• discovery of neanderthals
  – Engis Cave 1829; Forbes’ Quarry 1848; *Feldhofer Cave 1856; Spy 1886; 1930s in West Asia
  – King vs. Virchow
    • extinct species vs. pathology?
• geological antiquity
  – \(^{18}O/^{16}O\) Stages 186-25 ka
    • early: Baiche-Saint-Vaast 186 ka; Krapina 130 ka; Saccopastore 127-71 ka; Tabun E and Zuttiyeh Cave OIS 5? (dating gap)
    • middle: Europe and West Asia OIS 4 (71-45 ka)
    • late: Zafarraya 33ka; Arcy-sur-Cure 34 ka; Saint-Cesaire 36 ka; Vindija 28ka! (bone collagen)
• neanderthal anatomy
  – cranial/post-cranial robusticity
• contemporary hominids
  – earliest AMH
  – Europe: Les Eyzies 30 ka; Aurignacian ca. 40 ka
  – W. Asia: Skhul-Qafzeh 120-80 ka
• neanderthal functional anatomy
  – physical stress & endurance
    • upper body robusticity; “bowed” femur; mid-facial projection, large anterior dentition, rounded wear
  – cold adaptation
    • body shape/size; respiratory system; brain size
  – cognition/language
    • brain asymmetries; “relatively” flat basicranium; vertebral neural canals; Kebara hyoid
• species or sub-species?
  – pre-mating: chronological overlap, ecology overlap, mating behavior
  – post-mating: developmental biology
  – mtDNA from two Neandertals!

• Rudolf Virchow
  – fossils were modern humans displaying pathologies
    • rickets, arthritis, chronic pain
• William King
  – 1864 proposed that fossils from Europe were an “extinct species”
    • \textit{H. neanderthalensis}
• “pathology” argument impossible
  – would have to explain why all specimens display exact same pathological history
  – disease does not work this way…
• “great antiquity” established
  – association of neandertal fossils with stone tools and bones of extinct animals

• Oxygen Isotope Stages
  – OIS 6: 186-127 ka (penultimate glaciation)
  – OIS 5e-a: 127-71 ka (last interglacial)
  – OIS 4: 71-45 ka (early last glacial)
  – OIS 3: 45-25 ka (last interstadial)
  – OIS 2: 25-18 ka (last glacial maximum)
  – OIS 1: 18- present (terminal Pleistocene and Holocene)
• Neanderthals early group
  – OIS 6: 186-127 ka (penultimate glaciation)
    • Ehringsdorf Cave, Germany 242-186 ka U-Series/ESR
      – fauna and flora: 127-71 ka
    • Baiche-Saint-Vaast, France 190-159 ka
  – OIS 5e-a: 127-71 ka (last interglacial)
    • Krapina, Croatia 130 ka (most accepted)
    • Saccopastore, Italy
      – fauna and flora suggest OIS 5

• Neanderthals middle group
  – OIS 4: 71-45 ka (early glaciation)
    • majority of French fossils (?)
    • West Asian neanderthals
      – Kebara and Amud 65-47 ka
  – dating gap!

• Neanderthals late group
  – OIS 3: 45-25 ka (last interstadial)
    • Zafarraya 33ka
    • Arcy-sur-Cure 34 ka
    • Saint-Cesaire 36 ka
    • Vindija 28ka!
  – bone collagen dating
    • bone collagen often too young because of contamination

Amud 1, Israel

La Ferrasie, France

Saint-Cesaire, France

Krapina, Croatia ca. 130 ka
• cranial vault
  – long, low, relatively thin walled vault
  – mid-parietal maximum breadth
  – 1245-1740cc
  – double-arched browridge
  – supra-orbital sulcus
  – occipital bun
  – horizontal occipital torus
  – suprianiac fossa
  – less flexed basicrania

• facial anatomy
  – midline prognathicism
  – large nasal aperture
  – receding zygomatic
  – inflated maxillary above canine (no fossa)
  – large, round orbits
  – usually no chin
  – asymmetrical sigmoid notch on mandible

• dental anatomy
  – smaller cheek teeth
    (overlapping variability with AMH)
  – larger incisors
  – shovel-shaped maxillary incisors
  – rounded wear on all incisors (limited wear on P and M)
  – root fusion (taurodontism)
  – retromolar gap

• post-cranial anatomy
  – long cervical spines
  – modern hyoid bone
  – enlarged neural canals
  – thick, weakly curved ribs
  – broad, deep trunk
  – large muscle attachments
  – bowed femur shaft
  – short distal limb segments
  – average stature 166 cm (5’4”)

Amud 1, Israel
Saint-Cesaire, France
Shanidar 1, Iraq
Kebara 2, Israel
• neanderthal overview
  - long, low, “globular” skull
  - large cranial capacity
  - prognathic at midline with orbits and zygomatics “sweeping back”
  - robust, heavily muscled postcrania; barrel chested

Amud 1, Israel

• neanderthal contemporaries
  - East Asia =
    • late Homo erectus?
  - Sub-saharan Africa =
    • H. heidelbergensis?
    • early Anatomical Modern Humans?
  - West Asia =
    • early AMH!
    • Skhul-Qafzeh 120-80 ka
    • earlier than some neanderthals in West Asia!
  - Europe =
    • Cro-Magnon ca. 30 ka
    • Aurignacian Upper Paleolithic ca. 40 ka
      – this is a key issue!!!

