- dispersal of late *H. erectus*
  - entry into Europe
    - Orce, Spain ca. 1 mya
    - Gran Dolina >780 ka
    - abundant sites <500 ka
  - late *H. erectus* 600-250 ka
  - anatomical characteristics
    - Arago, Bilzingsleben 400 ka
    - Sima de los Huesos 300 ka
    - Stineheim, Swanscombe 250 ka
    - gradual “assembly” of neanderthal anatomy
  - Out of Africa, Again?
    - European carnivore guild
  - late *H. erectus* behavior
    - Torralba-Ambrona
    - cooperative hunting?
    - Bilzingsleben
      - structured use of space
      - hunter-gatherer social organization
    - Paleoclimate

- divergence of East Asian *Homo erectus*
  - allopatry = populations that occupy exclusive geographic ranges
  - sympathy = populations occupying the same, or overlapping ranges
  - allopatric populations do not exchange genes/culture and therefore can accumulate genetic/cultural differences via mutation/innovation

- if Asian *H. erectus* is an allopatric species…
  - “progressive” forms of late *H. erectus* in Asia must represent convergent evolution with archaic *Homo sapiens*
  - KEY: was Asian *H. erectus* reproductively isolated?
western Europe even more of a cul-de-sac?

- early group
  - Orce, Spain 1-0.78 mya
    - Oldowan stone tools
    - paleomag & fauna
  - Gran Dolina, Atapuerca, Spain
    - Oldowan and hominid fossils below Brunhes-Matuyama boundary (>780 ka)
    - *H. antecessor*?
    - *H. neanderthalensis*?

- middle group ca. 500
  - Arago, France
  - Bilzingsleben, Germany
  - Vertesszollos, Hungary
  - ancestral
    - occipital more angular
  - derived
    - parietal expansion
    - “incipient” retromolar gap

- late group ca. 300 ka
  - Sima de los Huesos
  - a “true” population
  - derived traits
    - robust mandible
    - robust lower limbs
    - double-arched brow ridges
    - incipient supraniac fossa
    - substantial mid-facial projection
    - large anterior teeth
    - retromolar space
    - rounded occipital profile

AT 5, Sima de los Huesos, Atapuerca, Spain
late *Homo erectus* anatomy
- ancestral traits
  - large brow ridges
  - low, flattened frontal bone
  - thick cranial walls
  - massive, chinless mandible
  - powerful postcranium
- derive traits
  - cranial capacity >1000 cc
  - rounded occipital region
  - expanded parietals
  - broader frontal bone
  - brow ridges distinctive arches
- anticipates neandertals?
  - similar to Asian trajectory?

classic neandertal
- robust, heavily muscled postcrania
- long, low, “globular” skull
- prognathic at midline
- occipital bun
- parietal expansion
- large cranial capacity
  - 1245-1740 cc
- retromolar gap
- root fusion (taurodontism)

Out of Africa, Again, and Again?
- late *H. erectus* (sensu lato; i.e., late *H. ergaster*)
  - evolved in Africa & dispersed ca. 500 ka
  - *Homo heidelbergensis*
    - we will consider again …come back after midterm
- late *H. erectus* (a.k.a. *H. antecessor*) first to permanently settle Europe
  - linked to Africa based on similarities between early groups in ancestral traits
  - …based on Acheulian in Europe

Klein phylogeny
Asian fossils are *H. erectus* (sensu stricto); European fossils are *H. neanderthalensis*

Rightmire phylogeny
Asian & European fossils are *H. heidelbergensis*
many (but not all) early European archaeological sites contain Acheulian bifaces

non-biface assemblages Clactonian, Tyacian...

Important assumptions about link between population biology and culture

Europe: why extensive only after 500 ka?
- no apparent biogeographic barrier?
- carnivore guild (group of larger carnivores) not African-like until after 500 ka
- No extensive “room” for hominids as a large-bodied predator until after this time?

dispersal a complex ecological process

late Homo erectus behavior
- cooperative hunting???
- Torralba-Ambrona, Spain, ca. 500 ka
  - faunal assemblage dominated by elephant and horse bones
  - Acheulian tools thinly scattered throughout bone assemblage
  - originally interpreted as elephant hunting camp
  - would require cooperation among individuals to be able to hunt such large and dangerous animals

Taphonomic reinterpretation
- most elephants old → natural death profile
- abundant carnivore coprolites → carnivore bone accumulation
- bones heavily weathered and abraded → stream flow and surface exposure
- few cutmarks → limited hominid involvement
late *Homo erectus* behavior
- cooperative hunting???
- Bilzingsleben, Germany, ca. 400 ka
  - elephant bones from young and old animals
  - elephant bone used as raw material for manufacturing tools
  - selective transport of “meaty” elements from young rhino as well as horse and bison
- Taphonomic issues
  - limited evidence of carnivore activity
  - animal fossils suggest that elephants scavenged, but rhino, horse and bison were hunted
- Note: wooden hunting spears from Schoningen, Germany (also ca. 400 ka) are good evidence of extensive hunting activity

structure use of space
- Bilzingsleben ca. 400 ka
  - evidence
    - ovals/circles of debris
    - discrete clusters of charcoal
    - discrete clusters of “ anvils” and worked stone/bone
  - interpretation
    - structures
    - family hearths
    - communal workshop
  - modern hg organization?
    - living area divided between families
    - communal area for socializing and cooperative labor
  - home base hypothesis finally works?
    - sexual division of labor; intensive social activity

cold

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warm

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glacial periods when massive ice sheets expanded on the continents
Milankovitch Cycles
- eccentricity 100 ka
- obliquity 41 ka
- precession 19/22 ka
- changes distribution of incoming solar energy just enough to shift liquid water to ice (or visa versa)
- summer insolation in the Northern hemisphere is insufficient to melt winter snowfall; ice sheets grow!

Millennial-scale climate oscillations
- abrupt shifts in global temp every 1000-1200 years, driven by
- oceanic and atmospheric circulation are primary cause

oxygen isotopes $^{18}$O/$^{16}$O
- fluctuations in the $^{18}$O/$^{16}$O ratio in the carbonate (CaCO$_3$) “shells” of marine organisms record changes in the amount of ice on the continents
- proxy record for changes between cold-glacial and warm-interglacial conditions
- eye on the ball…
- fluctuations produced changes in environmental conditions for human behavioral evolution
- Climate change leads to dramatic reorganization of terrestrial ecosystems
  - Shift of species/communities in space
  - Creation of new "assemblages" of species

$^{18}$O depleted relative to $^{16}$O = Interglacial
$^{18}$O enriched relative to $^{16}$O = Glacial

Cold Glacial labeled with EVEN numbers
Warm Interglacial labeled with ODD numbers

Sea level – Transformed continents
Last Glacial Maximum 18-22 ka
–120 m below modern