AGE-AT-DEATH ESTIMATION – Notes for Human biology course

- **chronological age:** it is defined by time: how many calendrical years, months, and days have passed since birth
- **biological age:** refers to the physiological state of an individual (e.g. which is reflected in skeletal remains)
- a general correlation exists between biological and chronological age
- we can use the biological age estimate (from the remains) to predict chronological age
- biological age is dependent on genetic and environmental factors and consequently activity, health and nutrition may all influence biological age by altering the aging rate of various tissues
- because these influences may vary between individuals, at any given chronological age, individuals within a population may display various biological ages
- the accumulation of these extrinsic factors resulting in greater variation in biological age by ageing
- because growth and development are programmed more strictly by genetics than adult degenerative processes, skeletal growth characteristics such as long-bone lengths, epiphyseal fusion and dental eruption provide a more precise and accurate indication of age than most adult skeletal traits
- markers of adulthood: the complete fusion of all long-bone epiphyses, the eruption of the third molars, the fusion of the spheno-occipital synchondrosis
- age estimation depends in part on the skeletal elements available for analysis
- metric and non-metric traits as well as the composition of the bones can be used for age estimation
- any disturbance of normal growth patterns, such as nutritional deficiency or chronic illness, introduces a potential source of error in age estimation
- the multifactorial techniques increase accuracy
- determination of age at death from the bones and teeth gets less precise as a person gets older: age estimation is usually most accurate in individuals still growing: in mature individuals, most standards generally rely on the highly variable deterioration of morphological markers (e.g. pubic symphysis; sacro-iliac joint; sternal rib ends) that are more influenced by environmental factors, as opposed to the more predictable and well-documented developmental markers characteristic of the juvenile skeleton (e.g. dental development; skeletal growth and maturation)

Age-at-death estimation – In subadults

- **dentition:**

- a developmental characteristic for age assessment
- teeth begin to develop before birth, and they continue in various stages of formation and loss until around 18 years of age
- there are many dental standards available
- by observing the stage of tooth formation, the stages can be compared to charts and tables to determine the appropriate age interval
- age estimation from teeth can be performed using radiographic evaluation of root development and mineralization (preferred) and/or macroscopic observation of tooth emergence patterns
- the timing of developmental stages of dental development, the times of eruption of temporary and permanent teeth are fairly constant
- the temporary teeth will guide from six months to thirty-three months while the permanent teeth will help from six years to twenty-five years in age estimation
- weakness: development of teeth is known to be affected by dietary, climatic, racial and geographical variations
- ***method of Ubelaker:*** a widely applied dental aging standard (the composite visual system)
- provides schematic representations of tooth formation and eruption suitable for individuals aged 5 months in uterus through to 25 years
- in cases with a developing dentition the estimated age range can be narrowed to 2–4 years
- limitation of dental developmental standards: at around 14 years most teeth are fully developed and age estimation becomes increasingly difficult – at this stage the third molars are the only teeth still developing (it is also frequently congenitally absent)

- **skeletal growth:**

- skeletal maturity is a developmental measurement of bone size, shape and degree of ossification relative to full maturity
- subadult age-at-death estimations are based on metrical analysis and the macroscopic (including radiographic where required) assessment of the morphology of ossification centers, including their size and timing of initial appearance, through to subsequent fusion
- **bone development:** bones can be classified according to their shapes:
- long bones (humerus, femur, etc.); short bones (ossa carpi, vertebrae, etc.); flat bones (os parietale, scapula, etc.); irregular (os ethmoidale, os sphenoidale, etc.)
- the general structure of a long bone: at each end of a long bone there is an expanded portion (epiphysis), which forms a joint with another bone; the corpus of the bone, which is located between the epiphyses (diaphysis)
- in long bones, the growth and elongation continue from birth through adolescence
- elongation is achieved by the activity of two cartilage plates (epiphyseal plates) – located between the diaphysis and epiphyses of the bones
- the plates expand, forming new cells, and increasing the length of the diaphysis
- the length of the diaphysis increases at both ends – each epiphyses of the bone moves progressively apart
- as the thickness of epiphyseal plates gradually decreases and the bone lengthening process ends
- different bones stop lengthening at different ages, but ossification is fully complete by age 25
- medical imaging of the living people offers a useful complementary source of data
- features of bones for age estimation: epiphyseal fusion: a useful method for assessing juvenile remains; long bone length (diaphyseal length): especially useful for assessing infant remains (for fetal and newborn remains); long bone length (diaphyseal length; method of Stloukal and Hanakova 1978); epiphyseal fusion (methods of Ferembach et al. 1979 and Schinz et al. 1952)

