

# BACK AND LIMBS - OUTLINES

## INTRODUCTION TO ANATOMICAL TERMS

### I. ANATOMIC POSITION

- a. All terms are in reference to this position
- b. Standing/lying supine with palms and feet forward

### II. ANATOMIC PLANES

- a. Median (Midsagittal) – divides into left and right halves
- b. Saggital – parallel to the median (infinite number)
- c. Frontal (coronal) – divides into front and back halves
- d. Transverse (horizontal) – divides into top, bottom (infinite number)
  - \* Radiology slides: able to see fracture, screws accurately from saggital cross-section but not frontal

### III. TERMS OF RELATIONSHIP

- a. Superior (rostral, cephalic) /Inferior (caudal)
- b. Anterior/Posterior
- c. Medial/Lateral
- d. Proximal/Distal
- e. Extrinsic/Intrinsic
- f. Valgus/Varus – bone distal to the joint deviates away from /towards the midline
  - \* 1) pick joint 2)look at bone distal to joint 3) look at long axis: towards or away?
- g. Superficial/Deep
- h. Bilateral/Unilateral
- i. Ipsilateral/Contralateral – same/opposite side as
  - \* Weak hip on one side → leg contralateral will sag...
- j. Palmar/Dorsal (hands); Plantar/Dorsal (feet)

### IV. TERMS OF MOVEMENT

- a. Flexion/Extension – occurs in saggital plane (bending/straightening)
  - \* Description of action includes name of body segment/joint/bone (not only motion, but where motion takes place)
  - \* Ex: “deltoid produces flexion of the arm/shoulder/humerus”
- b. Abduction/Adduction – occurs in frontal (coronal) plane (away from/towards body)
- c. Medial (internal)/Lateral (external) rotation – movement of ventral surface towards/away from median
- d. Elevation/Depression
- e. Protraction/Retraction – movement anteriorly/towards median
- f. Joint-Specific:
  - \* Protrusion/retrusion – movement of jaw(TMJ) forward/back
  - \* Supination/pronation – palms up/down
  - \* Opposition/reposition – thumb touches digits
  - \* Dorsiflexion/plantar flexion – foot toward dorsal/plantar position
  - \* Inversion/eversion – plantar side of foot faces median/away

## V. OTHER MUSCULOSKELETAL TERMS

- a. Ligaments – band or sheets of fibrous connective tissue that connects 2 or more bones or structures
- b. Tendons – connect muscle to bone
- c. Fascia – sheet of fibrous connective tissue that envelop muscles and separates different layers or groups of structures
- d. Two sites of muscle attachment:
  - \* Origin: proximal attachment
  - \* Insertion: distal attachment

Don't have to know which site is which – only have to know that there are two points of attachment
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## OVERVIEW OF THE SKELETAL SYSTEM

### I. CLASSIFICATION OF BONES

- a. Overview
  - i. Comprised of 206 bones – classified by location, shape, or structure
  - ii. Articulation – point where 2 or more bones come together (movement)
- b. Location
  - i. Axial – bones of head, back, chest
  - ii. Appendicular – upper and lower extremities, pelvic girdle (not axial because function has to do with lower extremities)
  - iii. Sesamoid – bone embedded within tendon, typically where tendon passes over joint → increases mechanical efficiency of tendon (change angle – more power)
- c. Shape
  - i. Long/short, flat, irregular (vertebra)
  - ii. Important for embryology – develop differently
- d. Structure
  - i. Spongy (trabecular) – not completely random – organized based on load, stress
  - ii. Compact
- e. Osteology (self study)
  - i. bone markings, formations → reveals function of structures around it
  - ii. landmarks can be related to passage of nerves or vessels, muscle attachment

### II. CLASSIFICATION OF JOINTS

- a. Overview
  - i. Joints structured in specific way → allows specific type of motion
  - ii. Classified according to what is between them:
    - 1. Fibrous – fibrous tissue between
    - 2. Cartilaginous or fibrocartilaginous
    - 3. Synovial – synovial fluid
- b. Fibrous Joints

Least mobile
↑
↓
Most mobile

- i. Suture – interlocking (ex: skull)
  - ii. Syndesmosis – sheet of connective tissue between bones (ex: radius and ulna)
  - iii. Gomphosis – peglike articulation – only teeth
- c. Cartilaginous Joints
  - i. Synchondrosis (primary CJ) – 2 distinct regions of bone joined by growth plate (complete ossified in mature skeleton → no synchondrosis)
  - ii. Symphysis (secondary) – fibrocartilaginous disc remains between bones (ex: two pelvic bones)
- d. Synovial Joints
  - i. Structure:
    1. **capsule** surrounding two bones, enclosing joint cavity
    2. Cavity lined with **synovial membrane** – produces fluid, lubricates joint
    3. Articulating ends of bones are covered in **hyaline cartilage**
    4. Potential for increase in friction between joints and surrounded structures → **bursa** = connective tissue sac associated with joints which facilitate movement by reducing friction (“thin cushion”) → glides
  - ii. Types: based on how many axes of movement (# planes), shape of articulating surface
    1. Plane – 2 flat surfaces, bones glide against each other
    2. Uniaxial – movement around single axis (within single plane)
      - a. Hinge (knee)
      - b. Pivot (elbow)
    3. Biaxial – two axes (fingers – move in sagittal and frontal planes)
      - a. Condylloid (fingers)
      - b. Saddle (base of thumb)
    4. Triaxial – three plans
      - a. Ball and socket (shoulder – flex/ext, AB/AD, rotation)

### III. INNERVATION AND BLOOD SUPPLY TO JOINTS

- a. **Periarticular arterial anastomosis** around each joint – vessels approach joint from all directions (so if finger bent, doesn’t cut off blood supply)
- b. **Mechanoreceptors** – for proprioception – send information about position of joint back to CNS → when to stop extending
- c. **Hilton’s Law** – nerve supply to a joint is by the same nerves that innervate muscles

### IV. CLINICAL CORRELATE: ARTHRITIS

- a. Rheumatoid Arthritis
  - i. Autoimmune disease – inflammatory (body attacks joints)
  - ii. → clinical presentation is bilateral – affects both extremities equally
- b. Osteoarthritis
  - i. Mechanical breakdown – caused by overuse, imbalance related to activity
  - ii. → may be unilateral

\*correctly describing movements that occur allows us to measure and analyze movement and related pathology.

## BACK, VERTEBRAL COLUMN & SPINAL CORD

### I. VERTEBRAL COLUMN

#### a. Components

##### i. Vertebra

1. 26 total: 7 cervical, 12 thoracic, 5 lumbar, 1 sacrum (5 at birth fuse), 1 coccyx (4 at birth)

##### ii. Associated Discs

##### iii. Associated ligaments

#### b. Curvatures

##### i. Normal (Netter 153)

1. Primary – all regions have forward flexion
  - a. Thoracic
  - b. sacral
2. Secondary – some forward curvatures reverse through development:
  - a. Cervical – crawling → holding head up
  - b. Lumbar – walking (end of 1y) → have to shift weight

##### ii. Abnormal

1. **Kyphosis** – excessive forward flexion of thoracic spine (sagittal plane)
2. **Lordosis** – excessive lumbar curvature – can occur temporarily during pregnancy; called Lordosis if chronic (sagittal plane)
3. **Scoliosis** – abnormal lateral curvature (frontal plane)

#### c. Joints of the vertebral column

##### i. Movements:

1. Flexion/extension
2. Lateral flexion – can't really use ad-, abduction, because both are away from spine (spine is in middle)
3. Rotation

##### ii. Joints

#### 1. Zygapophyseal (facet)

- a. posterior,
- b. between interlocking articular processes of stacked vertebra
- c. synovial plane joints → fair amount of motion
- d. interlocking → prevents fw and bk shifting
- e. are not weight-bearing – meant to glide

#### 2. Intervertebral (symphysis)

- a. anterior, between big wide vertebral bodies



- b. thick, fibral, cartilaginous discs – meant to transmit weight and force (a little motion but not primary function)
    - c. structure:
      - i. nucleous pulposis (inner) - gelatinous
      - ii. annulus fibrosis – concentric rings of conn tissue
  - 3. Ligaments – support joints, guard excess movement
    - a. **Anterior and posterior longitudinal ligaments** – prevent extension too far forward/back
    - b. **Interspinous and supraspinous ligaments** - between spine of vertebra/ on external surface of vertebra
    - c. **Ligamentum flavum** – lining vertebral canal – protects the spinal cord within spinal canal
  - iii. Clinical correlation: herniated disc
    - 1. Usually between two lumbar vertebra (L4-L5) or L5-S10
    - 2. Due to uneven force on intervertebral disc (disc degeneration, weight, posture, improper lifting)
    - 3. Different degrees of damage: disc degeneration, prolapse, extrusion
    - 4. Laminectomy:
      - a. remove portion of lamina to access damaged disc, pull out
      - b. Heals with connective tissue, but may need bone graft
- \*Keep alignment on spine when lifting so intervert discs bear weight

## II. SPINAL CORD AND MENINGES

- a. Spinal Cord
  - i. Stacked vertebral → central canal, contains SC
  - ii. 31 segments: 8 cerv, 12 thor, 5 lumb, 5 sacr, 1 coccygeal
  - iii. No uniform diameter – enlarged in cervical and lumbar regions – necessary to innervate upper and lower extremities
  - iv. Terminal end = **conus medullaris**, ends at L1,-L2 (before vertebral column ends)
- b. Meninges – 3 layers of connective tissue that protect
  - i. **Dura mater** (outer)
    - 1. Forms spinal dural sac – tubular sheath within vert canal
  - ii. **Arachnoid mater**
    - 1. **Subarachnoid space** (below arachnoid) – has cerebrospinal fluid – helps bathe and nourish, give buoyancy to spinal cord
  - iii. **Pia mater** (innermost)
    - 1. Lateral projections = **denticulate ligaments** – help stabilize spinal cord laterally
    - 2. **Filum terminale** – extension of pia mater within dural sac; dural sac closes off and is joined by layer of dura →
    - 3. **Filum terminale externa** – part that attaches to coccyx, stabilizes spinal cord vertically \***cauda equina**