Skhul 5, Israel

• anatomy of contemporaries
  - defined mostly on the absence of neanderthal traits!
  - large, rounded vault
  - less robust upper body
  - wide variability b/c
    • include fossils from a wide geographic area
      – sub-populations
    • mix of fossils from a broad temporal period
      – time averaging

• neanderthal functional anatomy
  - physical stress & endurance
    • upper body robusticity greater in neanderthals than contemporaries suggests greater muscular stresses on upper body
      – lower bodies similarly robust when scaled for body mass
    • slightly “bowed” femur with rounded shaft suggests greater stresses imposed by gluteus maximus which inserts onto gluteal ridge
    • midfacial projection, larger incisors and rounded wear on incisors suggest that anterior dentition used extensively as a “tool”
      – similar anterior dentition wear patterns seen in Inuit population
  - cold adaptation
    • body shape/size appears to follow Bergmann’s & Allen’s rules
      – $V = x^3$ while $SA = x^2$
    • distal limb segments are short relative to proximal limb segments (seen in many arctic populations)
    • barrel-shaped chest and massive nasal aperture and nasal cavities for air warming
    • brain size also follows Bergmann’s and Allen’s rules!
neanderthal functional anatomy

- cognition and language
  - brain asymmetries appear to be modern
    - left asymmetry in occipital region; right asymmetry in frontal
  - “relatively” flat basicranium
    - appears to have an impact on where the larynx “sits” in the throat, which impacts how well sound can be modified by the mouth
    - Klein concludes that Neanderthals maybe only produce a more limited range of sounds
      » Would this impair the development of a fully functional language?
  - vertebral neural canals are large compared to AMH
    - suggests at least a modern level of neuro-muscular control over ribcage and thus airflow used in vocalization
  - Kebara hyoid is essentially modern
    - hyoid bone forms the basis of muscular and cartilage attachments for the larynx and some muscles for floor of the mouth
    - may suggest that mouth muscles and larynx were fully functional as a speech organ

species or sub-species

- sub-species = a set of populations of a species that occupy different geographic areas and possess somewhat different characters; geographical variants of the same species
  - NOT REPRODUCTIVELY ISOLATED
- biological species = organisms that can mate and produce fertile offspring
  - REPRODUCTIVELY ISOLATED

pre-mating reproductive isolation =
- mechanisms that prevent mating from happening

post-mating reproductive isolation =
- mechanisms that prevent a fetus from developing to term OR
- mechanisms that lead hybrid offspring to be infertile themselves

Homo sapiens neanderthalensis or Homo neanderthalensis?

Klein phylogeny
heavily invested in model of neanderthals as separate species

- species or sub-species
  - pre-mating reproductive isolation = mechanisms that prevent mating from happening

- possible isolation IF…
  - there was no chronological overlap between neanderthals and anatomically modern humans
    » if they don’t meet in time they can’t mate
  - there was no ecological overlap between neanderthals and anatomically modern humans
    » if they don’t meet in space then they can’t mate
  - the behavioral features of one or both hominids were too unusual to produce any matings
    » if the “launch sequence” is wrong then no mating…
• species or sub-species
  – post-mating reproductive isolation = mechanisms that prevent development from happening
    • possible isolation **IF**…
      – developmental schedules are so different that a hybrid fetus does not develop properly and is spontaneously aborted
      – if sterile offspring result from successful matings

  • post-mating isolation
    – neanderthal developmental schedule…
      – reconstructed on basis of neanderthal fossils of different ages
      – some derived neanderthal features arise very early in development
        » large endocranial capacity
        » mid-facial projection
        » robusticity
      – early ontogeny of traits suggest more ancient evolution; longer period of separation
        » ontogeny recapitulates phylogeny

• mtDNA from neanderthal fossils!
  – Feldhofer neanderthal > 45 ka
  – Mesaiskaya neanderthal 29 ka

  – both fossils suggest greater genetic distance from AMH
    • HV1 and HV2
    • 23.8 mutations (differences) in mtDNA compared with AMH vs. 4.35 between any two modern Europeans

  – but, what does mtDNA tell us about reproductive isolation?