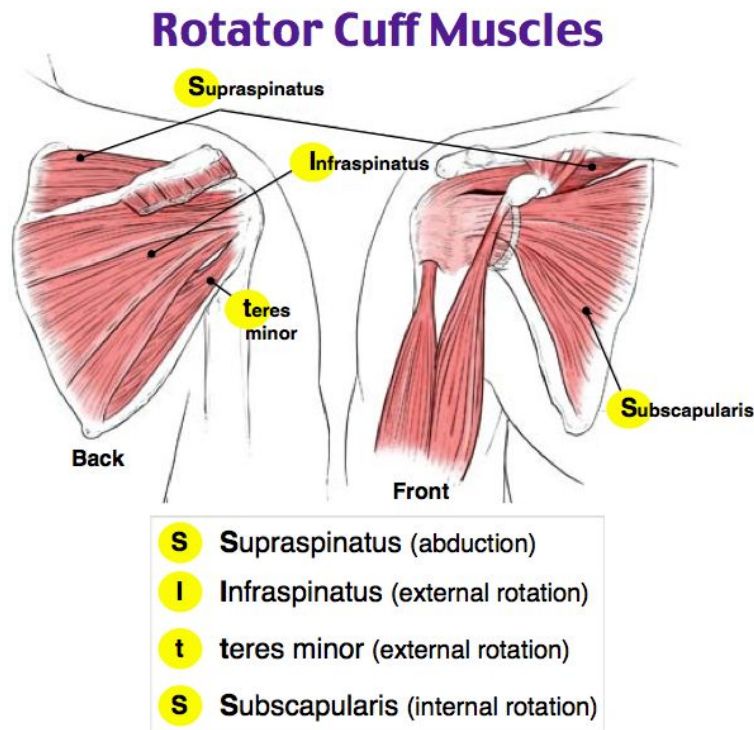


The shoulder joint is much more mobile than the hip joint and is in fact the most mobile joint in the body, allowing our arm to go into almost any position we want. We have a wide array of both superficial and deep muscles that work together to both stabilize the shoulder and allow us to swing from branches, do a handstand, and reach for things we need. This mobility comes at a cost however, as anyone who has dislocated their shoulder can attest.

Let us first examine **the glenohumeral joint**. Unlike the head of the femur, which fits snugly into the acetabulum, the head of the scapula only covers a small portion of the head of the humerus, and is often described of as a golf ball on a tee.

Four muscles are employed to keep the humeral head in the scapular socket during shoulder movements, together these are known as the rotator cuff: **supraspinatus, infraspinatus, teres**

minor, and **subscapularis** (SITS muscles). The supraspinatus is the one most commonly torn or injured, as it can be worn down through mechanical abrasion and impingement on the acromion bone.

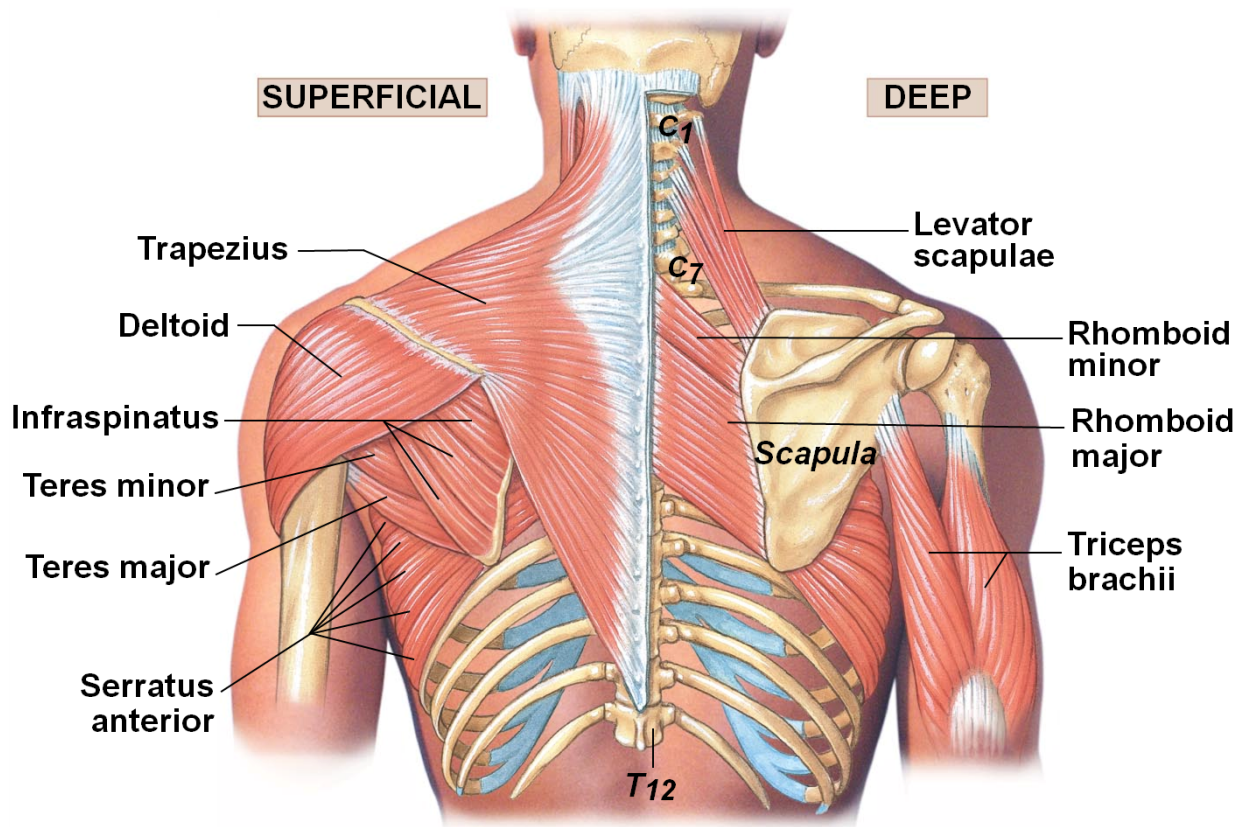


The acromioclavicular joint is at the top of the shoulder and its movement allows the arm to rise above the head, helping the movement of the scapula and giving the arm greater rotation for asanas such as Downward Facing Dog.

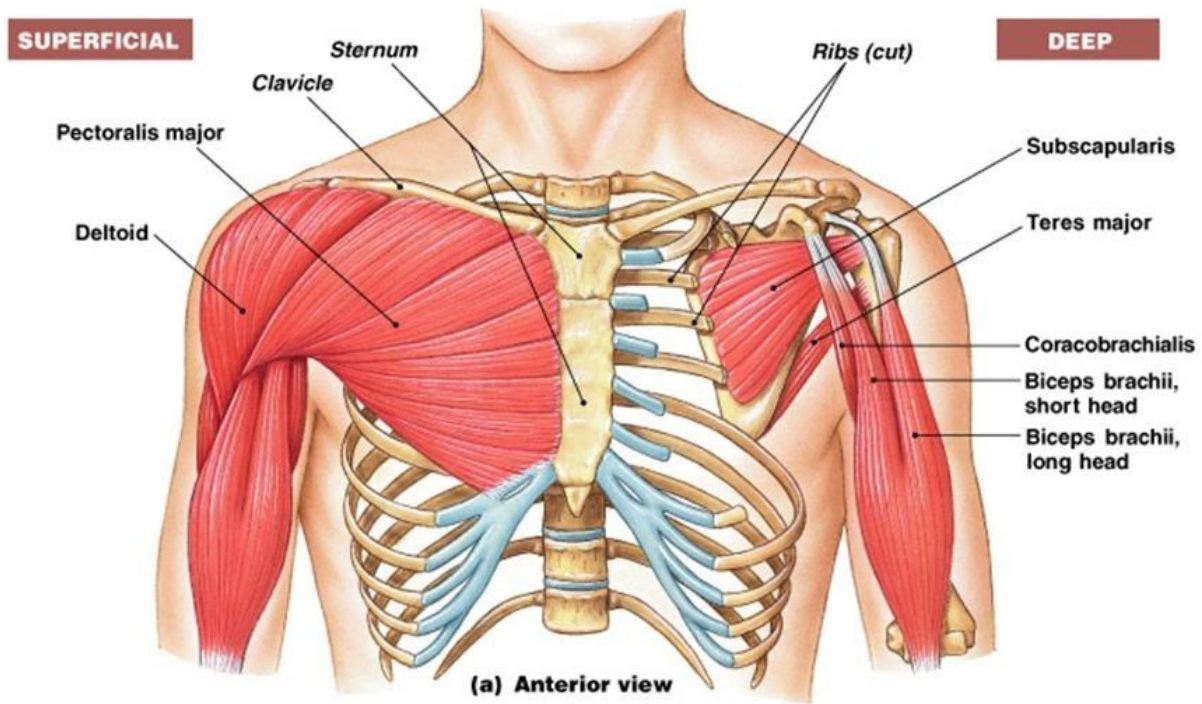
At the medial end of the clavicle is the sternoclavicular joint, where the convex shape of the manubrium interfaces with the rounded end of the clavicle.