### III. SEGMENTAL NERVES AND VESSELS

#### a. Vessels

##### i. Arteries

1. vertebral arteries unite → 1 anterior spinal artery nourish anterior 2/3 (both sides)
2. 2 posterior arteries (smaller) – only supply posterior 1/3
3. Reinforced by radicular (radiating) arteries
  - a. **Great radicular artery** – v big one

##### ii. Veins

1. Complex, so referred to as 4 vertebral plexuses: anterior external, ant int, post, ext, post int
2. Communicate with venous sinuses in cranial cavity (base of skull)

#### b. Nerves

##### i. 31 pairs: 8 cerv, 12 thor, 5 lumb, 5 sac, 1 coccygeal

##### ii. Formation:

1. posterior roots coming off spinal cord → sensory; anterior roots → motor → form mixed spinal nerve (both sensory and motor)
2. each spinal nerve → **rami**:
  - a. dorsal ramus – muscles and skin of back
  - b. ventral ramus – thoracic wall, extremities

##### iii. **intervertebral foramen**: spinal nerves exit laterally via these holes; foramen formed by vertebral arch and zygapophyseal joint

##### iv. only 7 cervical vertebra, but 8 spinal nerves → nerve C7 comes out foramen above C7, and C8 comes out below (btw C7 and T1)

##### v. spinal cord ends at lumbar region → last nerves have to go all the way down column before exiting → **cauda equina** (horse's tail) – bundle of spinal nerve roots below L1; part of PNS

1. Clinical application: spinal taps – want to puncture here instead of spinal cord, so if you inject too far not as much damage
2. Spina bifida – deformity in which there is failure of fusion of vertebra → SC protrudes into space
  - a. Asymptomatic (spina bifida occulta)
  - b. SB Cystica – fluid-filled cyst protrudes
  - c. Meningocele – only meninges protrude
  - d. Myelomeningocele – spinal cord and cauda equine protrude
  - e. Level of lesion → level of impairment

#### c. Myotomes and Dermatomes

- i. Myotome – all the muscles that are innervated by a single spinal cord segment (“the myotome of that level”)
- ii. Dermatome – area of skin innervated – not motor, but sensory

- iii. Used clinically to determine area of injury – “can you feel this?” keep going until sensation cut off; test which muscle functions are impaired (ie flexion but no extension)

#### IV. **MUSCLES**

- a. Superficial Layer – **trapezius, latissimus dorsi, levator scapulae, rhomboid major, minor**
- a. Intermediate Layer – **serratus posterior inferior and superior**
- b. Deeper Layers – **erector spinae, splenius capitus & cervicis, semispinalis capitis**

## **INTRO TO THE NERVOUS SYSTEM**

### I. **THE NEURON**

- a. General structures
  - i. Nervous system – composed of cells with long processes
  - ii. Nerve fibers = bundles of cells
  - iii. Branch points = cells leaving bundle (if you sever the nerves after branching, you avoid severing entire bundle)
- b. Structure of neuron
  - i. **Soma** (cell body) – contains nucleus, other cell components
  - ii. **Axon** – nearly uniform diameter
    - 1. **Axon hillock** – sums up all inputs, generates and action potential
  - iii. **Terminal arborization (terminal branches)** – end of axon
  - iv. **Dendrites/dendritic process** – branched extensions of cell body
- c. Shapes
  - i. **Multipolar**
  - ii. **Bipolar** – axon and dendrites arise from single, common dendritic process
  - iii. **(pseudo)unipolar** – single **neuronal process** divides into two axonal processes (no dendrites)
- d. Signalling
  - i. Presynaptic neuron
    - 1. Axon hillock – summarizes inputs (stimulatory and inhibitory)
    - 2. Action potential – wave of depolarization spreads along axon
    - 3. Neurotransmitters – released at points of synapse with other neurons
  - ii. Postsynaptic neuron
    - 1. Receptor molecules – in membrane of post. neuron – produce local change in transmembrane electric potential
      - \* Beta blockers: block huge class of receptors
    - 2. Electric potential different can be increased or decreased:
      - hyperpolarization = inhibition; hypo = stimulation

### II. **ORGANIZATION OF THE NERVOUS SYSTEM**

- a. Anatomical subdivisions
  - i. Central nervous system (CNS) – brain and spinal cord
  - ii. Peripheral Nervous System (PNS) – everything else
    - 1. Group of peripheral nerve cell bodies = **ganglia**
    - 2. Any neuron whose soma is in PNS = ganglion cell
  - iii. Many neurons lie in both (delineation is arbitrary)
- b. Organization of spinal cord
  - i. 31 pairs
  - ii. Body segments – correspond to spinal nerve
  - iii. Extremities: **plexus** of fibers from several segments
    - 1. Brachial plexus (C5-T1)
    - 2. Lumbosacral plexus (L2-S3)

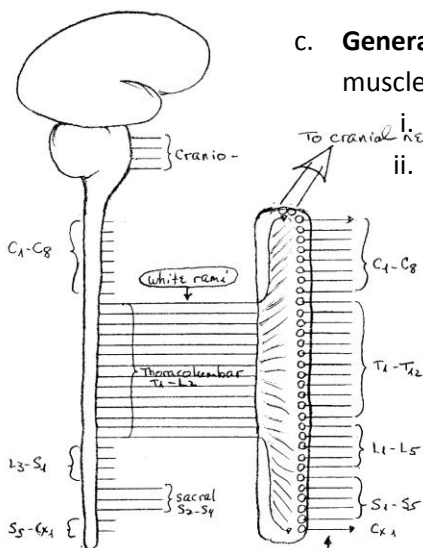
### III. FUNCTIONAL SUBDIVISIONS

- a. Afferent/Efferent
  - i. Afferent (sensory)
    - 1. Peripheral sensory ending and CNS connected by unipolar neuron → no synapse
    - 2. Pass through spinal cord through dorsal root
  - ii. Efferent (motor)
    - 1. Interval between CNS and peripheral target (effector organ) bridged by 1-2 neurons → synapse
    - 2. Pass out of spinal cord in ventral root
- b. Somatic/Visceral – division based on types of tissues, structures being innervated
  - i. Somatic - what we are aware of and can control (voluntary)
    - 1. sensory return from endings in skin, deeper musc. tissue
    - 2. motor outflow to voluntary, striated muscles
    - 3. direct, single-neuron pathway
  - ii. Visceral (autonomic)
    - 1. Sensory return from walls and lining of organs (viscera) - includes heart, very large blood vessels
    - 2. Motor outflow to cardiac muscle, smooth muscle and glands
    - 3. Indirect enervation: 2-neuron pathway: nerve cell body in CNS → motor ganglion cell in PNS
      - a) **Sympathetic system** – axons enter/leave thoracic and lumbar regions of SC (T1-L2)
      - b) **Parasympathetic system** – axons enter/leave brain stem, via cranial nerves, or sacral regions of SC (S2-4)
      - c) Usually work together to control complex visceral functions

### IV. NEURAL MODALITIES (GENERAL)

4 types of traffic – 4 types of fiber = neuro modalities

- a. **General Somatic Efferent (GSE)** – outflow to voluntary striated muscle (single neuron); axons sent through ventral roots
- b. **General Somatic Afferent (GSA)** – inflow from sensory endings in non-visceral tissue (single neuron); axons sent through dorsal roots
  - i. **Exteroception** – sensing outside world: temp, touch, pressure, pain (from skin, bone and muscle)
  - ii. **Proprioception** – knowledge of self – where you are in space: position, movement (from muscles, joints, tendons- ex touching finger to nose)
- c. **General Visceral Efferent (GVE)** – outflow to cardiac muscle, involuntary smooth muscle, glands (two neurons) – ventral roots



- i. [Parasympathetic – none in back and limbs]
- ii. Sympathetic –
  1. Preganglionic fibers from T1-L2 leave each nerve as bundle = **white ramus communicans**
  2. sympathetic chain ganglia – parallel to vert column, contains motor ganglion cells that serve all body levels (output becomes diffuse)
  3. Bundle of postganglionic axons = **gray ramus** – reach sweat glands, arrector pili muscles (raise hair follicles), invol smooth muscle of blood vessel walls

\* Only T1-L2 spinal nerves → serve all parts of body

- d. **General Visceral Afferent (GVA)** – inflow from sensory endings in viscera, large blood vessels (single neuron) dorsal roots – not in back and limbs]

	<b>Somatic - VOLUNTARY</b>	<b>Visceral - AUTONOMIC</b>
<b>Afferent DORSAL</b>	sensing – proprioception, exteroception <u>No synapse (unipolar cell)</u>	Sensory from viscera <u>No synapse</u>
<b>Efferent VENTRAL</b>	Voluntary muscle <u>No synapse</u>	Smooth and cardiac muscle, glands <u>2 neurons – preganglionic and postganglionic</u>

