General osteology
Bone cells

• osteoblast (*osteoblastus*)
  – active bone cell forming osteoid
    (non-mineralizovaná bone tissue)

• osteocyte (*osteocytus*)
  – cell in resting stage
  – in lacunae of bone tissue

• osteoclast (*osteoclastus*)
  – type of macrophage
  – reabsorption of a bone matrix
Bone matrix (*matrix ossea*)

- **organic component = ossein**
  - formed by osteoblasts
  - collagen type I, amorphous ground substance (*substantia fundamentalis*)

- **inorganic component**
  - predominates Ca, P, in a form of a crystalline hydroxyapatite and amorphous calcium phosphate
  - is stored at the surface of fibrils (later also inside)
Bone tissue I

• primary bone tissue = fibrillar (*textus osseus reticulofibrosus*, woven bone)
  – first type of a bone tissue appearing during development
  – temporary – in adulthood appears only in several places in the body (dental alveoli, healing, reparation processes)
Bone tissue II

- secondary bone tissue – lamellar *(textus osseus lamellaris, lamellar membranous bone)*
  - formed through conversion of woven bone
  - collagen fibres organized in lamellae
Bone tissue III

• bone lamellae of Havers (lamellae osseae)
  – longitudinal lamellae organized concentrically around osteonic canals of Havers (canales osteoni)
  – isotropic x anisotropic layers
• external circumferential lamellae (lamellae circumferentiales externae)
  – formed by apposition
• interstitial lamellae (lamellae interstitiales)
Bone tissue IV

- substantia compacta
  (textus osseus compactus; compact bone)
  – on the surface of the bones
  – ensures the strength

- substantia spongiosa
  (textus osseus spongiosus; trabecular bone, spongy bone)
  – inside of the bones
  – ensures the flexibility
Shape of the bones

• os longum (long bone)
• os breve (short bone)
• os planum (flat bone)
• os irregulare (irregular bone)
• os pneumaticum (pneumatized bone)
  – inside there is a cavity or cavities, padded by mucosa and filled with air
• ossa sesamoidea (sesamoid bone)
  – small bones placed in tendons
Os longum (long bone)

- **body**
  - thick layer of a compact bone
- **articular ends**
  - thin layer of a compact bone
  - inside there is a spongy bone
- **epiphysis**
  - terminal rounded part
  - during development separated by growth cartilage
- **metaphysis**
  - segment between epiphysis and diaphysis
  - in childhood locality of a growth cartilage
  - supplied by its own vessels
- **diaphysis**
  - middle part, body
- **apophysis**
  - part of a bone with separate ossification centre
  - bone protuberance for insertion of a tendon
Os breve (short bone)

- substantia corticalis (thin layer of a substantia compacta) on the surface
- spongy bone is inside
- irregular shape
- irregular articular surfaces

- carpal and tarsal bones
- vertebrae
Os planum (flat bone)

• substantia compacta
  – lamina externa
  – lamina interna
• substantia spongiosa
  – diploe
• scapula
• bones of the calvaria
Bone marrow (*medulla ossium*)

- **fills in all the spaces in a spongy bone and marrow cavities of the diaphyses of long bones**
- red bone marrow (*medulla ossium rubra*)
  - haemopoiesis
  - 3-D net of the reticular connective tissue, weaved by wide capillaries
- yellow bone marrow (*medulla ossium flava*)
  - replaces the red bone marrow by penetrating the fat cells
- grey bone marrow (*medulla ossium grisea*)
  - generated from the yellow marrow by loss of fat
Distribution of the red bone marrow in childhood and adulthood
Sternal puncture

• cytological examination of the bone marrow
Trepanobiopsy

• biopsy of the part of the bone marrow with spongy bone and bone marrow for histological analysis

• taking from the wing of ilium
Periosteum I

• covers the outer surface of a bone (= fibrous envelope of a bone)

• is absent:
  – on connections with the muscle, with joint capsule
  – on articular ends of the bones covered by cartilage

• Sharpey fibres (*fasciculi collageni perforantes, perforating collagen fibre bundle*)
  – periosteal fibres piercing the bone (fixation of the periosteum)
Periosteum II

• layers
  – *stratum fibrosum (fibrous layer)*
    • superficially
    • dense fibrous tissue, lengthwise situated fibres
  – *stratum osteogenicum (osteogenic layer)*
    • deep
    • irregularly situated fibres and *numerous vessels* penetrating the bone in *Volkmann* canals
    • growth of the bone widthwise in growth or regeneration by osteoblasts

• rich sensory inervation – *pain*
Endosteum

- between the bone tissue and the bone marrow
- similar structure and character to the periosteum
Genesis and development of the bones I