Beyond the rotator cuff, there are then larger and more superficial muscles that cover the arm, shoulders and back, to keep the scapula in place, allow for dynamic range of movement, and give strength and stability to the upper body.

Muscles of the shoulder joint			
Movement	Prime Mover	Origin	Insertion
Flexion	Anterior deltoid	Clavicle, scapula and acromion process	Humerus
	Upper part of pectoralis major	Clavicle, sternum and ribs	Humerus
	Coracobrachialis	Scapula	Humerus
	Serratus anterior	Side of ribs	Scapula
Extension	Posterior deltoid	Clavicle, scapula and acromion process	Humerus
	Latissimus dorsi	Ilium, lumbar and thoracic vertebrae	Humerus
	Teres major	Scapula	Humerus
Horizontal flexion	Pectoralis major	Clavicle, sternum and ribs	Humerus
Horizontal extension	Trapezius	Cervical and thoracic vertebrae	Scapula
Abduction	Medial deltoid	Clavicle, scapula and acromion	Humerus
	Supraspinatus	Scapula	Humerus
Adduction	Lower part of pectoralis major	Clavicle, ribs and sternum	Humerus
	Latissimus dorsi	Ilium, lumbar and thoracic vertebrae	Humerus
	Teres major	Scapula	Humerus
	Teres minor	Scapula	Humerus
Medial rotation	Pectoralis major	Clavicle, sternum and ribs	Humerus
	Subscapularis	Scapula	Humerus
	Latissimus dorsi	Ilium, lumbar and thoracic vertebrae	Humerus
	Teres major	Scapula	Humerus
	Anterior deltoid	Clavicle, scapula and acromion process	Humerus
Lateral rotation	Infraspinatus	Scapula	Humerus
	Teres minor	Scapula	Humerus
	Posterior deltoid	Clavicle, scapula and acromion process	Humerus
	Lower trapezius	Cervical and thoracic vertebrae	Scapula



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Case study: Eagle Pose and Reverse Prayer

What's happening anatomically in Eagle pose, and in reverse prayer?



What stretches would you recommend to help get into these poses?

Shoulder Questions

What muscles play a role in shoulder strength and stability in:

- Upward Dog
- Handstand
- Forearm stand

Lastly, consider the plight of the modern office worker:



Anatomically, what's happening in the shoulders?

Which muscles might need to be stretched? Which muscles might need to be strengthened?

What yoga poses might you recommend for your corporate private yoga client?

Lesson 8: The Foot, Ankle, and Knee

Now that we have covered most of the major joints close to the axial skeleton, let us focus more on the appendicular skeleton, focusing on the **foot, ankle, and knee**.

This part of the body is of course, our lowest part, and thus provides the foundation for almost everything we do, from standing, walking, running, and simply moving about our lives. In yoga, our feet are the base for all of our standing postures, and will form an intimate connection with the knee when it bends to come into poses like Warrior II or High Lunge.

The ability for the foot and ankle to quickly adapt to changing forces immediately comes to play once we balance on one leg.

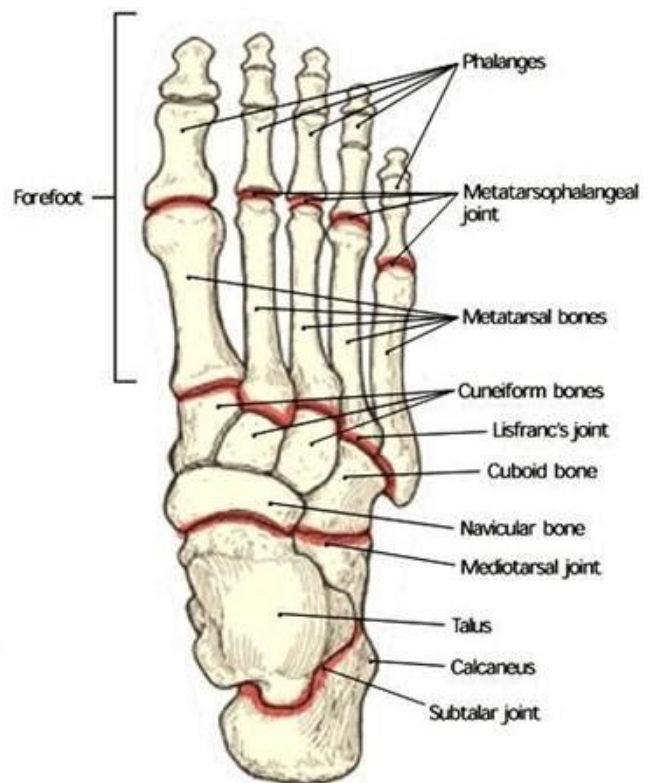
The Foot

Every single day, we walk on our feet. They are the foundation of all of our standing postures. Each foot is made up of 26 bones, 30 joints and more than 100 muscles, tendons and ligaments, all of which work together to provide support, balance, and mobility.

Bones of the feet

Nearly one-fourth of the body's bones are in our feet. The 26 bones of the foot consist of eight distinct types, including the **tarsals, metatarsals, phalanges, cuneiforms, talus, navicular, and cuboid bones**.

- **Calcaneus (the heel bone):** The largest bone of the foot, it is commonly referred to as the heel of the foot. It points upward, while the remaining bones of the feet point downward.
- **Talus (the ankle bone):** This irregularly shaped bone creates the lower portion of the ankle joint. It is the second largest bone in the foot.



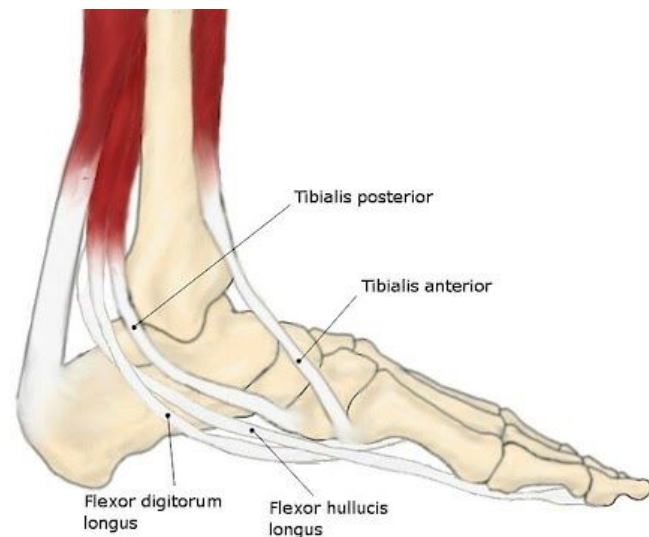
- **Navicular:** This curved bone sits between the talus and cuneiforms. Tight shoes can irritate the navicular bones.
- **Cuneiforms:** These three small bones are closest to the five metatarsal bones. They sit in a row that begins at the inside of the foot, and moves toward the cuboid on the outside of the foot.
- **Cuboid:** This multifaceted bone sits on the outside of the foot near the fifth phalanx (little toe). The cuboid is easy to locate on the outer edge of the foot.
- **Metatarsals** – five bones (labeled one through five, starting with the big toe) that make up the forefoot. Sometimes the metatarsals are called the “rays” of the foot like sun rays that fan out.
- **Phalanges** (singular: phalanx) – the 14 bones that make up the toes. The big toe consists of two phalanges – the distal and proximal. The other toes have three.
- **Sesamoids** – two small, pea-shaped bones that lie beneath the head of the first metatarsal in the ball of the foot.

The cuboid, navicular and medial, intermediate and lateral cuneiforms are all considered **tarsal bones**, the five irregularly shaped bones of the midfoot that form the foot's arch.