## V. THE SPINAL NERVE

- a. Basic Structure
  - i. Ventral root – axons of multipolar neurons (going outward to stri vol muscle)
  - ii. Dorsal root- axon processes of unipolar neurons
    1. Grow centrally into dorsal portion of cord
    2. Grow peripherally out towards sensory endings (skin, deep musc tissue)
  - iii. Trunk – where ventral and dorsal roots converge (both motor and sens fibers)
  - iv. Primary rami – form when nerve divides into 2 bundles (each both motor and sensory)

1. DPR – dorsal primary ramus – turns dorsally → medial or lateral branches – supply deep muscle and skin of the back
2. VPR – ventral primary ramus (larger) – turns anteriorly → runs as intercostal nerve – supplies vol stri muscle of thoracic wall
3. VPR also has nerve fibers destined for skin overlying intercostal space
  - a) Lateral cutaneous branch (mid-axillary line)
  - b) Anterior cutaneous branch (sternum)

\* Two different systems: one circumferential segmental system (spinal nerve), longitudinal system → joined by the rami communicans

- b. Addition of sympathetic motor outflow – postganglionic sympathetic GVE fibers are added to every spinal nerve (sweat glands, pili muscles, blood vessels all over body)
  - i. Preganglionic axon in cord segment → VPR → white rami → sympathetic chain) → synapse → post ganglionic axon → grey rami
    1. Distributed in VPR → all cells
    2. Turn back into DPR for distribution

## VI. CLINICAL CORRELATIONS

- a. if you sever a spinal cord segment, only a small portion is deinnervated because other nerves overlap
- b. Dermatomes and myotomes
  - i. two basic concepts that allow us to locate injured segment
  - ii. Dermatome – area of innervated skin; myotome – innervated muscle
  - iii. Myotomes are more circumscribed; dermatomes spread out
- c. Fate of embryonic body segments in the trunk and limbs...
- d. Analysis of nerve injuries
  - i. Damage to ventral root – monosegmental motor deficit
  - ii. Damage to dorsal – monosegmental sensory deficit
  - iii. Damage to trunk – monosegmental motor and sensory deficits
  - iv. Damage along primary ramus – depends on axons present in nerve at site of injury:
    1. Fibers beyond site of injury are compromised
    2. Fibers that branched before site of injury (closer to CNS) are unaffected
    3. Fibers that have joined nerve are compromised
- v. Injury to spinal cord
  1. Segments above function normally
  2. Segments below can function, but can't communicate with brain (can't use striated muscle at will, but it does respond to local sensory input)

# EMBRYOLOGY

## I. TERMS

### A. Human development

#### i. Prenatal Period

1. **(preembryonic period)** – first 2 weeks
2. **Embryonic period** – through day 56 (8 weeks)
3. **Fetal period** – weeks 9-38

#### ii. Postnatal period – birth to adulthood

### B. Ways of counting age:

- i. **Fertilization age** – age counting from time of fertilization
- ii. **Gestational age** – from first day of last normal menstrual period (doctors use this - 2 weeks longer than fert. age)

### C. Miscellaneous

#### i. Teratogens – environmental agents that cause congenital abnormalities

1. the embryonic period is a critical period of susceptibility to teratogens

## II. OVULATION AND FERTILIZATION

### A. Females

#### i. In the embryo

1. **Primordial germ cells** form in yolk sac of female embryo
2. PGCs migrate into the developing ovary, differentiate into **oogonia**
3. Oogonia undergo mitosis → millions of oogonia
4. Oogonia differentiate into **primary oocytes**
  - \* now they can no longer undergo mitosis
5. primary oocytes are surrounded by follicular (connective tissue) cells → **primary follicle** formed
6. first meiotic division begins, but halted in prophase I

#### ii. Ovulation (puberty and every month following)

1. Follicle-stimulating hormone (FSH) stimulates a few oocytes (in primordial follicles) each month
2. Follicle maturation:
  - \* Follicle cells become cuboidal → now called **granulosa cells**, form **zona pellucida** -this is the **primary follicle**
  - \* Intercellular spaces fill with fluid = **secondary follicle**
  - \* oocyte pushed to the side, surrounded by **corona radiata**
  - \* granulosa cells produce **estrogen**
3. Oocyte maturation:
  - \* High levels of estrogen → hormonal surge
  - \* Oocyte completes first meiotic division → secondary oocyte and **polar body** (lacks cytoplasm; will degenerate)
  - \* Secondary oocyte begins meiosis II, but is halted in metaphase

4. Ovulation:
  - \* Mature follicle forms bulge on ovary surface
  - \* Secondary oocyte, zp, and cr is expelled and swept up by distal end of oviduct
  - \* Remaining granulosa cells in ovary form **corpus luteum** – produces **progesterone** and estrogen → prepares uterus for implantation
- iii. Conception/Menstruation
  - \* implantation → conceptus produces hCG → CL remains
  - \* OR no implantation → CL degenerates → menstruation

## B. Males

- i. In the embryo
  1. About 250 compartments within each testis, seminiferous tubules within each compartment
  2. Only Sertoli cells and primordial germ cells in seminiferous tubules
- ii. Spermatogenesis
  1. Testosterone (from **Leydig cells** in interstitial space) → cells differentiate into **spermatogonia** → mitosis
  2. Daughter cells differentiate into **primary spermatocytes**
  3. spermatocytes → meiosis
  4. Second meiosis → **spermatids**
- iii. **Spermiogenesis**: spermatids become **spermatozoa**
  1. Excess cytoplasm eliminated
  2. Special structures added (mitochondria, flagellum)
  3. **Acrosomal vesicle** added to nucleus – needed to penetrate egg
    - \* takes approx. 64 days for ii and iii
- iv. **Capacitation**: maturation of spermatozoa, necessary for fertilization
  1. Glycoprotein coat added to sperm in duct system
  2. Coat must be removed in uterus, uterine tubules = **capacitation**

## III. FERTILIZATION AND ZYGOTE DEVELOPMENT

### A. Fertilization

- i. Sperm usually encounter egg in ampulla of uterine tube:
  1. Penetration of corona radiata – sperm releases enzymes from acrosomal cap → breaks through network holding cells together
    - \* Multiple sperms release enzymes, but only one will get through
  2. Penetration of zona pellucida – **acrosomal reaction**
  3. Fusion of membranes of sperm and egg – about 12 hours after fert.
- ii. Consequences of fertilization:
  1. Fusion triggers release of granules → composition of zp and egg plasma membrane change → other sperm can't penetrate = **zona reaction**
  2. Oocyte completes meiosis II

3. Male pronucleus forms: enlarged nucleus, tail degenerates
4. Two nuclei fuse → zygote
5. Chromosomes prepare for mitosis

\* No increase in total cytoplasmic mass

#### B. Cleavage

- i. Daughter cells = **blastomeres**; become smaller with each division (egg was very big; cells reach normal size after several divisions)
- ii. By 3 days: 12-32 blastomeres = **morula**
- iii. Day 3-4: morula enters uterus

#### C. Compaction

- i. 9 cell stage: cells form a ball and closely adhere → more interaction  
Joined blastomeres form outside layer - smooth surface surrounded inner cells

#### D. Cavitation

- i. Fluid cavity (**blastocoele**) forms → separates inner cells from outer
- ii. Inner and outer cells attached at **embryonic pole**
- iii. Now called **blastocyst**
- iv. Inner cells = **embryoblast**; outer cells = **trophoblast** – contributes to placenta

#### E. Hatching

- i. Blastocyst now needs to grow in size, attach to uterine lining → must shed zp
- ii. Zp thins out and degenerates, outer blastomeres release enzymes that digest a hole in zp → blastocyst “hatches”

### IV. Implantation

#### A. Day 6: trophoblast attaches to (proliferated) endometrium at embryonic pole

#### B. Changes:

- i. Trophoblast becomes 2 layers
  1. **Syncytiotrophoblast** – some cells fuse to form multinucleated “cell”, expands into endometrium
    - \* Produces hCG → stimulates ovary to produce progesterone → uterine lining maintained
  2. **Cytotrophoblast** – inner layer remains unfused and mitotically active – as they divide they migrate to 1.

#### ii. Decidua reaction:

1. Stromal cells enlarge, fill with glycoprotein and lipids
2. Prevents maternal immune reaction to conceptus
3. Syncytiotrophoblast penetrates stromal cells and erodes them to release nutrients
4. Glands in stroma enlarge, blood supply increases → help nourish conceptus until placenta takes over

#### C. Complications

- i. **Ectopic pregnancy** - implantation outside uterus = LIFE-THREATENING (internal bleeding)

- ii. **Placenta previa** – implantation near cervix → bleeding during pregnancy and/or excessively so during delivery

## PRINCIPLES OF SKELETAL MUSCLE ACTION

### I. INTRODUCTION

- A. Elements of skeletal muscle function
  - i. At least 2 points of attachment
  - ii. Stimulated by somatic nervous system
  - iii. Active muscle = tension generated
  - iv. Muscle shortens → attachments brought closer = movement
- B. Axioms
  - i. For a muscle to have effect, it must cross a joint.
  - ii. A muscle has the ability to effect any joint it crosses (sometimes not obvious which joints a muscle crosses – start at muscle attachment and trace along bone to other attachment)