• dual phylogenetic development
  – 1. in subcutaneous fibrous tissue
    • primary bones
    • origin by **membranous** ossification (ossification from fibrous tissue)
  – 2. part of profound skeleton - cartilaginous
    • secondary bones
    • origin by **chondral** ossification – two types:
      – 1. perichondral ossification (**ossificatio perichondralis**) – superficial ossification from perichondrium
      – 2. endochondral ossification (**ossificatio endochondralis**) – ossification inside of the cartilage
Genesis and development of the bones II

• differentiation of mesenchymal cells into osteoblasts
  production of uncalcified precursors osteoid, in it is
  the generation of fibrils and conversion of osteoblasts into
  osteocytes

• osteoblasts form bone lamellae – further increase in the
  amount by apposition

• restructuring of the bone by osteoclasts: reabsorption and
  subsequent substitution with the new bone

• A) (intra)membranous ossification (\textit{ossificatio desmalis})
  – proliferation and vascularization in mesenchyme in the middle of the future bone,
    spreads to the periphery
  – \textit{bones of calvaria, bones of facial skeleton, most of the clavicle}

• B) chondral ossification (\textit{ossificatio chondralis})
  – 2 stages
    • hypertrophy and destruction of chondrocytes
    • penetration of osteogenic buds (osteoprogenitoric cells and blood capillaries) into
      abandoned areas
Ossification of long bones

- begins as perichondral, in the middle of the length of the bone
- subsequently is endochondral (transformations in cartilage precedes)
- penetration of buds of mesenchyme with vessels into altered cartilage → differentiation of cells of primitive bone marrow and osteoblasts
- ossification centre (*centrum ossificationis*)
- diaphysis and epiphyses have ossification centres of their own
- during time of growth there is a growth plate (*epiphysial cartilage; cartilago epiphysialis*) between diaphysis and epiphysis

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Growth of bone lengthwise I

• growth plate
  – resting zone (zona quiescens)
  – proliferation zone (zona proliferationis)
  – hypertrophic zone (zona hypertrophica)
  – calcification zone (zona calcificationis)
  – ossification zone (zona ossificationis)
Growth of bone lengthwise II

• different activity of distal and proximal growth cartilage
  – humerus and crural bones: more proximal
  – femur and forearm bones: more distal
    ➢ characteristic direction of entry of vasa nutricia

• growth plate disappears between 14th – 18th year → end of growth
Growth of bone widthwise

- from periosteum, partially also from endosteum
- principle of apposition and reabsorption
- participation of osteoblasts from osteogenic layer of periosteum
Growth of flat bones

• is under way from places of cranial sutures
Ossification of short bones

• exclusively endochondral
• pneumatized bones develop progressively after birth by intussusception of mucosa of nasal cavity (or tympanic cavity into temporal bone)

– sinus sphenoidalis, frontalis, maxillaris, cellulae ethmoidales, mastoideae
Bone age I

• indicator of biological age, determines the level of maturity of a bone
• detected by X-ray picture of a hand and distal forearm of the left upper limb (UL)
• methods:
  – *Greulich-Pyle*
    • comparing X-ray pics with photographic standards
  – *Tanner-Whitehouse*
    • rating of shape, size of ossification centres of 20 bones and their reciprocal relation
Bone age II

bone age     3 years  11 years  16,5 years

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Vascular supply of bones I

• to diaphysis
  – a. nutricia
    • arises from the 1st vessel that entered the diaphysis by ossification
    • connected to vessels in bone tissue (from periosteum)
  – periosteal vessels
    • the greatest amount of vessels entering the bone
    • enter through Volkmann canals
  – aa. metaphysariae
    • branching deep in spongy bone
      – nutrition for bone tissue and marrow

• to epiphysis
  – aa. epiphysariae
Vascular supply of bones II

• short bones
  – similar to epiphyses of the long bones
  – entry of the vessels on surfaces facing the joint capsules and ligaments

• flat bones
  – aa. nutriciae
  – periosteal vessels

• veins
  – along the arteries and canals of their own
Inervation of bones

• rich inervation of the periosteum (pain by hitting)

• thin neural fibres going parallel along vessels up to the *Havers* canals (most likely supply only vessels)
Bone restructuring

- osteoclasts eliminate the bone from the surface or from the inside of the osteon
- new cavities are filled up with new concentric lamellae from the periphery to the centre →
new *Havers* canal
Mechanical characteristics of bones

- very firm
- ability to tolerate enormous static strain
Osteoporosis

= loss of Ca and other minerals
- affected is especially the spongy bone
- effortless fragility, decrease of body height, reduced mobility

normal

pathological

http://www.shoulderkneecenter.com/hip_symptoms.htm
http://liveonearth.livejournal.com/512848.html

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Osteopetrosis

- disturbed activity of osteoclasts
- damaged reabsorption of a bone
- reduction of the bone cavity, compression of surrounding structures, increased fragility
Osteomalacia

- lack of vitamin D in adulthood
- deformities, noticeable muscle weakness

http://mymed.ro/rahitismul-i-osteomalacia.html