Muscles of the feet

Twenty muscles give the foot its shape, support and the ability to move. The main muscles of the foot are:

- **the tibialis posterior**, which supports the foot's arch
- **the tibialis anterior**, which allows the foot to move upward
- **the tibialis peroneal**, which controls movement on the outside of the ankle
- **the extensors**, which help raise the toes, making it possible to take a step
- **the flexors**, which help stabilize the toes. These flexors include **digitum longus, fibularis longus, fibularis tertius, fibularis brevis.**

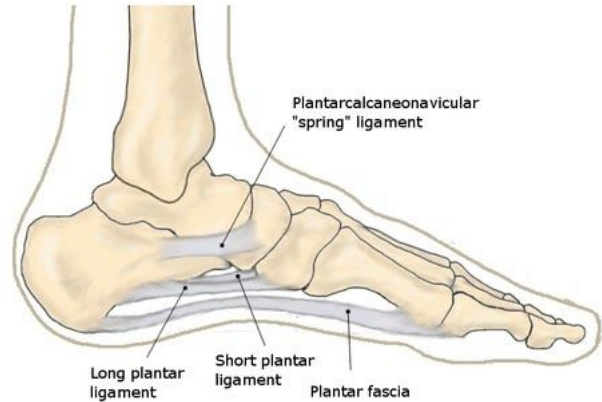


Tendons and Ligaments of the feet

Many tendons attach these muscles to the bones and ligaments that hold the bones together to maintain the foot's arch. The main tendon of the foot is the Achilles tendon, which runs from the

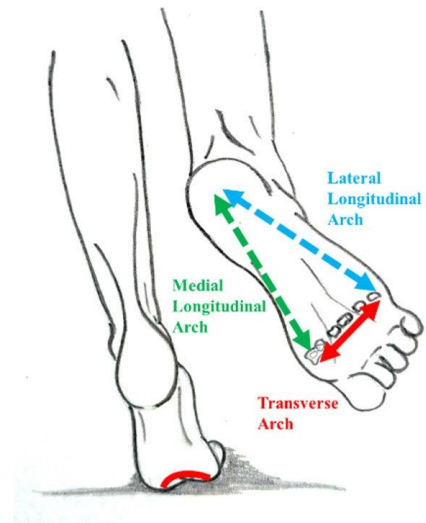
calf muscle to the heel. The Achilles tendon makes it possible to run, jump, climb stairs and stand on your toes. The main ligaments of the foot are:

- **plantar fascia** – the longest ligament of the foot. The ligament, which runs along the sole of the foot, from the heel to the toes, forms the arch. By stretching and contracting, the plantar fascia helps us balance and gives the foot strength for walking.
- **plantar calcaneonavicular ligament** – a ligament of the sole of the foot that connects the calcaneus and navicular and supports the head of the talus.
- **calcaneocuboid ligament** – the ligament that connects the calcaneus and the tarsal bones and helps the plantar fascia support the arch of the foot.



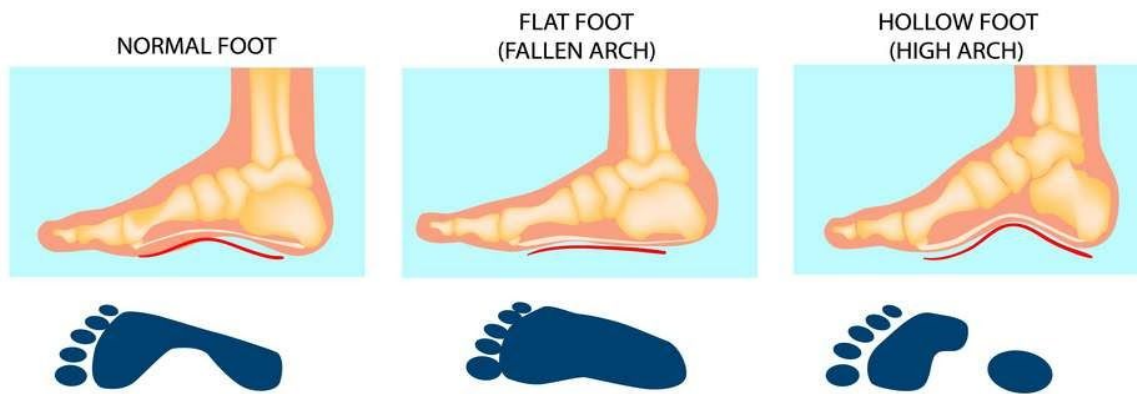
The Arches of the Foot.

The foot has three arches: two longitudinal (**medial and lateral**) arches and one **anterior transverse arch**. They are formed by the tarsal and metatarsal bones, and supported by ligaments and tendons in the foot.

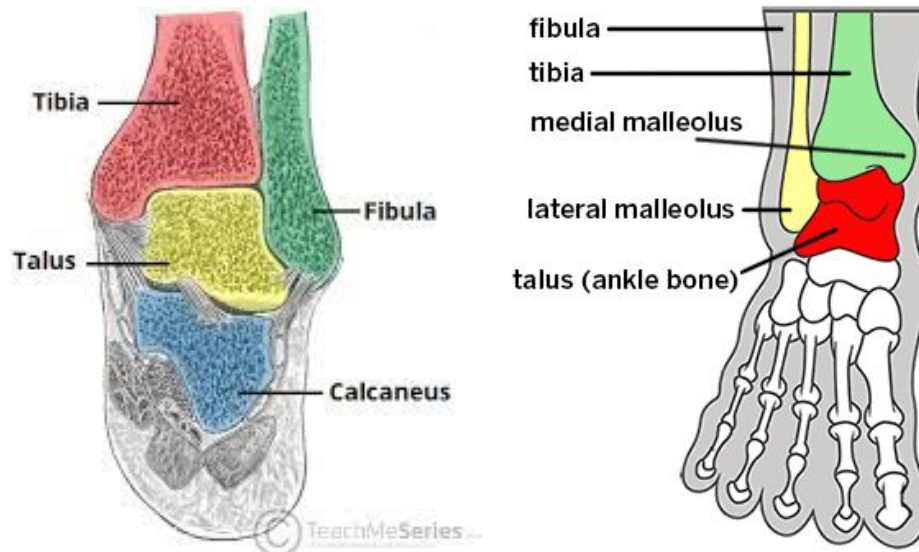


The medial arch is relatively more elastic than the other arches, gaining additional support from the tiabilias posterior and peroneus longus muscles from above. The lateral arch posses a special locking mechanism, allowing much less movement.

Common issues of the foot include leaning forward, leaning back, and a flattening of the arches.



The Ankle

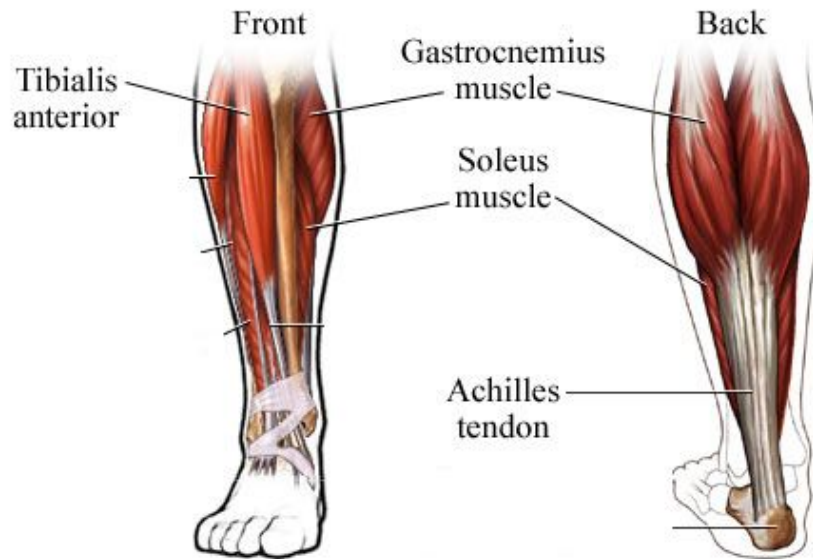


The ankle joint is formed by the bones of the leg (tibia and fibula) and the foot (talus). Functionally, it is a hinge type joint, permitting dorsiflexion and plantarflexion of the foot.

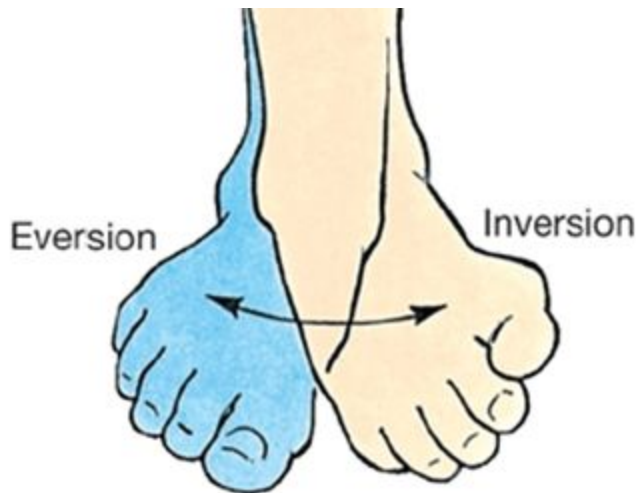
Plantar and Dorsiflexion

In yoga, many of our prone backbends tend to use plantarflexion. Forward folds tend to be dorsiflexion.