### II. STRUCTURE

- A. Histological Organization of skeletal muscle
  - i. Individual muscle fibers surrounded by **endomysium**
  - ii. Fibers wrapped into **fascicule** and separated from each other by **perimysium**
  - iii. All fibers bound into one muscle by **epimysium**
  - iv. At ends of muscle fibers, three layers condense into connective tissue = **periosteum**
  - v. **Myotendinous junction** = where muscle fibers end
  - vi. Periosteum blends with tendons as it approaches attachment site
  - vii. **Sharpey's fibers** – penetrate bone and anchor periosteum to bone
- B. Contractile apparatus
  - i. **Sarcomere** = interval between 2 striations (Z lines/Z bands)
  - ii. **Thick filaments** extend from M line
  - iii. **thin filaments** (with **actin** molecules ) extend from Z band and overlap with **myosin heads** of thick filaments
  - iv. held together by structure protein **titin**
- C. Sliding filament theory
  - i. **tension** = repeated making/breaking bonds between myosin heads and actin molecules on thin filaments
  - ii. if tension is sufficient to overcome load (including deforming some connective tissue), muscle will contract
  - iii. each sarcomere shortens by .6 micrometers → muscle has to have many sarcomeres

- iv. to generate force, have to have more bonds forming at once → more fibers per muscle
- D. Transmission of force – how does sarcomere action attach to muscle attachments?
  - i. Actin filaments – don't attach to discrete Z-line – attach to macromolecular meshwork (intracellular) → complexed with transmembrane **integrins** → in extracellular compartment, integrins attach to **lamina**, elements of connective tissue matrix
  - ii. Sarcomere is part of macromolecular meshwork → muscle is elastic – can spring back
  - iii. all structural elements can be deformed, but are also resilient: once work is done, there is stored energy → element of recoil

### III. GROSS CONFIGURATION OF MUSCLES

- A. **Strap muscles** – many sarcomeres in series → wide range of motion
- B. **Multipennate** – pack lots of motive power into short area (ie deltoid)
- C. Other configurations? (not mentioned in lecture)

### IV. MODES OF CONTRACTION

- A. **Concentric contraction** – tension overcomes resistance → shortens
- B. **Isometric contraction** – tension doesn't overcome → no motion
- C. **Eccentric contraction** – tension increases, but muscle lengthens (as in biceps as you lower something heavy by extending arm)

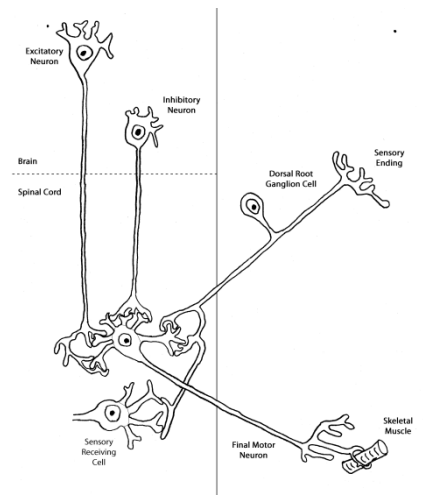
### V. CONTROL OF MUSCLE CONTRACTION

- A. Efferent innervation
  - i. **Final alpha-motor neuron** (“once they say go that's it”)– body in ventral grey rami of spinal cord
  - ii. **Muscle spindles** allow contraction to be preset, monitor progress
- B. **Motor unit** – alpha-motor neuron and cell muscle fibers it innervates
  - i. Can grade contraction
  - ii. Can control which part of muscle is used (ie deltoid)
- C. Afferent return – exteroception and proprioception

### VI. ANALYSIS OF MUSCLE ACTIONS

- A. Angular – change joint angle
- B. Shunt – end of bone moves towards/away (gravity can cause too)
- C. Translation/Shear – end of bone displaced
- D. Spin – bone spinning about long axis

### VII. REFLEXES



- A. Afferent and efferent control of a voluntary muscle
- B. Inhibitory neuron – can block reflex
- C. Damage:
  - i. Cut afferent → no reflex, voluntary action maintained
  - ii. Cut efferent → sensory input intact, but no reflex or voluntary action
  - iii. Cut spinal cord → no voluntary action, but reflex intact (also no inhibition of reflex)

## PECTORAL REGION AND SHOULDER

### I. PECTORAL REGION

- a. Mammary gland
  - i. Between 2<sup>nd</sup> and 6<sup>th</sup> ribs, lateral border of sternum and midaxillary line
  - ii. Overlies pectoralis and serratus anterior
  - iii. Attached to skin by **suspensory ligaments/ligaments of Cooper**
  - iv. **Retromammary space** – between breast and pectoral fascia, contains blood and lymph vessels, nerves; allows some movement of breast on thoracic wall
- b. Blood supply
  - i. Thoracoacromial branches
  - ii. Lateral thoracic artery and branches
  - iii. Branches from posterior intercostal arteries
  - iv. Internal thoracic artery → perforating branches → medial mammary branches
- c. Lymphatic drainage
  - i. most to subareolar lymphatic plexus
  - ii. >75% then to anterior or pectoral nodes of axillary group → clavicular lymph nodes → main lymphatic trunk → venous system (some may drain to other axillary nodes)
  - iii. Rest goes to parasternal lymph nodes → brachomediastinal lymphatic trunk → venous system
- d. Breast cancer
  - i. Usually adenocarcinomas from epithelial cells of lactiferous ducts
  - ii. Spreads through lymphatic vessels (may spread via venous system to brain)
  - iii. Drains to axillary lymph nodes = common site of metastasis
  - iv. May also develop in supraclavicular lymph nodes, opposite breast, abdomen

### II. SHOULDER

- a. Osteology
  - i. **Sternum** – body, jugular notch, manubrium, xiphoid process
  - ii. **Clavicle** – acromial facet, coracoid tubercle, sternal facet, subclavian groove, impression for costoclavicular ligament, anterior/posterior surface  
\*curve shift = common site of fracture

- iii. **Scapula** – acromion, coracoid process, glenoid cavity, medial/lat borders, spine, superior/inf angles, suprascapular notch, supraglenoid/infraglen tubercle, supraspinous/infraspinous fossa
  - iv. **Humerus** – deltoid tuberosity, greater/lesser tubercle, head, bicipital groove, spiral groove  
\*anatomical neck is site of growth plate in development, surgical neck is common site of fracture
- b. Articulations and associated structures
- i. Sternoclavicular (SC) joint – saddle type; has fibrocart. disc (helps with weight dist.); elevation/depression, protraction/retraction, rotation (as you raise shoulder)
    - 1. Sternoclavicular, interclavicular, costoclavicular ligaments
  - ii. Acromioclavicular (AC) joint – plane type synovial joint (glides), has fibrocart. disc; rotation
    - 1. Acromioclavicular ligament, coracoclavicular ligament
  - iii. Glenohumeral (GH) joint – ball and socket synovial joint; flex/ext, AB/AD, int/ext rotation \*glenoid fossa much smaller than humeral head “bowling ball and golf tee” → lacks stability, can dislocate, stabilized by non-contractile and contractile elements:
    - 1. Glenoid labrum – fibrocart. disc within joint, builds up edges; glenoid cavity, labrum, joint capsule
    - 2. Glenohumeral ligaments – superior, medial, inferior (SGHL, MGHL, IGHL)
    - 3. Coracohumeral ligament – thickens capsule
    - 4. Coracoacromial ligament – helps pack structures
    - 5. Transverse humeral ligament
    - 6. Subacromial/subdeltoid bursa – between coracoacromial arch and supraspin. tendon; gliding (contains synovial fluid) → decreases friction
    - 7. Contractile elements = muscles of rotator cuff – see end
  - iv. Scapulothoracic joint – functional, not structural joint; elev/depress, protraction/retract, down/up rotation
- c. Kinematics
- i. Shoulder
    - 1. Flexion/Extension – in saggital plane
    - 2. Abduction/Adduction – coronal and horizontal plane
    - 3. With shoulder in AB – internal/external rotation in saggital and horizontal planes
  - ii. Scapulohumeral rhythm
    - 1. scapulothoracic and GH both move to elevate shoulder
    - 2. Have to laterally rotate humerus (move greater tuberosity out of the way) to achieve full ROM (abduction)
- d. Musculature
- i. Posterior axioappendicular muscles (extrinsic)

1. Posterior
    - a. Superficial
      - i. **Trapezius**- elevate and upward rotate scapula (upper), adducts (middle), depress and downward rotate (lower)
      - ii. **Latissimus Dorsi** – shoulder extension, adduction, IR
    - b. Deep
      - i. **Levator Scapulae** – elev and down rotation of scap
      - ii. **Rhomboid Major** – AD/retract, down rotates scap
      - iii. **Rhomboid minor** – works with major
  2. Anterior
    - a. **Pectoralis major** – adducts, medially rotates humerus
    - b. **Pec minor** – stabilize scapula
    - c. **Serratus Anterior** – protract and upward rotation of scapula, compresses against thoracic wall
    - d. **Subclavius** – anchor and depress scap
  - ii. Scapulohumeral muscles (intrinsic)
    1. **Deltoid** – flex (anterior), abduct (middle) , extend (poster) shoulder
    2. **Teres Major** – medial, internal rotation of shoulder
    3. Rotator cuff muscles (SITS)
      - a. **Subscapularis** – medial, internal rotation
      - b. **Supraspinatus** – shoulder abduction
      - c. **Infraspinatus** – lateral\*, external rotation
      - d. **Teres Minor** – lateral\*, external rotation
- Order of attachment on humeral head from medial to lateral
- \*prevents impaction of greater tubercle on acromion
- Muscles and tendons prevent GH dislocation:
- i. Shunt or distraction/compression (away/tow joint)
  - ii. Sheer/translation (up and down)
  - iii. Angular motion
- e. Rotator cuff injury:
    - i. Use of upper limb above horizontal (throwing, swimming)
    - ii. Allow humeral head and rot cuff to impinge on coracoacromial arch
    - iii. May produce irritation of arch, inflamm of cuff, esp supraspinatus tendon
    - iv. Rupture of this tendon → upward shift of humerus

