INTRODUCTION TO
LOCOMOTOR APPARATUS

1. Osteology: the scientific study of bones
2. Types of bones
3. Structure of mature bone
4. Bone as an organ
5. Osseous tissue and bone marrow
6. Arthrology: the study of joints
7. Types of joints
8. The structure of synovial joints
9. Myology: the study of muscles
10. Structure and form of skeletal muscles
11. The actions of muscles
Locomotor apparatus

- **passive part (skeleton):**
  - bones – osteology, osteologia
  - joints – arthrology, arthrologia

- **active part:**
  - skeletal muscles – myology, myologia
The scientific study of bones

- **skeleton** – 206 bones in the adult human body
- **individual bone structure:**
  - compact bone, *substantia compacta*
  - cortical bone, *substantia corticalis*
  - cancellous or spongy bone, *substantia spongiosa*
- **periosteum** or articular cartilage
- **endosteum**
Types of bones

- According to their shape and proportions:
  - long (trabecular) bones, *ossa longa* – most bones of the limbs
  - short bones, *ossa brevia* – the bones of the wrist and ankle
  - flat bones, *ossa plana* – most of the bones of the skull, sternum
  - irregular bones, *ossa irregularia* – the bones of the spine, hips, and cranial base
    - pneumatic (hollow) bones, *ossa pneumatica* – the bones of the facial skull
    - sesamoid bones, *ossa sesamoidea* – bones embedded in tendons (patella)
✓ long (trabecular) bones, *ossa longa* – limbs

- a shaft, the *diaphysis* ⇒ thick compact bone
- medullary cavity – bone marrow, red (in children) or yellow (in adults)
- rounded ends – *epiphyses*, proximal and distal
  ⇒ spongy bone + thin compact bone
- *metaphysis* ⇒ bone growth plate (epiphyseal plate)

epiphysis vs. apophysis
 ✓ short bones, *ossa brevia* – wrist and ankle, tarsal bones, vertebral bodies

- thin cortical bone
- spongy bone \(\Rightarrow\) red bone marrow
✓ flat bones, *ossa plana* – skull vault, sternum, ribs, scapula, hip bone

- two layers of compact bone
- spongy bone $\Rightarrow$ red bone marrow
- *diploë* – variable in thickness, bones of the skull vault, *calvaria*
Types of bones

✓ irregular bones, *ossa irregularia* – vertebrae, bones of facial skull, cranial base
  • spongy bone ⇒ red bone marrow
  • thin compact bone

➢ pneumatic bones, *ossa pneumatica* – facial skull

➢ sesamoid bones, *ossa sesamoidea* – embedded in tendons
Bone structure

- Trajectory structure – at the organ level
  - trabecular bone
Structure of mature bone

- Lamellar structure – at the tissue level
  - lamellar bone
Bone as an organ

- Chemical composition:
  - water – 50%
  - lipids – 16%
  - proteins (collagen) – 12%
  - inorganic constituents (bone salts) – 22%
    (calcium in the form of hydroxyapatite)

- Osteon (Haversian system):
  - 5-20 osteonic concentric (primary) lamellae
  - circumferential lamellae (secondary lamellae)
  - interstitial lamellae
  - central, Haversian canal
  - Volkmann’s canals
Bone as a tissue

- Types of bone cells:
  - osteoblasts, *osteoblasti*
  - osteocytes, *osteocyti*
  - osteoclasts, *osteoclasti*

- Bone (extracellular) matrix:
  - organic part (35%) – elasticity
    - collagen type I – 95%
    - glycosaminoglycans – keratan sulfate, chondroitin sulfate and hyaluronic acid
  - inorganic part (65%) – hardness and rigidity; crystalline mineral salts, mostly crystals of hydroxyapatite
    - calcium phosphate – 85%
    - calcium carbonate – 6-10%
    - magnesium phosphate – up to 1.5%
    - calcium fluoride – traces
Bone marrow, *medulla ossium*

- **red bone marrow,** *medulla ossium rubra* – epiphyses of long bones, spongy bone of short and flat bones: vertebrae, sternum, ribs, pelvic bones etc. ~ 1500 g
  - haemopoiesis
  - biological defense
- **yellow (fatty) bone marrow,** *medulla ossium flava* – in the hollow interior of the middle portion of long bones
“Higgins, control yourself and sit down!”
Arthrology, *arthrologia*

- The science concerned with the structure, function, dysfunction and treatment of joints (articulations)

- **Synarthrosis** (BNA) – form of articulation in which the bones are rigidly joined by solid connective tissue:
  - fibrous
  - cartilaginous
  - osseus

- **Diarthrosis** (BNA) or *Synovial joint* – a freely movable joint:
  - articular cavity
  - passive and active body movements

**NB:** The prefix "arthro-" refers to joints, *Gr. ἄρθρον* arthron, a joint

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Fibrous joints, *juncturcae fibrosae*