There's one muscle on the front of the leg for dorsiflexion, **tibialis anterior**. There are three on the back of the leg for plantar flexion: the **gastrocnemius**, **soleus**, and **plantaris**.



Inversion and Eversion



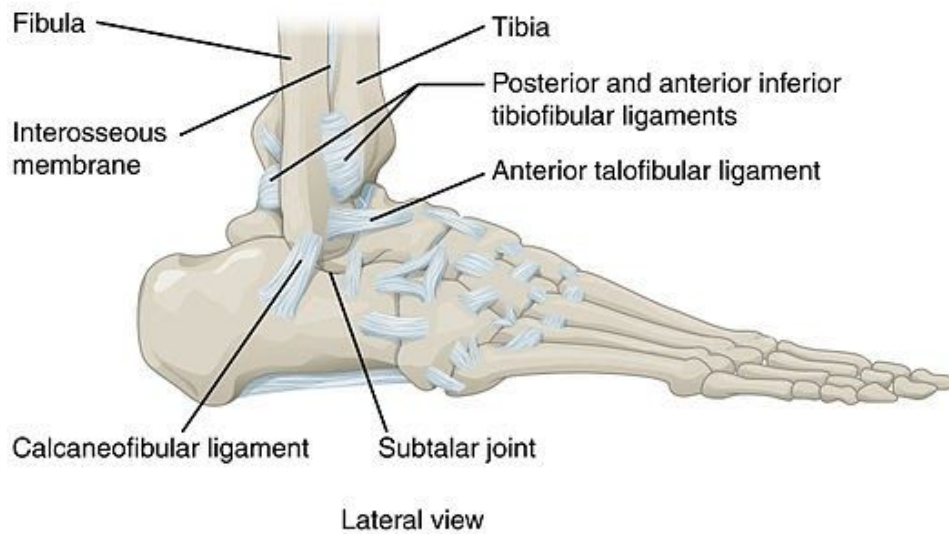
It is very easy to invert the foot. In many poses like tabletop and upward dog we unconsciously do invert the foot. Lotus pose and many marichi variations have deep inversion, as a result some people do sometimes feel pain in ankle.

Ankle Sprains

An ankle sprain refers to partial or complete tears in the ligaments of the ankle joint. It usually occurs via excessive inversion to a plantarflexed and weight-bearing foot. The lateral ligament is more likely to be damaged for two main reasons:

- The lateral ligament is weaker than the medial ligament.
- The lateral ligament resists inversion.

The anterior talofibular ligament is the lateral ligament most at risk of irreversible damage.

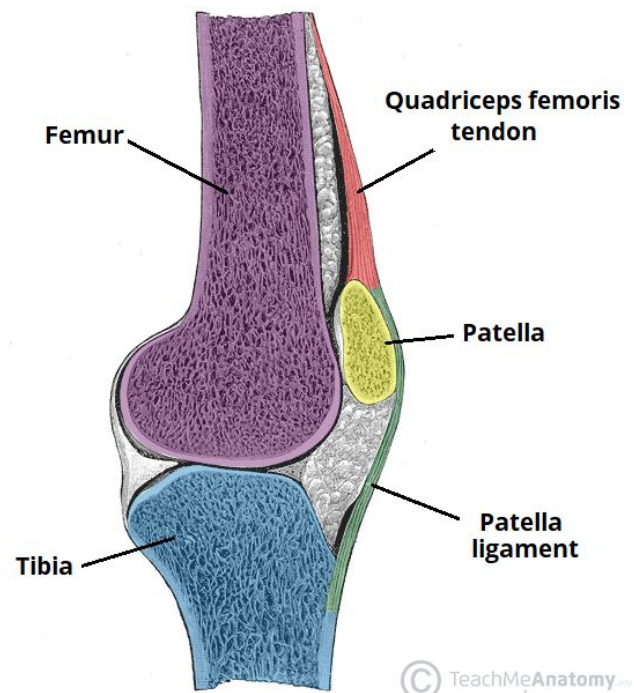


The Knee

The knee represents the incredibly important connection between the bottom and top halves of the legs, and receives considerable force from both sides.

The joint surfaces are lined with hyaline cartilage, and are enclosed within a single joint cavity.

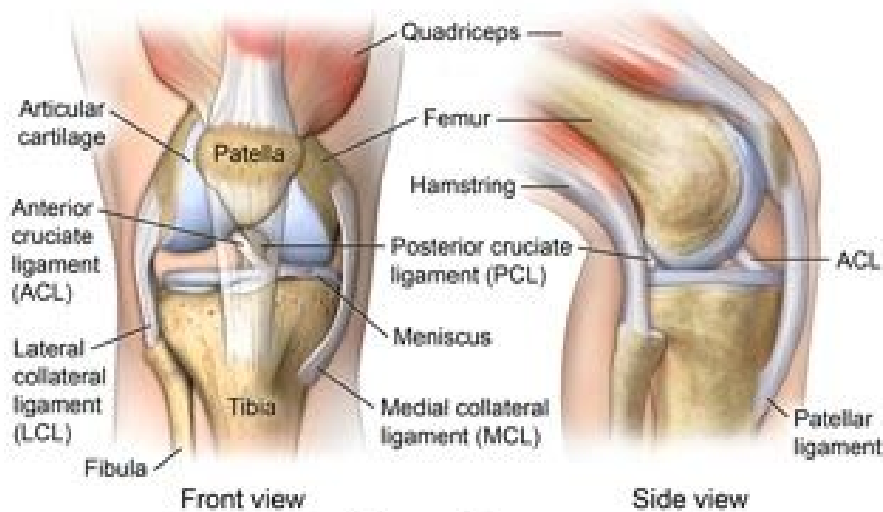
The knee joint is formed by articulations between the patella, femur and tibia. Upon closer examination we can see that it is actually two joints, **tibiofemoral** and **patellofemoral** joints:



- **Tibiofemoral** – medial and lateral condyles of the femur articulate with the tibial condyles. It is the weight-bearing component of the knee joint. It is a **hinge type synovial joint** (also a **bicondylar** joint), which mainly allows for flexion and extension (and a small degree of medial and lateral rotation).
- **Patellofemoral** – anterior aspect of the distal femur articulates with the patella. It allows the tendon of the quadriceps femoris (knee extensor) to be inserted directly over the knee

– increasing the efficiency of the muscle. As the patella is both formed and resides within the quadriceps femoris tendon, it provides a fulcrum to increase the power of the knee extensor, and serves as a stabilising structure that reduces frictional forces placed on femoral condyles.

Ligaments of the Knee



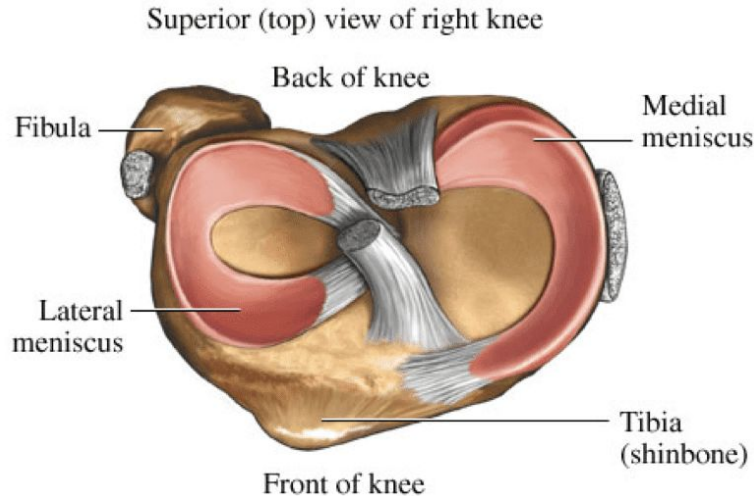
The medial and lateral collateral ligaments (MCL and LCL) run along the sides of the knee and limit sideways motion. The MCL protects the medial side of the knee, while the LCL protects the lateral side from an inside bending force, such as when a yogi places their foot on their knee in tree pose.

Inside the knee joint are two cruciate ligaments: the ACL and PCL. The ACL, connected the tibia to the femur at the center of the knee, limits rotation and forward motion of the tibia away from the femur, and is a crucial source of stability. This is where ankle over knee alignment is so critical. The PCL, limits hyperextension, and not often injured in yoga.