Age-at-death estimation – In adults

- the methods are largely based on morphological and degenerative changes of bones
- limitations: (1) individualistic factors (e.g. lifestyle, health and nutrition) can influence skeletal remodelling throughout life; (2) different parts of the skeleton can thus 'age' at different rates

- age estimation from the os coxae (pubic symphysis): Todd's method *(1920):*

- include both males and females of different ethnic backgrounds and to incorporate additional patterns of symphyseal metamorphosis
- symphyseal face rugged → smooth
- dorsal and ventral delimiting margins appear → oval outline completed
- no extremity on the upper and lower surface → extremities clearly defined
- trait progression begins with billowing of the pubic symphysis in young adults
- these billows begin to fill in on the dorsal margin and ossific nodules appear on the superior and inferior surfaces
- as the billows continue to fill in and the ossific nodules spread, dorsal and ventral margins become better defined, forming the symphyseal rim in middle-aged adults
- the pubic symphysis is characterized by more degenerative features such as lipping, erosion, and breakdown of the symphyseal rim

Phase 1: Symphyseal face rugged, traversed by horizontal ridges separated by well-marked grooves, there being no distinction in size between the upper and lower ridges. None of the following structures are present: nodules fusing with the surface, a delimiting margin, or definition of extremities. (Age, 18-19)

Phase 2: Symphyseal surface still rugged. Horizontal grooves are becoming filled near their dorsal limit with new, finely textured bone. Bony nodules may be present, fusing with upper symphyseal face. Dorsal delimiting margin begins to develop. No delimitation of the extremities. Ventral bevel commences. (Age, 20-21)

Phase 3: Symphyseal face shows progressive obliteration of ridge and furrow system. Commencing formation of a dorsal platform. Bony nodules may be present. Definition of dorsal margin, with sharp lipping. Ventral bevel more pronounced. Extremities not delimited. (Age, 22-24)

Phase 4: Great increase of ventral beveled area. Corresponding diminution of ridge and furrow formation. Complete definition of dorsal margin through the formation of the dorsal platform. Commencing delimitation of lower extremity. (Age, 25-26)

Phase 5: Little change in symphyseal face and dorsal platform. Margin more clearly defined and more sharply lipped. Lower extremity better defined. Upper extremity forming with or without the intervention of a bony nodule. (Age, 27-30)

Phase 6: Increasing definition of extremities. Development and practical completion of ventral rampart. Retention of some granular appearance of symphyseal face indicating that activity has not yet ceased. Failure of ventral aspect of pubis adjacent to ventral rampart to become transformed into a compact surface. The rampart may therefore be somewhat undermined. Retention of the pectinate outline of the dorsal margin and slight ridge and furrow system. No lipping of ventral margin and no increased lipping of dorsal margin. (Age, 30-35)

Phase 7: Face and ventral aspect change from granular to fine-grained or dense bone. Slight changes in symphyseal face and marked changes in ventral aspect from diminishing activity. No formation of symphyseal rim. No ossification of tendinous and ligamentous attachments. (Age, 35-39)

Phase 8: Symphyseal face and ventral aspect of pubic bone generally smooth and inactive. Oval outline complete. Extremities clearly defined. No distinct "rim" to symphyseal face. No marked lipping of ventral or dorsal margin. Development of ossification in tendinous and ligamentous attachments, especially those of sacro-tuberous ligament and gracilis muscle. (Age, 40-45)

Phase 9: Symphyseal face presents a more or less marked rim. Dorsal margin uniformly lipped; ventral margin irregularly lipped. (Age, 45-49)

Phase 10: Ventral margin eroded at a greater or lesser extent of its length, continuing somewhat onto the symphyseal face. Rarefaction of face and irregular ossification. Disfigurement increases with age.