- by fibrous connective tissue, **syndesmosis** (Gr. *syndesmos*, ligament) (syn, together + *desmos*, fiber):
  - interosseous membranes, *membranae interosseae*
  - interosseous ligaments, *ligamenta interossea*
  - sutures, *suturae*:
    - *sutura serrata*
    - *sutura plana*
    - *sutura squamosa*
  - **gomphosis** (or peg-and-socket joint) – specialized type restricted to the fixation of teeth in the mandible and maxillae

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Cartilaginous joints, juncturae cartilagineae

- by cartilage tissue, articulatio cartilaginea:
  - hyaline cartilage, synchondrosis
  - fibrocartilage:
    - symphysis
    - hemiarthrosis
  - temporary and permanent
Osseous joints, *juncturae osseae*

- by bone (osseous) tissue, **synostosis:**
  - functionally ⇔ temporary *synchondroses*
  - pathologically:
    - joint disorders
    - stiffness of a joint,
      **ankylosis** (Gr. ἀγκύλος, bent, crooked)
    - the surgical fixation of a joint, **arthrodesis**
Synovial joints, *juncturae synoviales s. articulationes*

- according to the number of articular surfaces:
  - simple joint, *art. simplex*
  - compound joint, *art. compósita*
  - complex joint (two cavities), *art. complexa*
  - united (combined) joint – functional combination of anatomically distinct joints
Structure of synovial joints, diarthroses

- articular surfaces
- articular capsule
- synovial (joint) cavity
- ligaments
Biomechanics of joints

- Two types of movements:
  - translational
  - rotational

- Character of movements ⇒ shape of articular surfaces

- Freedom of movements ⇒ congruence of articular surfaces
Morphological classification of synovial joints

- according to the shape of the articular surfaces:
  - **spheroidal** (ball-and-socket) joints, \textit{artt. spheroida}
  - **pivot** (trochoid) joints, \textit{artt. trochoidea}
  - **condyloid** (ellipsoid) joints, \textit{artt. ellipsoidea}
  - **sellar** (saddle) joints, \textit{artt. sellaris}
  - **hinge** joints, \textit{ginglymus}
  - **plane** joints, \textit{artt. plana}
The scientific study of muscles,

- human body ~ 650 muscles:
  - 30 facial muscles
- 40% of the body mass
- striated (skeletal) muscle tissue
- cross striated and voluntary – CNS innervation:
  - quick, voluntary control of contraction/relaxation
- active part of the locomotor apparatus:
  - skeletal muscles
  - initial and end portions of the digestive tract
  - muscles of the head (incl. eye, ear)
  - muscles of respiration
Structural organization of a skeletal muscle

- Central, active part – muscle (fleshy) belly
- End, mechanical parts – tendon, *tendo, inis*:
  - Origin of a muscle: *origo*
  - Attachment point: *insertio*
Types of skeletal muscles

- According to their appearance:
  - long muscles
  - short muscles
  - flat muscles – *aponeurosis*

- According to the arrangement patterns:
  - simple muscles
  - compound muscles – in the limbs:
    - with more than one initial origins:
      - two separate origins – *m. biceps brachii*
      - three-headed – *m. triceps brachii*
      - four-headed – *m. quadriceps femoris*
    - with more than one insertion points – *mm. flexores digitorum sup. et prof.*
  - with an intermediate tendon or intersections:
    - biventer muscles – in the neck, *m. omohyoideus*
    - *intersectiones tendineae* – *m. rectus abdominis*
Shapes of skeletal muscles

According to the arrangement patterns of the fascicles – 5 types:

☑ fusiform muscle, 
**m. fusiformis** – in the limbs

☑ pennate muscle
  - **m. unipennatus** – **mm. interossei palmares**
  - **m. bipennatus** – **mm. interossei dorsales**

☑ convergent muscles, 
flat muscles, **m. planus** – in the back and abdominal wall
  - quadrilateral,
  - rhomboid,
  - triangular etc.

☑ annular muscle, **m. anularis**
  – around body openings
  - sphincter, **m. sphincter**
  - circular, **m. orbicularis**

☑ parallel muscles – biceps, triceps
General structure of the muscle fleshy belly

- **striated muscle fibers**
- **connective tissue skeleton:**
  - layers of connective tissue
  - blood vessels
  - lymph vessels
  - nerve fibers
Biomechanics of skeletal muscles

- **Internal mechanics:**
  - muscle contractility
  - muscle force – load-bearing capacity:
    - physiological cross sectional area
    - muscle force vector ⇒ direction and strength of a force
  - effects of muscle actions:
    - weight loading of a muscle
    - muscle length of loading
    - lever arm length
Biomechanics of skeletal muscles

- External mechanics:
  - punctum fixum
  - punctum mobile
  - fulcrum
  - effort
  - resistance (load)

- class 1 lever
  (lever of equilibrium)

- class 2 lever:
  - type I:
    (lever of force)
  - type II:
    (lever of velocity)
Biomechanics of skeletal muscles

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Archimedes’ Lever

Thank you...