Meniscus Tears

Each of your knees has two menisci — C-shaped pieces of cartilage that act like a cushion between your shinbone and your thighbone. A torn meniscus causes pain, swelling and stiffness. You also might feel a block to knee motion and have trouble extending your knee fully.

A torn meniscus is one of the most common knee injuries. Any activity that causes you to forcefully twist or rotate your knee, especially when putting your full weight on it, can lead to a torn meniscus.



Meniscus tears can occur in all age groups. Traumatic tears are most common in active people from age 10-45. Degenerative tears are most common in people from age 40 upward.

- **Degenerative Meniscal Tears** - Degenerative meniscal tears are thought to occur as part of the aging process when the collagen fibers within the meniscus start to break down and lend less support to the structure of the meniscus. Degenerative tears are usually horizontal in the meniscus producing both an upper and lower segment of meniscus.
- **Traumatic Meniscal Tears** - Most traumatic meniscal tears occur as a result of a twisting injury when the knee rotates but the foot stays fixed in position. The meniscus can also tear from extreme bending of the knee. The combination of bend, rotation, and sudden kick that occurs in some forms of martial arts is associated with lateral meniscal tears.

Tears in the medial meniscus are the most common in yoga, whether originally injured during an asana or exacerbated in an asana such as Lotus pose or others where forced rotation at the hip joint can transfer stress into the knee when the foot is held in place by the floor or another part of the body.

Lesson 9: Putting it All Together: The Anatomy of a Backbend

If you want to go deeper into an expression of a pose, it helps to know what your muscles need to do.

For the muscles that are working--**the agonists**--it will help to get them stronger. For the muscles that are lengthening, **the antagonists**, they will need to become more flexible and relaxed.

Getting deeper into our backbends offers a nice case study for learning about key muscles in the body. If we take a look at the following variation of bow pose,



we can see that the entire back body is contracting to get the body off of the ground, while the front body is lengthening. Anatomically from the bottom up we see:

- **plantarflexion**
- **knee flexion**
- **hip extension**
- **spinal extension**
- **shoulder flexion**
- **elbow flexion.**

To get deeper into this pose and most other backbends, we need to strengthen the agonists for these movements and stretch the antagonists.

Basic Backbend Principles

1. **Strong legs:** rotating the inner thighs inwards and back.
2. **Core Engagement:** support your back by pulling the belly in and up, protecting the lower back.
3. **Shoulders down:** firm the bottom tips of the shoulder-blades in towards each other and (as if your shoulder-blades are hands gently pressing into your upper back).
4. **Long neck:** Keep the neck long and happy and aim for an even arch over the whole spine.
5. **Counterposes:** Always do a counterpose, like child's pose, forward fold, or rabbit, after 1-3 backbends.
6. **Courage and vulnerability:** People do not usually enter into backbends in their day to day activities, so even coming into one can be scary. Backbends also open the heart, and can bring up challenging emotions. This is why courage and vulnerability is key.

Being a Yoga Practitioner vs. Being a Yoga Teacher

As yoga practitioners, we can follow Sri. K. Pattabhi Jois's advice, "Do your practice and all is Coming." It doesn't matter if you have a PhD in philosophy, are an experienced doctor, or brand new to any athletic activity, the practice of yoga challenges us all in the exact places we need to grow the most.

From an anatomical perspective, we call this the "peeling the onion approach." In every yoga posture we move until we become inhibited in some way. Without perhaps knowing exactly which muscle is tight or which muscle is weak, we come back to the pose the next day and the next day until--often suddenly--an opening occurs and we are able to reach a deeper expression of the pose.



However, after peeling away one restriction in one muscle, we simply encounter another. So we then work on peeling the next layer of the onion away. This is a perfectly acceptable approach to practicing yoga.

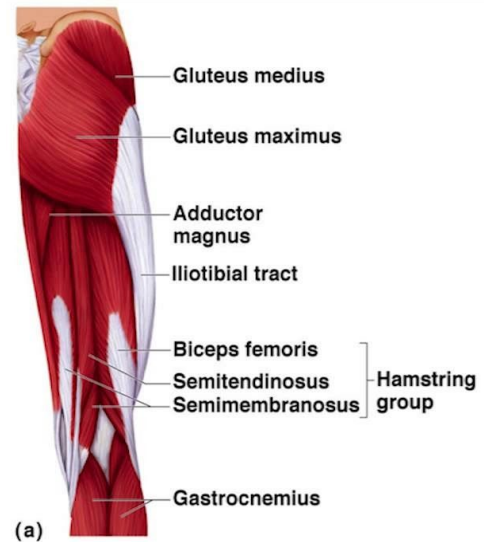
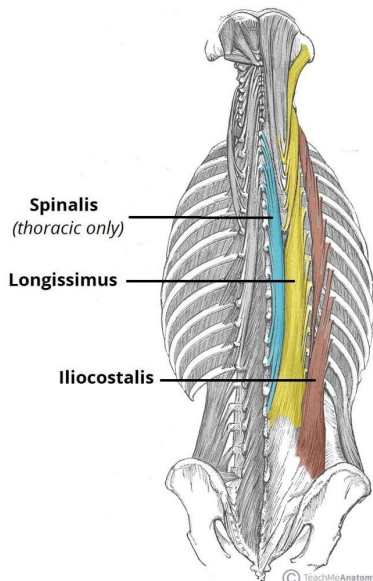
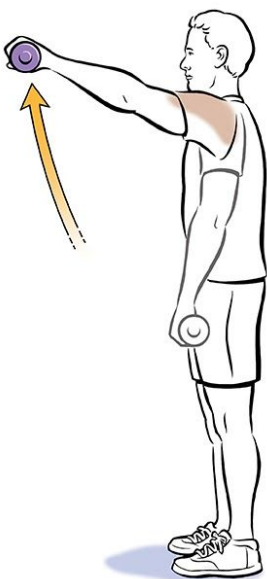
But as yoga teachers, if we want to be of the best help to our students, it will help to be able to identify exactly what their bodies might need, in order to specifically target the correct issues.

In this vein, it will greatly help the yoga teacher to know what muscles are playing what role in a pose.

The next two pages cover the main agonists and antagonists we find in our backbends. As you continue to explore these poses in your own practice and with your students, try to identify how these muscles interact to create the desired anatomical position.