- age estimation from the sternal end of the ribs: Iscan's method *(1984):*

- by studying features of the costochondral junction of the right fourth rib:
- the shape and depth of pit formation
- changes in the walls and surrounding rim
- overall bone texture and density
- the first stage: the sternal end of the fourth rib is flat → with age, a pit begins to develop that gradually gets deeper and wider → as the pit increases in size, the margins of the pit walls get thinner and more irregular → bony spurs will form on the margins of the walls due to the ossification of the costal cartilage that joins the ribs to the sternum: final stage

Stage 0: the articular surface is flat or billowy with a regular rim and rounded edges. The bone itself is smooth, firm, and very solid.
Stage 1: There is a beginning amorphous indentation in the articular surface, but billowing may also still be present. The rim is rounded and regular. In some cases scallops may start to appear at the edges. The bone is still firm, smooth, and solid
Stage 2: the pit is now deeper and has assumed a V-shaped appearance formed by the anterior and posterior walls; the walls are thick and smooth with a scalloped or slightly wavy rim with rounded edges; the bone is firm and solid.
Stage 3: the deepening pit has taken on a narrow to moderately U-shape; walls are still fairly thick with rounded edges; some scalloping may still be present but the rim is becoming more irregular; the bone is still quite firm and solid.
Stage 4: pit depth is increasing, but the shape is still a narrow to moderately wide U; the walls are thinner, but the edges remain rounded; the rim is more irregular with no uniform scalloping pattern remaining; there is some decrease in the weight and firmness of the bone, however, the overall quality of the bone is still good
Stage 5: there is little change in pit depth, but the shape in this phase is predominantly a moderately wide U; walls show further thinning and the edges are becoming sharp. Irregularity is increasing in the rim; scalloping pattern is completely gone and has been replaced with irregular bony projections; the condition of the bone is fairly good, however, there are some signs of deterioration with evidence of porosity and loss of density
Stage 6: the pit is noticeably deep with a wide U-shape; the walls are thin with sharp edges; the rim is irregular and exhibits some rather long bony projections that are frequently more pronounced at the superior and inferior borders; the bone is noticeably lighter in weight, thinner, and more porous, especially inside the pit
Stage 7: pit is deep with a wide to very wide U-shape; the walls are thin and fragile with sharp, irregular edges and bony projections; the bone is light in weight and brittle with significant deterioration in quality and obvious porosity
Stage 8: the pit is very deep and widely U-shaped; in some cases the floor of the pit is absent or filled with bony projections; the walls are extremely thin, fragile, and brittle, with sharp, highly irregular edges and bony projections; the bone is very lightweight, thin, brittle, friable, and porous; „window" formation is sometimes seen in the walls

- age estimation from cranial sutures:

- most systems involve macroscopically rating the degree of suture closure into one of several categories, ranging from completely open through to complete obliteration
- a composite score is then calculated and used to derive a mean age estimate, although the range within closure groups for the aforementioned systems is generally is in the order of 30+ years

- method of Meindl and Lovejoy (1985)

- the scoring system

0 = open, no evidence of ectocranial closure – 0% synostosis
1 = some closure has occurred – 1-50% synostosis
2 = a marked degree of closure – 51-99% synostosis
3 = complete obliteration (site is completely fused) – 100% synostosis

- the observation sites: the authors narrowed down 10 specific sites for observation and limited their study to **ectocranial** sutures to increase the practicality

- the observation sites (points):

1: midlambdoid
2: lambda
3: obelion
4: anterior sagittal
5: bregma
6: midcoronal
7: pterion
8: sphenofrontal
9: inferior sphenotemporal
10: superior sphenotemporal