## THE BRACHIAL PLEXUS

### I. NERVE SUPPLY

- a. Ventral rami of C5-T1 (from from both anterior (motor) and posterior (sensory) roots)
- b. Organization
  - i. **Roots** – formed by ventral rami
  - ii. **Trunks** – roots combine into **superior, middle, inferior**
  - iii. **Divisions** – trunks divide into **anterior** and **posterior**
  - iv. **Cords** – divisions combine into **medial, lateral, posterior** – all wrapped around axillary artery, named according to relation to it
  - v. **Branches** – cords divide into 2 nerves each – **musculocutaneous, median** (from 2 cords), **ulnar, radial, axillary**
    1. **Superclavicular** branches – come off roots (a, b) or trunks (c, d)
      - a. **Dorsal scapular nerve (C5)** – innervates rhomboid major, rhomboid minor, levator scapulae
      - b. **Long thoracic nerve (C5-7)** – serratus anterior
      - c. **Suprascapular nerve (C5, 6)** – supraspinatus, infraspinatus
      - d. **Nerve to subclavius (C5, 6)** - subclavius
    2. **Infraclavicular** branches – come off cords (after clavicle)
      - a. Lateral:
        - i. **lateral pectoral n.** – innervates pectoralis major
      - b. Medial:
        - i. **medial pectoral n** – pec major and minor
        - ii. **medial brachial cutaneous n** (sensory only)
        - iii. **medial antebrachial cutaneous n** (sensory only)
      - c. Posterior:
        - i. **upper subscapular n** - subscapularis
        - ii. **lower subscapular n** – subscap and teres major
        - iii. **thoracodorsal n** – latissimus dorsi
- c. Terminal branches
  - i. Proximal to distal gradient:
    1. Superior rami (C5, C6) → proximal muscles (pectoral grid and shoulder)
    2. Intermediate rami (C6-C8) → elbow and wrist
    3. Inferior rami (C8-T1) → distal muscles (hand muscles)
  - ii. Anterior and Posterior division:
    1. Anterior arm, forearm, hand – act mainly as flexors – innervated by nerves that contain anterior division fibers (musculocutaneous, ulnar, median, lateral, medial pectoral)
    2. Posterior arm and forearm – act mainly as extensors – nerves that contain posterior fibers (**axillary, radial, upper/mid/lower subscapular**)
- d. Terminal nerves
  - i. **Musculocutaneous** – supplies coracobrachialis, brachialis, biceps brachii

- ii. **Median** (ID medial and lateral roots)
  - 1. 6 ½ of forearm – pronator teres, flexor carpi radialis, palmaris longus, flexor digitorum superficialis, flexor digitorum profundis (lateral half), flexor pollicis longus, pronator quadratus
  - 2. Hand: HALF LOAF
    - a. HALF Lumbricals (1 and 2)
    - b. Opponens pollicis, Abductor pollicis brevis, Flexor pollicis brevis
- iii. **Ulnar**
  - 1. 1 ½ of forearm – flexor carpi ulnaris and medial half of flexor digitorum profundis
  - 2. All hand except HALF LOAF
- iv. **Axillary** – deltoid, teres minor
- v. **Radial** – posterior arm and forearm; no hand

## II. CLINICAL CORRELATIONS

- a. Upper brachial plexus damage (C5 and C6)
  - i. **Erb's palsy (Erb-Duchenne paralysis)** – nerve injury almost always during childbirth, can affect arm growth, limited motor ability, loss of sensory perception between shoulder and elbow, circulatory problems (temp regulation, immune response)
    - 1. **Waiter's Tip position** – sign of Erb's paralysis – arm adducted, internally rotated; forearm pronated; hand and wrist flexed
- b. Lower brachial plexus damage (C8 and T1)
  - i. **Klumpke's paralysis** – forearm and hand; due to childbirth injury
- c. Long thoracic nerve damage
  - i. May occur in mastectomy surgery → **winged scapula**
- d. Radial nerve
  - i. **Crutch palsy** due to excessive and prolonged pressure – may include loss of wrist extension – “wrist drop”
  - ii. May also affect axillary nerve → loss of shoulder abduction

## AXILLA, ARM AND ELBOW

### I. AXILLA

- a. Boundaries
  - i. Pec major and minor - scapula, subscap, lats, teres major
  - ii. Ribs and intercostal spaces – intertubercular groove of humerus
  - iii. Skin and fascia of arm – clavicle, scap and rib 1
- b. Axillary vein ( superficial)
  - i. Forms at inferior border of teres major

- ii. Formed by brachial veins, basilic vein (superficial vessel of upper extremities)
- iii. Drains into subclavian vein
- iv. Blood flow:
  1. Arises from dorsal veins of hand
  2. **Cephalic (lateral)** – drains into termination of axillary vein
  3. **basilic (medial) vein** - drains into origin of axillary vein
  4. Connected by **medial cubital vein** (where blood is drawn)

**c. Axillary artery**

- i. Blood flow: aorta → brachiocephalic artery/trunk → subclavian artery → axillary artery (continuous with subclav – changes names)
- ii. Begins at lateral border of 1<sup>st</sup> rib, ends t inf border of teres major
- iii. At end, becomes **brachial artery**
- iv. 3 parts:
  1. Lateral border of 1<sup>st</sup> rib – medial border of pec minor
  2. Posterior to pec minor
  3. Lat border of pec minor to inferior border of teres major
- v. Branches of axillary artery
  1. Axillary I
    - a. **Superior thoracic artery** → first 2 intercostal spaces, serratus anterior
  2. Axillary II
    - a. **Thoracoacromial trunk** → **acromion, clavicle, pectoral, deltoid** (ACPD)
    - b. **Lateral thoracic artery** – joins with long thoracic nerve → serratus anterior, pectoral, breast
  3. Axillary III
    - a. **Subscapular artery**
      - i. **Circumflex scapular a** → teres major, minor, infraspinatus
      - ii. **Thoracodorsal artery** → lats
    - b. **Anterior humeral circumflex** → anterior arm muscles
    - c. **Posterior humeral circumflex** - with axillary nerve, through space around surgical neck of humerus → deltoid, teres major, minor, long head of triceps

**d. Subclavian artery** – also supplies scapular region

- i. Transverse cervical artery – branches into dorsal scapular artery
- ii. Suprascapular artery

**e. Brachial artery**

- i. Axillary artery becomes brachial a at inferior end of teres major
- ii. **brachial profunda artery** = branch
- iii. At end, divides into **radial and ulnar** (anterior and posterior divisions) **arteries**
- iv. Anastomosis of elbow vessels

- f. Anastomosis
  - i. Joining of vessels, makes them able to feed each others' territories (occlusion of one → region still supplied by other)
  - ii. Common around major joints
  - iii. Scapular anastomosis:
    - 1. Lacerated subclavian or axillary artery
    - 2. Blood flow in subscapular a reverses direction
    - 3. Blood reaches third part of axillary a
- II. ELBOW COMPLEX
  - a. Osteology
    - i. Distal humerus
      - 1. Condyle (articulating surface)
        - a. Capitulum – articulates with radius
        - b. Trochlea – articulates with ulna
      - 2. Epicondyles
        - a. Medial – primary attachment site for flexors
        - b. Lateral – primary attachment site for extensors
      - 3. Fossae – radial, coronoid, olecranon
    - ii. Radius and ulna - joined by interosseus membrane (see Netters)
  - b. Articulations and supporting structures (all share joint capsule)
    - i. Joints
      - 1. Humeroulnar – hinge: flexion/extension
      - 2. Humeroradial – modified hinge: flexion/extension, supination/pronation
      - 3. Proximal radioulnar – pivot: supination/pronation
      - 4. Distal radioulnar – pivot: supination/pronation
    - ii. Carrying angle
      - 1. Slight valgus – men 10-15°, 15-20°
      - 2. Trochlea extends further than capitulum → shoves elbow in lateral dir
    - iii. Ligaments
      - 1. Annular – encircles head of radius, forms circle w/ radial notch, holds radius against ulna, prevents distal dislocation
        - a. Nursemaid's elbow – if you pull too hard in a kid (weaker tendons), dislocates head of radius
        - b. Monteggia fracture – dislocation of proximal radioulnar joint in association with forearm fracture
      - 2. Lateral collateral (radiocollateral) – blends with annular ligament, protects against medial deviation
      - 3. Medial collateral (ulnocollateral) – medial epicondyle to coronoid and olecranon process, protects against medial deviation of forearm; transverse fibers (olecranon to coronoid) deepen socket for trochlea
    - iv. Other accessory structures

**Collateral** ligaments – prevent deviation in opposite direction

1. Bursa – related to triceps tendon and skin – decrease friction, disperse pressure at elbow joint
  2. Interosseus membrane – connects radius and ulna – force received by radius is transmitted to ulna, then to humerus
- c. Arthrokinematics
- i. Olecranon process pulls away from humerus → flexion
  - ii. Radial head spins on capitulum, rotates around fixed ulna → supination
- d. Arm muscles acting on elbow
- i. Anterior
    1. **Biceps brachii** – flexes elbow
      - a. Short head – to coracoids process of scapula
      - b. Long head – to supraglenoid tubercle
      - c. Both heads – to radius (via bicipital tendon)
    2. **Brachialis** – flexes forearm
      - a. Att to distal, anterior humerus, coronoid process of ulna
    3. **Coracobrachialis**
  - ii. Posterior
    1. **Triceps brachii** – extends elbow
      - a. Long head – infraglenoid tubercle
      - b. Lateral head – posterior sup. Humerus
      - c. Medial head (DEEP) – post inferior humerus
      - d. At other end, all heads att to olecranon
    2. **Aconeus** – extends forearm (assists tricep – weaker)
      - a. Att to lateral epicondyle, olecranon
    3. **Brachioradialis** – flexes elbow
      - a. Att. to lateral supracondylar ridge, lateral distal radius
        - \* origin and innervations are posterior, but action like anterior
  - iii. Muscles acting on radioulnar joints
    1. **Supinator** – supinates forearm
      - a. Att to lateral epicondyle, supinator fossa, crest of ulna – lateral, post, ant surface of radius
    2. **Pronator teres** – pronates and flexes forearm
      - a. 2 heads att to coronoid process and medial epicondyle
      - b. Lateral surface of radius
    3. **Pronator quadratus** – pronates forearm
      - a. Distal ant ulna, dis ant radius
        - \* biceps also supinates

### III. CUBITAL FOSSA

- a.