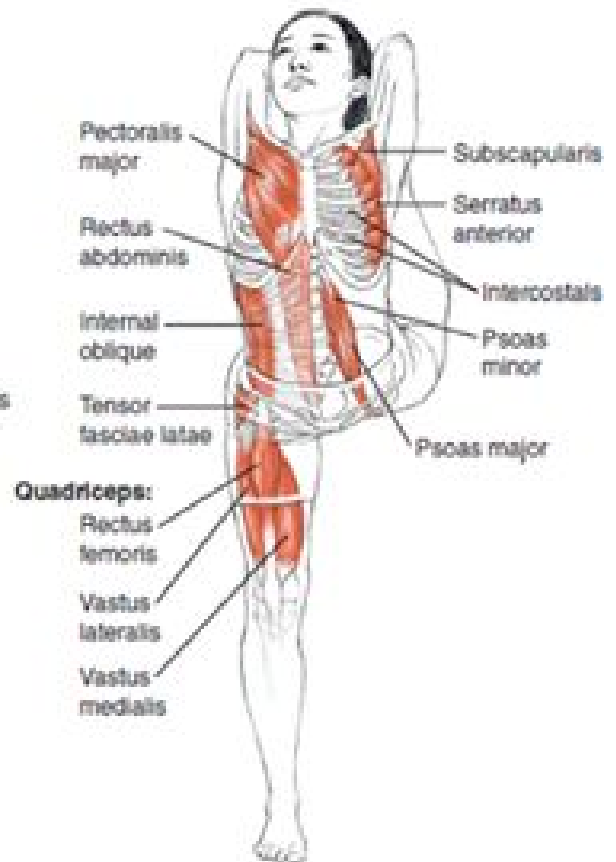
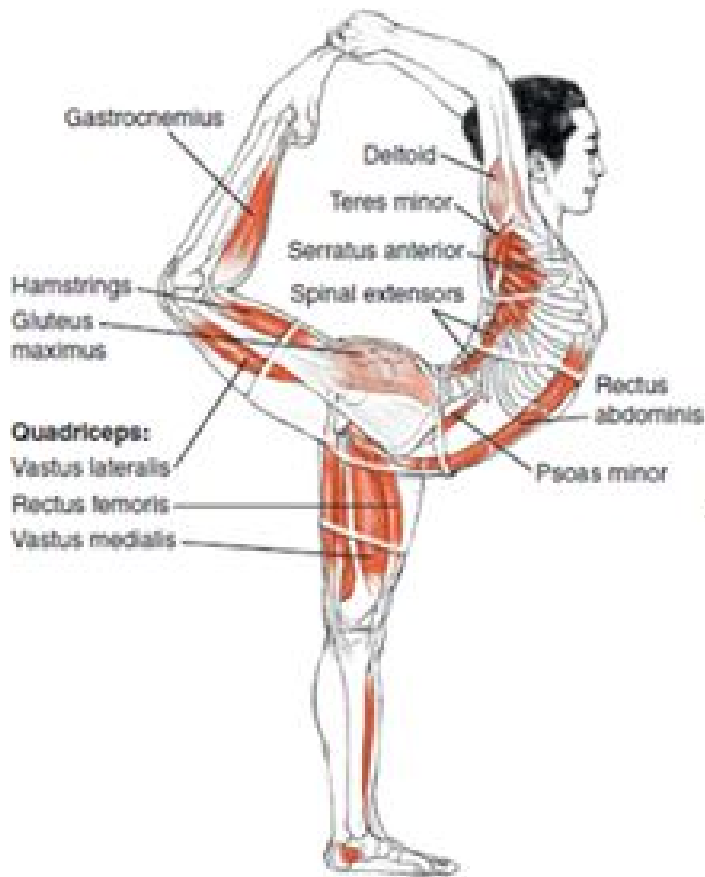
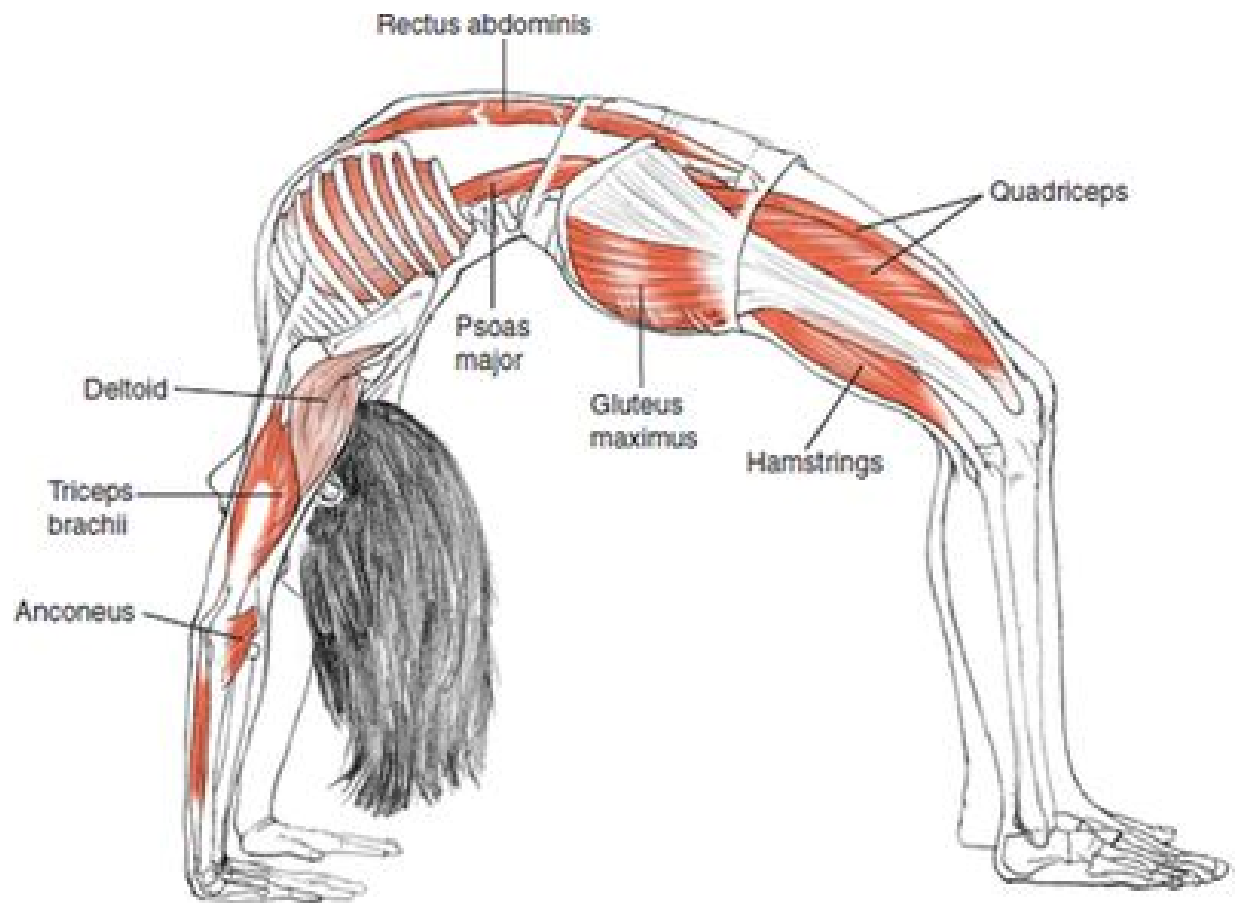
Back body muscles to Strengthen

<u>Movement</u>	<u>Muscle</u>	<u>Origin</u>	<u>Insertion</u>	<u>Yoga poses</u>
Hip extension, Knee flexion	Gluteus Maximus	Ilium, sacrum, coccyx	Gluteal tuberosity of femur	Warrior III Upward Plank Locust (trdtnl)
	Biceps Femoris	Long head: Ischial tuberosity Short head: Posterior mid-shaft of femur	Head of fibula	
	Semimembranosus	Ischial tuberosity	Posterior medial condyle of tibia	
	Semitendinosus	Ischial tuberosity	Medial surface of proximal tibia	
	Adductor Magnus	Inferior ischial ramus	Linea aspera of femur	
Spinal Extension	iliocostalis	iliac crest and sacrum	angles of the ribs	Cobra Peacock Locust (arms up)
	longissimus	transverse process at inferior vertebral levels	transverse process at superior vertebral levels and mastoid process	
	spinalis	spinous processes at inferior vertebral levels	spinous processes at superior vertebral levels and base of the skull	
	Semispinalis capitis	transverse processes of C7-T12	capitis: back of skull between nuchal lines;	
Shoulder Flexion, elbow flexion	Anterior deltoid	lateral one-third of the clavicle, acromion, the lower lip of the crest of the spine of the scapula	deltoid tuberosity of the humerus	Chair pose Downward dog Dolphin Puppy
	Biceps brachii	short head: tip of the coracoid process of the scapula; long head: supraglenoid tubercle of the scapula	tuberosity of the radius	



Front body muscles to stretch

<u>Movement</u>	<u>Muscle</u>	<u>Origin</u>	<u>Insertion</u>	<u>Yoga poses</u>
Hip extension, Knee flexion	Rectus femoris	straight head: anterior inferior iliac spine; reflected head: above the superior rim of the acetabulum	patella and tibial tuberosity (via the patellar ligament)	Hero's pose Lunges Splits
	Vastus lateralis	lateral intermuscular septum, lateral lip of the linea aspera and the gluteal tuberosity	patella and medial patellar retinaculum	
	Vastus medialis	medial intermuscular septum, medial lip of the linea aspera	patella and medial patellar retinaculum	
	Vastus intermedius	anterior and lateral surface of the femur	patella	
	Sartorius	anterior superior iliac spine	medial surface of the tibia (pes anserinus)	
Spinal Extension	Rectus abdominis	pubis and the pubic symphysis	xiphoid process of the sternum and costal cartilages 5-7	Cobra Cow Upward dog Fish Side-bend
	Intercostals	upper borders of a rib	fibers course up and medially to insert on the inferior margin of the rib above	
	Serratus anterior	ribs 1-8 or 9	medial border of the scapula on its costal (deep) surface	
Shoulder Flexion, elbow flexion	Latissimus dorsi	vertebral spines from T7 to the sacrum, posterior third of the iliac crest, lower 3 or 4 ribs, sometimes from the inferior angle of the scapula	floor of the intertubercular groove	Puppy pose Wall down dog Cow-face arms
	Pectoralis major	medial 1/2 of the clavicle, manubrium & body of sternum, costal cartilages of ribs 2-6, sometimes from the rectus sheath of the upper abdominal wall	crest of the greater tubercle of the humerus	
	Pectoralis minor	ribs 3-5	coracoid process of the scapula	
	Subscapularis	medial two-thirds of the costal surface of the scapula (subscapular fossa)	lesser tubercle of the humerus	
	Triceps brachii	long head: infraglenoid tubercle of the scapula; lateral head: posterolateral humerus & lateral intermuscular septum; medial head: posteromedial surface of the inferior 1/2 of the humerus	olecranon process of the ulna	



Lesson 10: Flexibility and Stretching Principles

Before we close out our final lesson, let us consider a few more intermediate stretching principles to consider in your yoga practice and teaching. This lesson will cover different types of flexibility and stretching.

What is flexibility?

Flexibility is defined as: *the absolute range of movement in a joint or series of joints that is attainable in a momentary effort with the help of a partner or a piece of equipment.* This definition tells us that flexibility is not something general but is specific to a particular joint or set of joints.

It is a myth that some people are innately flexible throughout their entire body. Being flexible in one particular area or joint does not necessarily imply being flexible in another. Being "loose" in the upper body does not mean you will have a "loose" lower body.

Furthermore, flexibility in a joint is also specific to the action performed at the joint. The ability to do front splits doesn't imply the ability to do side splits even though both actions occur at the hip.

Types of Flexibility

Many people are unaware of the fact that there are different types of flexibility. These different types of flexibility are grouped according to the various types of activities involved in athletic training. The ones which involve motion are called dynamic and the ones which do not are called static. The different types of flexibility are:

Dynamic flexibility (also called *kinetic flexibility*) is the ability to perform dynamic (or kinetic) movements of the muscles to bring a limb through its full range of motion in the joints.

Static-active flexibility (also called *active flexibility*) is the ability to assume and maintain extended positions using only the tension of the agonists and synergists while the antagonists are being stretched. For example, lifting the leg and keeping it high without any external support (other than from your own leg muscles).

Static-passive flexibility (also called *passive flexibility*) is the ability to assume extended positions and then maintain them using only your weight, the support of your limbs, or some other apparatus (such as a chair or a barre). Being able to perform the splits is an example of

static-passive flexibility.

Active flexibility is harder to develop than passive flexibility (which is what most people think of as "flexibility"); not only does active flexibility require passive flexibility in order to assume an initial extended position, it also requires muscle strength to be able to hold and maintain that position.

Factors affecting flexibility

Internal influences

- the type of joint (some joints simply aren't meant to be flexible)
- the internal resistance within a joint
- bony structures which limit movement
- the elasticity of muscle tissue (muscle tissue that is scarred due to a previous injury is not very elastic)
- the elasticity of tendons and ligaments (ligaments do not stretch much and tendons should not stretch at all)
- the elasticity of skin (skin actually has some degree of elasticity, but not much)
- the ability of a muscle to relax and contract to achieve the greatest range of movement
- the temperature of the joint and associated tissues (joints and muscles offer better flexibility at body temperatures that are 1 to 2 degrees higher than normal)

External influences

- the temperature of the place where one is training (a warmer temperature is more conducive to increased flexibility)
- the time of day (most people are more flexible in the afternoon than in the morning, being the most flexible around 2:30pm-4pm)
- the stage in the recovery process of a joint (or muscle) after injury (injured joints and muscles will usually offer a lesser degree of flexibility than healthy ones)
- age (pre-adolescents are generally more flexible than adults)
- gender (females are generally more flexible than males)
- one's ability to perform a particular exercise (practice makes perfect)
- one's commitment to achieving flexibility
- the restrictions of any clothing or equipment
- Some sources also suggest that water is an important dietary element with regard to flexibility. Increased water intake is believed to contribute to increased mobility, as well as increased total body relaxation.

Types of Stretching

Just as there are different types of flexibility, there are also different types of stretching. Stretches are either dynamic (meaning they involve motion) or static (meaning they involve no motion). Dynamic stretches affect dynamic flexibility and static stretches affect static flexibility.

The different types of stretching are:

1. Ballistic stretching
2. Dynamic stretching
3. Static, passive, or relaxed stretching
4. Active stretching
5. PNF stretching

Ballistic stretching uses the momentum of a moving body or a limb in an attempt to force it beyond its normal range of motion. This is stretching, or "warming up", by bouncing into (or out of) a stretched position, using the stretched muscles as a spring which pulls you out of the stretched position. This type of stretching is not considered useful and can lead to injury.

Dynamic stretching consists of controlled leg and arm swings that take you gently to the limits of your range of motion. An example of dynamic stretching would be slow, controlled leg swings, arm swings, or torso twists. While dynamic stretching is useful for many athletes, it is not traditionally part of a yoga practice (although some teachers do argue that Sun Salutations—or any yoga movement that moves in and out of poses with the breath—is a kind of dynamic stretching).

As practitioners interested in gaining flexibility, we are primarily concerned with static stretching, active stretching, isometric stretching, and PNF stretching. Let's go through each of these one by one.

Static Stretching

In a static-passive stretch, the body is placed with mindful alignment into a position where a load, usually the weight of the body under the force of gravity, pulls on a targeted muscle and is held a minimum of twenty seconds.

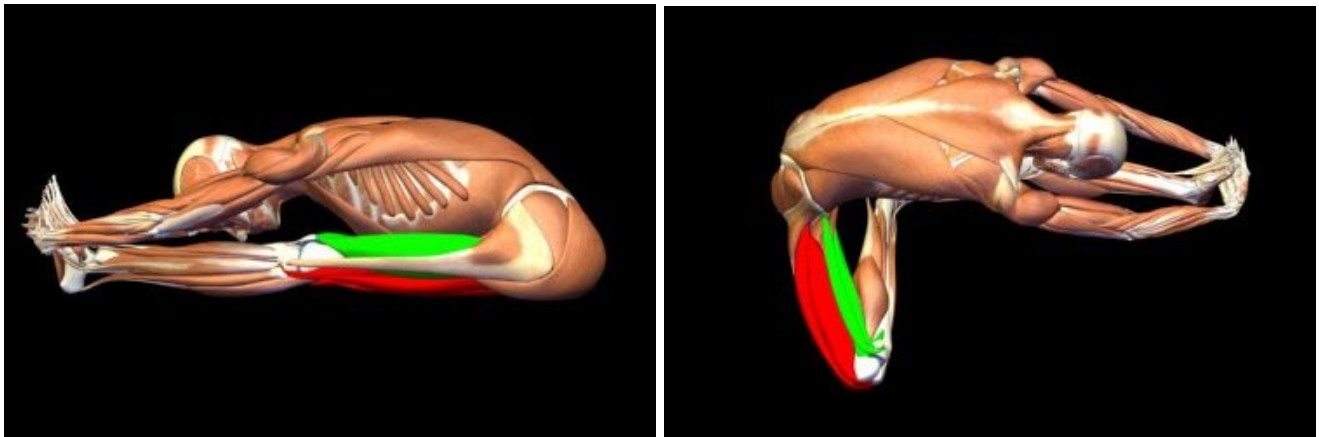
No deliberate contraction is initiated. This is the most simplistic form of stretching while still being safe and effective. Seated forward folds are one example of this form of stretching. The stretch is created as the weight and load of the torso folding over the legs exerts a pull on the targeted muscles along the back of the body in the stretch.

Active Stretching: Using Reciprocal Inhibition, A Physiological Yin/Yang

An active stretch is one where you assume a position and then hold it there with no assistance other than using the strength of your agonist muscles. Active stretching increases active flexibility and strengthens the agonistic muscles. Active stretches are usually quite difficult to hold and maintain for more than 10 seconds and rarely need to be held any longer than 15 seconds.

For example, bringing your leg up high and then holding it there without anything (other than your leg muscles themselves) to keep the leg in that extended position. The tension of the agonists in an active stretch helps to relax the muscles being stretched (the antagonists) by reciprocal inhibition.

We already learned that every movement of the body involves a prime mover/agonist and a muscle that goes against this movement, known as the antagonist.