## FOREARM AND WRIST

### I. FOREARM

#### a. Blood Supply

- i. **Brachial artery** (formerly the axillary artery)
- ii. At elbow, branches into
  1. **Ulnar artery** (supplies medial side)
    - a. **Common interosseus artery**
      - i. Branches into **anterior and posterior interosseus arteries** – supply deep muscles in forearm
    - b. Ulnar a continues as **superficial palmar arch**
      - i. Branches into **common palmar digital arteries**
        1. Branch into **proper palm. dig. a's** – supply digits
    - c. **Deep palmar branch**
  2. **Radial artery** (supplies lateral side) – at wrist, splits:
    - a. **Superficial palmar branch** – arises at wrist
    - b. Distal part of radial artery-dorsal to wrist, crosses floor of anatomical snuffbox
      - i. Forms **deep palmar arch** (anastomosis with deep branch of ulnar a)
        1. Branches into palmar metacarpal arteries – supply hand; anastomosis with common pda's
        2. Princeps pollicis artery
    - c. **Radial recurrent artery** – branches off of radial a before split

#### b. Innervation

- i. Median branch
  1. **Anterior interosseus nerve (AIN)** – deep to pronator quadratus; supplies radial portion of flexor digitorum profundus, flexor pollicis longus, pronator quadratus
  2. **Palmar cutaneous branch** – sensory – central palm region
  3. **Recurrent branch** – motor – intrinsic muscles of thumb
- ii. Radial branch
  1. **Deep branch** – supplies supinator and extensor carpi radialis brevis
    - a. at supinator, called **posterior interosseus nerve (PIN)** – supplies extensor digitorum, extensor indicis, ext digiti minimi, ext poll long, ext poll brevis, abductor poll long, ext carpi ulnaris
  2. **Superficial sensory nerve**

### II. WRIST

#### a. Osteology

- i. Distal radius – much bigger distal head than ulna (ratio reversed)

- ii. Carpal bones –(clockwise starting at base of thumb) **scaphoid, lunate, triquetrum, pisiform, hammate, capitates, trapezoid, trapezium**
- iii. Palmar arches
  - 1. hand is naturally arched: longitudinal arch, proximal and distal transverse arches
  - 2. balances stability and mobility, increases surface contact, positions thumb for action
  - 3. ulnar side better for grasping, radial better for manipulation
- iv. Carpal tunnel- tunnel on palmar surface containing tendons and median nerve
- v. Guyon’s tunnel/ulnar canal – formed by pisiform, hook of hammate, pisohammate ligament (forms roof)– contains ulnar nerve and artery
- b. Articulations and Supporting Structures
  - i. Radiocarpal – condyloid (2 planes); wrist flex/ext and AB/AD
  - ii. Midcarpal –plany synovial; gliding motions between two rows
  - iii. Distal radioulnar – pivot synovial; supination/pronation
  - iv. Ligaments
    - 1. **Common extensor and flexor tendons** - joins muscles on lat/med epi
    - 2. **Extensor and flexor retinaculum** – broad sheets of connective tissue that stabilize bones on dorsal or ventral aspect – prevent “bowstringing”
    - 3. Radial and ulnar collateral ligaments – prevent excessive mediation
    - 4. Articular disc – between distal end of ulna and proximal carpals – provides gliding surface, cushions forces
- c. Arthrokinematics
  - i. Flexion/extension: both radiocarpal and midcarpal joints have to move to achieve full ROM (ratios: 60/40 for ext, 40/60 for flexion)
  - ii. Abduction/adduction (radial/ulnar deviation): no dedicated muscles achieve – co-contraction of flex/ext muscles: AB = ECRL and FCR, AD = ECU and FCU
- d. Forearm muscles acting on the wrist
  - i. Extensors – all originate at lateral epicondyle of humerus
    - 1. **Extensor carpi radialis longus** –to base of 2<sup>nd</sup> MC, radial innervation
    - 2. **Ext carpi rad brevis** – to bse of 3<sup>rd</sup> MC; deep radial innervation
    - 3. **Ext carpi ulnaris** – to base of 5<sup>th</sup> MC; PIN innervations
    - 4. **Aconeus**
  - ii. Flexors – all originate at medial epicondyle of humerus
    - 1. **Flexor carpi radialis** – to base of 2<sup>nd</sup> MC; median innervation
    - 2. **Flexor carpi ulnaris** – to pisiform, base of 5<sup>th</sup> MC; median innervation
    - 3. **Palmaris longus** – to fascia of palm; ulnar innerv \*not highly functional

### III. CLINICAL CORRELATIONS

- a. Colle’s Fracture
  - i. Dorsal displacement of distal fragment of radius

- ii. Usually due to fall on outstretched arm
  - iii. 70% in post-menopausal women (loss of protective effects of estrogen)
  - iv. Usually heals well (rich blood supply)
- b. Smith fracture (less common)
  - i. Palmar displacement of distal fragment of radius
  - ii. Usually due to fall on dorsum of hand with wrist flexion
- c. Lateral Epicondylitis
  - i. Repeated forceful flexion/ext of wrist → strains attachment of common extensor tendon → inflammation of periosteum of lat epicondyle
- d. Dupuytren's contracture
  - i. Benign, slowly progressive condition – causes contracture of palmar fascia
  - ii. Has to be treated surgically
- e. Scaphoid fracture
  - i. Usual from fall on palm
  - ii. most commonly fractured carpal
  - iii. may take several months to heal (poor blood supply)
  - iv. swelling over anatomical snuffbox – suspect scaphoid fracture
- f. High branching of brachial artery
  - i. Ulnar a branches off at elbow, causes it to run superficially to flexors
  - ii. Can be mistaken for vein, injection can result in capillary destruction, gangrene

## HANDS, DIGITS AND THUMB

- I. OSTEOLOGY
  - a. Metacarpals
  - b. Phalanges: proximal, medial and distal (for thumb just proximal and distal)
- II. ARTICULATIONS AND SUPPORTING STRUCTURES
  - a. Carpometacarpal (CMC)
    - i. Thumb: saddle; flex/ext, AD/AB, opposition (both flex and AB)
    - ii. 2-5: gliding
  - b. Metacarpophalangeal (MCP or MP)
    - i. Thumb: hinge; flex/ext parallel to plane of palm
    - ii. 2-5: condyloid; flex/ext, AB/AD (away from midline = 3<sup>rd</sup> finger)
  - c. Interphalangeal (IP)
    - i. Thumb: hinge
    - ii. 2-5: proximal (PIP) and distal (DIP) joints; hinge; flex/ext
  - d. Ligaments
    - i. Medial and lateral collateral ligaments - strengthen each MC and IP joint capsule, guard against excessive lateral deviation

- ii. Palmar – at MP joint, centers long flexor tendons, guards against hyperext
- iii. Transverse metacarpal ligament – holds heads of MCs together
- iv. **Palmar aponeurosis** – thick fascia covering soft tissues and flexor tendons

### III. KINEMATICS

- a. Non-manipulative patterns
  - i. Cylindrical (palmar) grip – thumb in AB
  - ii. Hook grip – digits in isometric contraction support weight
  - iii. Spherical grip – more open and round
- b. Manipulative prehension
  - i. Palmar pinch – most common – thumb + 2 or thumb + 2 + 3
  - ii. Lateral pinch – thumb against side of digits – ie turning key
  - iii. Tip-to-tip pinch – thumb with 2/3/4/5
- c. “Power grip”
  - i. fingers wrapped around an object with counterpressure from thumb
  - ii. involves long flexors to fingers, intrinsic muscles to digits, extensors of wrist

### IV. MUSCLES ACTING ON DIGITS AND THUMB

- a. Extrinsic – extrinsic to hand, but send tendons in – power and strength
  - i. Flexors
    - 1. **Flexor digitorum superficialis** – med epi of hum to base 2-5; flexes PIP
      - a. Tendon bifurcates – inserts on either side of middle phalanx
    - 2. **Flexor digitorum profundus** – prox ulna to base of 2-5; flexes DIP
    - 3. **Flexor pollicis longus** – ant rad to dist phalanx of thumb; flex thumb IP
  - \*Flexor sheath
    - a. Membranous portion – flattened sac surrounds tendons, reduces friction and promotes gliding
    - b. Retinacular portion – forms “pulleys” which stabilize tendon – pulley rupture causes bowstringing of tendon
- ii. Extensors
  - 1. Digits
    - a. **Extensor digitorum** (ED) – lat epi to ext expansion; ext MP, assists in ext IP
    - b. **Extensor indicis proprius** (EI) – post ulna and inteross membr to 2<sup>nd</sup> ext exp – ext 2<sup>nd</sup> MP
    - c. **Extensor digiti minimi** (EDM) – lat epi to ext exp of 5th
  - 2. Thumb
    - a. **Extensor pollicis longus** (EPL) – post dist ulna to base of dist phalanx of thumb; extends thumb IP
    - b. **Ext poll brevis** (EPB) – post dist rad to base of prox phal of thumb; extends MP and CMC

- c. **Abductor poll lungus (APL)** – post dist rad and ulna to base of first MC (comes around to ant. surface)– abducts thumb at CMC  
 \*Extensor expansion: elaboration on ED tendon on dorsum and sides of phalanx (medial and lateral bands);when pulled extends IPs – couples DIP and PIP
    - b. Intrinsic – start and end in hand – fine motor control and coordination
      - i. **Palmaris brevis** – covers and protects ulnar n and a – ID IN LAB ONLY
      - ii. Thumb – **opponens brevis, abductor pollicis brevis, flexor pollicis brevis**
      - iii. Hypothenar - **opponens digiti minimi, abductor digiti minimi, flexor digiti minimi**
      - iv. **Adductor pollicis** – 3<sup>rd</sup> MC to thumb; adducts thumb
      - v. **Lumbricals (4)** – FDP tendon to ext hood (cross on ant side); flex MP and ext PIP/DIP – break up composite motion
      - vi. **Dorsal and palmar interossei** – MC to prox phal and ext exp (attach between MCs);
        - 1. Dorsal – 4 of them - abduct
        - 2. Palmar – 3 - adduct
- \*Anatomical snuffbox: ab poll longus, ext poll brevis, ext poll longus

#### V. CUTANEOUS INNERVATION OF THE HAND

- a. Median (middle of palm, top mid of dorsal), radial (lateral dorsal and ½ palmar thumb), and ulnar (medial dorsal and palmar) nerves

#### VI. CLINICAL CORRELATIONS

- a. Clinical Test: AIN (Anterior interosseus nerve test)
  - i. loss of FPL and FDP to index finger → can't make "OK" sign (collapsed circle)
- b. De Quervain's Tenosynovitis
  - i. Inflammation of ext pollicis, ab poll longus tendons
  - ii. Results in pain and swelling over radial styloid
  - iii. Test by wrapping thumb, forcing ulnar deviation – pain?
- c. Digit pathology
  - i. Swan neck deformity
    - 1. slippage of collateral ligaments
    - 2. causes PIP hyperextension, DIP flexion
  - ii. Boutonniere Deformity
    - 1. Central tendon rupture – PIP joint protrudes through it
    - 2. PIP flexion, DIP extension
  - iii. Mallet Deformity
    - 1. Overstretching or rupture of extensor tendon
    - 2. Laxity of ext, results in decreases efficiency of extensor hood
    - 3. Inability to extend DIP
- d. Tenodesis grasp
  - i. Passive opening of fingers when wrist is flexed, passive closing when wrist ext

- ii. Impt in patients with C6 spinal cord injury
- e. Radial, Median, Ulnar Nerve injury
  - i. Radial
    - 1. at risk for injury due to proximity to humerus (fracture likely to cause nerve damage), or due to compression
    - 2. results in “wrist drop”
  - ii. Median
    - 1. Injury at elbow (compression or trauma) – extr and intr musc impaired
    - 2. Injury at wrist – weak 1, 2, 3 – “hand of benediction” if try to make fist
    - 3. At thumb
      - a. Superficial at thenar eminence – can be lacerated - severs recurrent branch
      - b. results in paralysis of thenar muscles, inability to oppose thumb
  - iii. Ulnar
    - 1. loss of Ab/Ad of digits
    - 2. Loss of intrinsic innervation (lumbricals – flex MP, ext IP)
    - 3. Extrinsic ext have unbalanced pull → “clawing” of ulnar digits  
\*different from hand of benediction because clawing at rest
- f. Carpal tunnel syndrome
  - i. Decreased space in tunnel compresses median nerve
  - ii. Leads to parasthesia or anesthesia of palm and digits, decreased muscle strength
  - iii. Can be caused by inflammation of FDS or FDP

## GLUTEAL, THIGH AND HIP

- I. SURFACE ANATOMY
  - a. Intergluteal cleft, buttocks, thigh, gluteal fold
  - b. Palpable landmarks: iliac crests/tuberosities (ant and post), pubic symphysis, greater trochanter (and and post), patella, medial and lateral epicondyles of femur, medial and lateral condyles of tibia, anterior surface of tibia, lateral and medial malleolus, calcaneal tuberosity
    - i. Line connecting post. iliac crests marks spot between L4 and L5
- II. HIP JOINT
  - a. Osteology
    - i. Prenatally 3 individual bones, then fuse together:
      - 1. Ilium – iliac crest, ant super iliac spine (ASIS), greater sciatic notch\*
      - 2. Ischium – ischial spine, lesser sciatic notch\*, ischial tuberosity (the “sit” bone – makes contact with chair)
      - 3. Pubis – pubic tubercle

\*ligaments complete circle – become foramen

ii. Acetabulum (“vinegar cup”) - joint

b. Ligaments

i. Sacrum and hip joint

1. Anterior and posterior – very stable, little motion
2. Inguinal ligament (iliac spine to pubic symphysis)- provides attachment point for many muscles; protects nerves and vessels
3. Sacrospinous ligament (spine of ischium to sacrum) – forms greater sciatic foramen
4. Sactotuberous ligament – forms lesser sciatic foramen

ii. Hip joint

1. 4 ligaments:

- a. Iliofemoral ligament
- b. Ischiofemoral ligament
- c. Pubalfemoral ligament – more inferior
- d. Ligamentus teres (ligament of the head of the femus)

2. Gaps: 2 small gaps in ligaments – can distinguish them, see through to joint capsule; dislocation common at these two regions

3. Ligaments travel in a spiral fashion – not straight

- a. as femur is flexion, ligaments start to unravel
- b. dislocations are common in the posterior direction, because hip is more vulnerable during flexion
- c. displacement through iliofemoral and ischiofemoral gap

4. Piriformis attaches at sacrum and inserts in femur. Travels through greater sciatic foramen, subdivides into suprapiriform and infrapiriform foramen

c. Axes of motion: flex/ext, AB/AD, exterior/internal rotation – toe goes out/inwards

### III. GLUTEAL REGION

a. Muscles and force vectors

i. Gluteus maximus – attaches to femur → extends thigh at hip; attaches to iliotibial tract →externally rotates

ii. Gluteus medius

iii. Gluteus minimus – attach to ilium → AB and internal rotation

iv. Tensor fasciae latae

v. Piriformis – externally rotates

vi. Superior gemellus

vii. Obturator internus – ext rotators, weak adductors (all below point of rotation

viii. Inferior gemellus so can only pull inwards)

b. Vasculature

i. Overview:

1. External iliac artery → femoral artery →

- a. Branch: **profunda femoris**
  - i. lateral circumflex fem a → ascending and descending branches
  - ii. Medial circ fem a (supplies neck and head of femur)
- b. Another branch (above knee) – **descending genicular** → medial geniculars (sup and inf)
- c. Fem a continues, passes through adductor hiatus and becomes **popliteal a** (now posterior) → anterior and post tibial, fibular
- ii. Important vasculature of hip joint
  - 1. Lateral circumflex fem a – ascending, transverse, descending branches
  - 2. Medial circum flex fem a- innervates head and neck of femur **\*most imp**
  - 3. Obturator artery → acetabular branch – head of femur
- c. Innervation

Gluteus maximus	Inferior gluteal nerve
Gluteus medius	Superior gluteal nerve
Gluteus minimis	
Piriformis	Ventral rami S1 and S2
Superior gemellus	Nerve to obturator internus
Obturator internus	
Inferior gemellus	Nerve to quadrator femoris
Quadratus femoris	

\*Superior gluteal nerve also innervates tensor fascia latae

\*Pudendal nerve – crosses sciatic foramen, innervates perineal region

\*Greater sciatic nerve – innervates lots, especially the posterior thigh

#### IV. THIGH

- a. Fascia – separate into 3 compartments
- b. Posterior Compartment (3 muscles)
  - i. Biceps femoris
    - 1. Short head – attaches to femur; innervated by common fibular nerve
    - 2. Long head – attaches all the way up; innervated by tibial nerve
  - ii. Semimembranosus – deep to semiten, thicker wider tendon; tibial nerve
  - iii. Semitendinosus – long thin tendon; tibial nerve
- c. Anterior Compartment (7) – all femoral nerve
  - i. Iliopsoas – ext rotation, flex of thigh at hip, flex torso; also ventral rami S1-S2
  - ii. Sartorius – inserts on tibia,
  - iii. Quadriceps
    - 1. Rectus femoris
    - 2. Vastus lateralis
    - 3. Vastus medialis
    - 4. Vastus intermedius (deep to rectus fem)
  - iv. Pectineus – also obturator

\*femoral triangle: inguinal lig, sartor, AD longus form; pectin and iliop = floor

- d. Medial Compartment (5) – obturator nerve
  - i. Obturator externus
  - ii. Gracilis
  - iii. Adductor longus
  - iv. Adductor brevis
  - v. Adductor magnus – spans medial and posterior compartments; also tibial n
- e. Innervation
  - i. Sacral plexus – runs posterior to hip joint; innervates all posterior thigh muscles, all leg, all foot
  - ii. Lumbar plexus – anterior to hip joint; all ant and medial compartment muscles