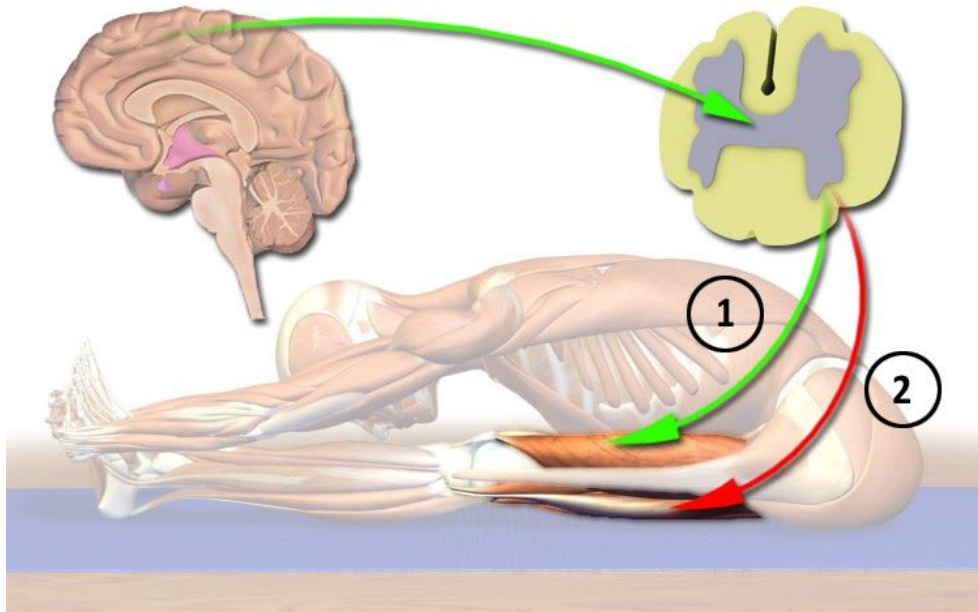


For *janu sirsasana*, in the straight leg, the quadriceps are the agonists and the hamstrings are the antagonists. In the flexed leg, the hamstrings are the agonists and the quadriceps are the antagonists.

It makes sense that there would be a corresponding physiological Yin/Yang to make biomechanical processes such as flexion and extension of the knee energy efficient, i.e., when the agonist muscle contracts, its antagonist relaxes. This process occurs unconsciously through a primitive spinal cord reflex arc called **reciprocal inhibition**.

Stretching applies tension to the muscle and its tendon. There is a nerve receptor (the Golgi tendon organ) that is located at the muscle-tendon junction. This receptor senses tension and relays a signal to the spinal cord. The spinal cord then signals the stretching muscle to relax.

This reflex arc acts as a protective circuit breaker to prevent the tendon from tearing at its attachment to the bone.



We can consciously access this reflex arc to deepen and improve our poses.

In *paschimottanasana*, the quadriceps muscle is the agonist and the hamstring muscles are the antagonists. Consciously engaging the quadriceps also signals the hamstrings to relax. This takes place via the spinal cord. The nerve impulse that results in contraction of the quadriceps is called excitatory and the impulse to the hamstrings is called inhibitory. Try this technique to get a bit deeper in this pose and then apply it to different agonist / antagonist muscle groups.

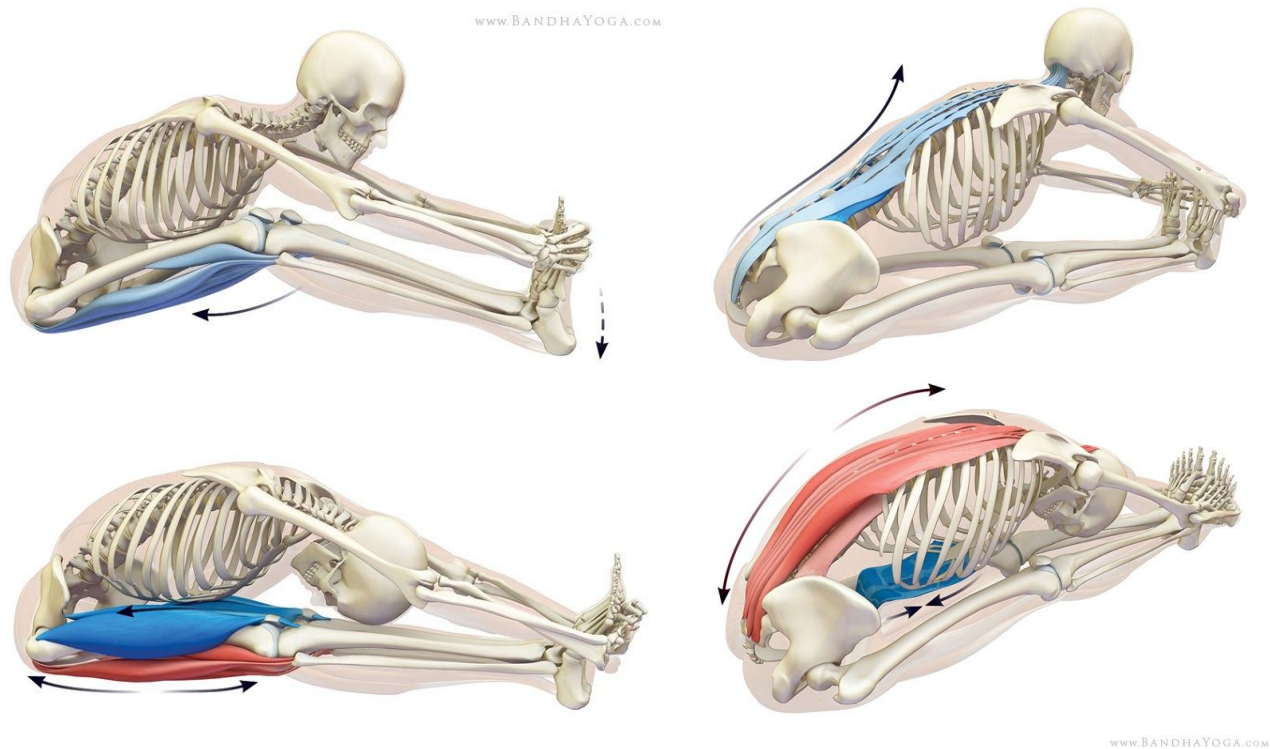
Now, we can consider what it takes to get the body into a cross legged, *sukhasana* pose. For cross legged seated position, we have external rotation and flexion of the hips, along with knee flexion and if we are working to stay upright, a bit of spinal extension.

1. _____
2. _____
3. _____
4. _____
5. _____

Proprioceptive neuromuscular facilitation (PNF)

We can also use a technique called facilitated stretching or proprioceptive neuromuscular facilitation (PNF) to lengthen muscles in yoga, using similar principles of reciprocal inhibition. PNF utilizes a spinal cord reflex arc and is an example of combining modern Western science with the ancient art of Yoga.

In general, in a PNF stretch there is generally a contraction of the targeted muscle right before the stretch. It is often referred to as the ‘contract/relax’ method.



Facilitated stretching involves contracting a muscle that you are lengthening. This increases the tension at the muscle-tendon junction and recruits more Golgi tendon organs than does stretching a muscle alone.

Facilitated stretching causes the spinal cord to signal the muscle to relax, in essence, creating "slack" in the muscle. You can then take up the slack to move deeper into the pose. For example, in Paschimottasana, slightly bend the knees and squeeze the trunk against the thighs. Then gently press the heels into the mat as if you are trying to flex the knees further. This engages the hamstrings and stimulates the Golgi tendon organs at the muscle-tendon junction. Hold this steady contraction for five to eight breaths before releasing it. This produces relaxation and increased length in the hamstrings. Then contract the quadriceps to straighten the knees and take up the slack created by the reflex arc. This has the added effect of producing reciprocal inhibition, which further relaxes the hamstrings into the stretch.

Follow the same steps in this pose with the quadratus lumborum and erector spinae. First, bend forward to stretch these back muscles. Hold the stretch by bending the arms, and then attempt to arch the back. This increases tension at the muscle-tendon junction of the erector spinae and quadratus lumborum, stimulates the Golgi tendon organs, and ultimately relaxes these muscles. Hold the arch of the back for five to eight smooth breaths. Then engage the abdominals and use the arms to draw yourself deeper into the pose, taking advantage of the new length created by the reflex arc. Activating the abdominals also produces reciprocal inhibition of the back muscles, relaxing them into the stretch.

Go slowly with facilitated stretching. Allow about 48 hours of recovery time before re-applying PNF to any given muscle group. It is not necessary to use strong muscular contractions to experience the benefits of these techniques. Start with gentle force and learn to moderate the contraction, "dialing" it in. Use similar care as you gradually release the action of the muscles. Remember that improvement comes from a balance between the conscious work on the poses and the unconscious work that takes place between practice sessions. The unconscious mind forms new and more efficient brain circuitry during this "in-between" time.

Now, try PNF stretches for the:

1. Quadriceps
2. Hamstrings
3. Adductors
4. Abductors

Appendices

Pose breakdown

Yoga Pose (English):		Sanskrit name:	
<u>Joint</u> <i>(Ankle, knee, elbow, etc)</i>	<u>Joint motion</u> <i>(flexion, extension, abduction, etc.)</i>	<u>Agonists/Antagonists pairs</u> <i>(biceps/triceps, hamstring/quadriceps, etc)</i>	<u>Type of contraction</u> <i>(concentric, isometric, eccentric)</i>
Notes:			