## V. CLINICAL CORRELATIONS

- a. Hip and gluteal region
  - i. Gluteal injection
    - 1. Inject upper outer quadrant to avoid nerve (place fingers on tubercle of iliac crest and ASIS, inject between fingers)
    - 2. Problems with superior gluteal nerve: 3 muscles (glut med, glut min, tfl) become weak/nonfunctional
  - ii. Trandelenburg gait
    - 1. Normal walking: lift right foot → left abductor muscles contract to lift right hip to balance
    - 2. If nerves damaged: left AB muscles don't contract → "hip drop" on right
    - 3. Compensation: body tilts to left to get over the rotation (trying to balance body over hip), then falls right as foot is placed down = back and forth motion
  - iii. Osteoarthritis of the hip
    - 1. Can compensate for AB weakness by holding weight on affected side (not a good idea if already weak)
    - 2. or holding cane on opposite side to relieve pressure
- b. Thigh
  - i. Impingement of cutaneous nerve
    - 1. Excessive pressure can impinge posterior femoral cutaneous nerve
    - 2. Obese people: belly coming over can impinge lateral fem cut nerve
    - 3. Symptom = parasthesia
  - ii. Patellar Tendon reflex
    - 1. Tests L2-L4; hand on quad should feel them contract
    - 2. Weak/absent knee jerk – may indicate problem with quad innervation
  - iii. Varicose veins
    - 1. Valves become incompetent over time
  - iv. Lymphatic problems – can lead to lymphedema

## KNEE, LEG, ANKLE, FOOT

### I. OSTEOLOGY

- a. Fibula, Tibia, calcaneous, talus, cuboid, cuneiform bones, metatarsals, phalanges
- b. Netter 515 – know these attachment points

### II. VASCULATURE AND INNERVATIONS

#### a. Arteries

##### i. Popliteal a

(Superior and inferior lateral and medial geniculars branch off)

1. Anterior tibial – passes through inteross membr, becomes dorsalis pedis at foot, → arcuate artery (acts as arch) → dorsal metatar, dorsal digital
2. Posterior tibial

(Fibular branches off)

- a. Medial plantar
- b. Lateral plantar → deep plantar arterial arch (under abductor hallicus)
  - i. Goes through to anterior side
  - ii. Meets up with medial plantar artery

#### b. Veins and nerves

- i. **Great saphenous vein** – starts at medial malleolus (anterior surface) and wraps to posterior side at popliteal fossa, wraps back to anterior side, becomes femoral vein
- ii. **Saphenous nerve** – companion to great saph vein
- iii. **Small saphenous** – comes up posterior leg
- iv. **Sural nerve** = companion to small saph \*important for nerve grafts

#### c. Innervations of lower extremity:

- i. Sciatic nerve – doesn't innervate muscles – branches
  1. Tibial nerve innervate all of posterior lower extremity EXCEPT short head of biceps femoris (common fibular nerve)
  2. Common fibular nerve
    - a. Deep fibular branch (anterior compartment)
    - b. Superficial fibular branch (lateral compartment)

### III. KNEE

#### a. Modified hinge joint

- i. Lateral/medial rotation allows for locking/unlocking of knee
- ii. All the weight of body rests on : foot → tibia → femur \*not fibula

#### b. Movements

- i. Flexion/extension – by hamstrings/quadriceps
- ii. Slight internal rotation of femur in extension – leg “locks”
- iii. External rotation (“unlocks”) by **popliteus muscle**

#### c. Articulations

- i. Femoral condyles

- ii. Fibial plateau – increases overall surface area of articulation
- iii. Patella

d. Ligaments

- i. Collateral ligaments – control medial/lateral stability and rotation
  - 1. Medial (tibial) collateral
  - 2. Lateral (fibular) collateral
- ii. Cruciate ligaments – control anterior/posterior translation and rotation
  - 1. Posterior – PCL
  - 2. Anterior – ACL – attaches to lateral condyle
- iii. Menisci
  - 1. Medial meniscus (C-shaped) – directly attaches to tibial collateral lig  
→ injuries affect both collateral lig and meniscus (very painful)
  - 2. Lateral meniscus (O-shaped) – not as close to collateral

IV. DEEP FASCIA AND COMPARTMENTS

a. Anterior compartment (4) – all innervated by deep fibular nerve

- i. Tibialis anterior – attaches on medial side; dorsiflexes ankle, inverts foot
- ii. Extensor hallucis longus – extends ankle (dorsiflexion), extends to big toe – pulls upwards and extends
- iii. Extensor digitorum longus – extends digits 2-5 (dorsiflexion)
- iv. Fibularis tertius – attaches on lateral side; dorsiflexes ankle, everts foot

b. Lateral (2) – superficial fibular nerve; both evert foot and weak plantar flexion

- i. Fibularis longus – tendon comes around, attaches on medial surface of foot
- ii. Fibularis brevis – attaches to lateral surface

c. Posterior (7)

- i. Superficial compartment (3)
  - 1. Gastrocnemius
  - 2. Soleus
  - 3. Plantaris – very long tendon, travels between soleus and gastroc
- ii. Deep compartment (4) – tibial nerve
  - 1. Tibialis posterior – plantar flex ankle, invert foot
  - 2. Flexor hallucis longus – flexes toe, plantar flexes ankle
  - 3. Flexor digitorum longus – flex 2-5, plantar flex ankle, supports long. arch
  - 4. Popliteus- weakly flex knee, laterally rotate femur to unlock, medial rotates tibia of unplanted limb

\*all tendons wrap around medial side – Tom, Dick, Very Nervous Harry

d. Fascia

- i. Interosseus septum – separates anterior compartment from posterior
- ii. Transverse septum – separate deep from superficial
- iii. Anterior and posterior septa – separate lateral compartment

V. ANKLE

a. Hinge type

b. Bones: tibio-fibular mortise (bones join together), talus – very stable

- c. Ligaments: medial/deltoid and lateral
- d. Movement
  - i. Dorsiflexion – anterior compartment – deep fibular nerve
  - ii. Plantar flexion – posterior superior, post deep, lateral compartment – tibial, superior fibular nerve

## VI. FOOT

- a. Bones
  - i. Tarsals (calcaneous, talus, navicular, cuboid, 3 cuneiforms)
  - ii. metatarsals
  - iii. phalanges
  - iv. sesamoid bones
- b. Arches
  - i. Longitudinal arch – front to back
  - ii. Transverse arch – side to side
  - iii. Medial arch
- c. Ligaments
  - i. Plantar calaneonavicular
  - ii. Calcaneous
  - iii. Navicular
  - iv. Long plantar – helps maintain longitudinal arch
  - v. Plantar aponeurosis
- d. Musculature
  - i. Anterior surface
    - 1. anterior compartment muscles...
    - 2. extensor hallucis brevis
    - 3. extensor digitorum brevis – only 3 tendons (not big or little toe)  
\*retinaculum: superior extensor, inferior extensor – tether down tendons to prevent bowstringing
  - ii. Medial surface
    - 1. Deep posterior (flex hall long, flex dig long, tib post)
    - 2. Calcaneous tendon – gastrocnemius, soleus, plantaris
    - 3. Inversion – tibialis posterior, tibialis anterior, ext hal long
    - 4. Eversion – fibularis brevis, longus, tertius
  - iii. Sole of foot – all lateral or medial plantar nerve
    - 1. Layer 1 – flex dig brev (med), AB hall (med), AB dig mini (lat)
    - 2. Layer 2 – quadratus plantae (aids in flexion-lat), lumbricals 1 (med) and 2-4 (lat)
    - 3. Layer 3 – flex hall brev (med), AD hall (lat), flex dig min brev (lat)
    - 4. Layer 4 – plantar (3) and dorsal (4) interossei (all lat)
- e. Vasculature and Innervation
  - i. Posterior tibial a → lateral and medial plantar a.
  - ii. Posterior tibial n → lat and med plantar n.

- f. Articulations – intertarsal joints
    - i. Talocalcaneonavicular, calcaneocuboid
    - ii. Transverse tarsal/midtarsal – made by both of above
  - g. Ligaments
    - i. Plantar calcaneonavicular = spring ligament
    - ii. Long and short plantar ligaments
- VII. CLINICAL ASPECTS
- a. Foot drop – damage to common fibular nerve → damage to anterior compartment → can't extend foot
  - b. Compartment syndrome – overuse → increased pressure → septa inflame → occludes blood supply – can lead to necrosis
  - c. Pott's fracture – just above ankle
  - d. Knee Damage
    - i. ACL injuries
      - 1. MOI: pivot and twist (ER femur/IR tibia), lateral force, hyperextension - force ruptures medial collateral, then medial meniscus, then ACL ("unhappy triad")
      - 2. Presentation: buckling, large joint effusion
      - 3. Lachman's test (anterior drawer): flex knee 90°, hold femur and pull tibia forwards → if it moves, then ACL is torn (if PCL torn can move femur back) \*test before swelling starts
    - ii. PCL
      - 1. MOI: posterior directed force to tibia (dashboard injury) or fall on flexed knee
      - 2. Presentation: instability, effusion
      - 3. Assessment – posterior sag, posterior drawer (see ACL)
    - iii. Meniscus injury
      - 1. MOI – pivot and twist; degenerative
      - 2. Presentation: locking and catching; joint line pain
      - 3. Assessments
        - a. Thessaly test – rotate femur on fixed tibia
        - b. McMurray test – flex/ext in lat, med rotation
      - 4. Types of injury
        - a. Parrot beak tear – free flap – catches when knee bent
        - b. Lateral tear – bucket handle tear
    - iv. MCL
      - 1. MOI – valgus stress/lateral blow to knee
      - 2. Presentation: medial pain and injury
      - 3. Assessment: palpation and valgus stress test
    - v. LCL
      - 1. MOI – varus stress/medial blow to knee
      - 2. Presentation: lateral pain

3. Assessment: palpation, varus stress test
  - vi. Osteoarthritis
  - vii. Anterior knee pain