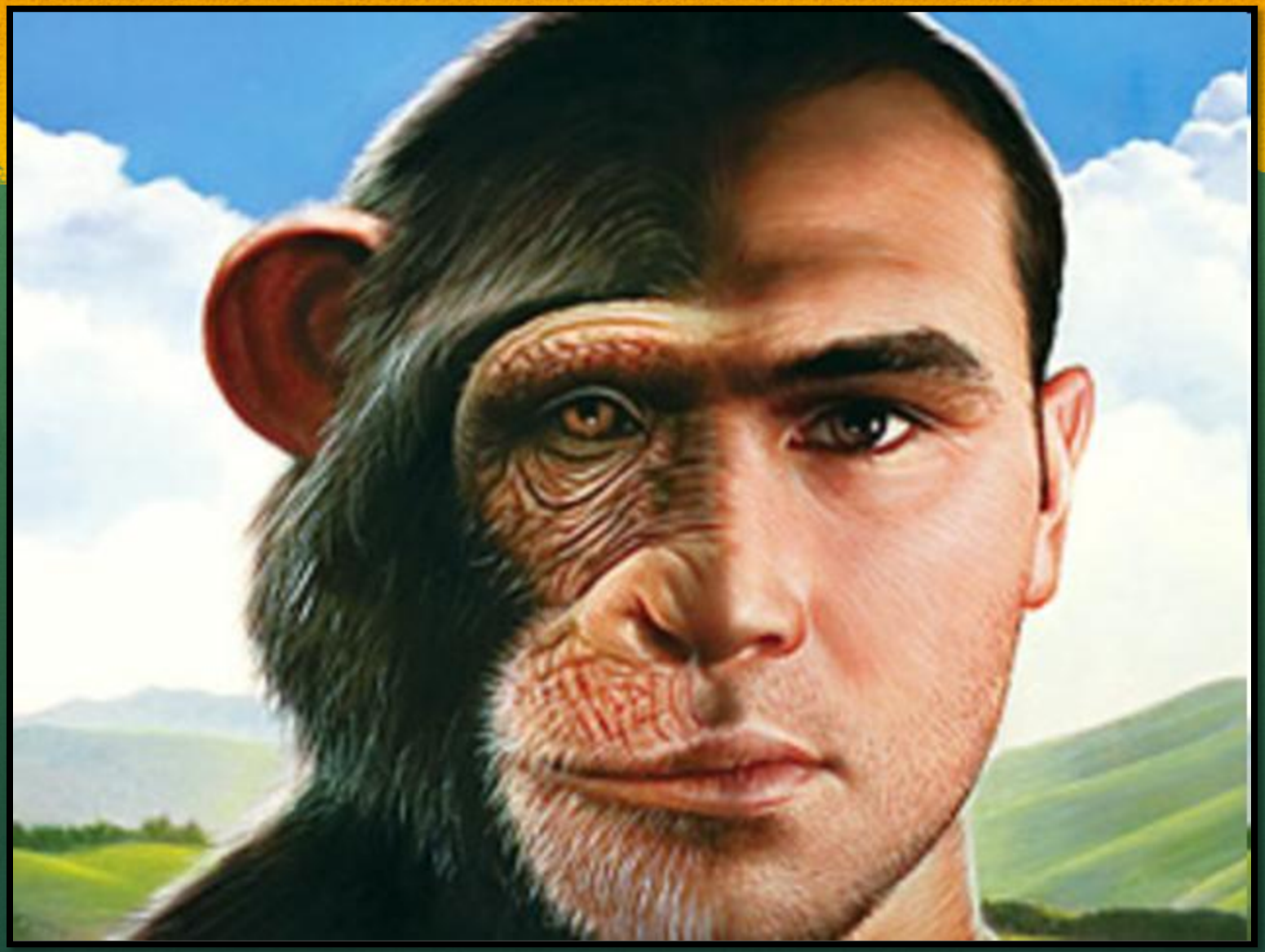
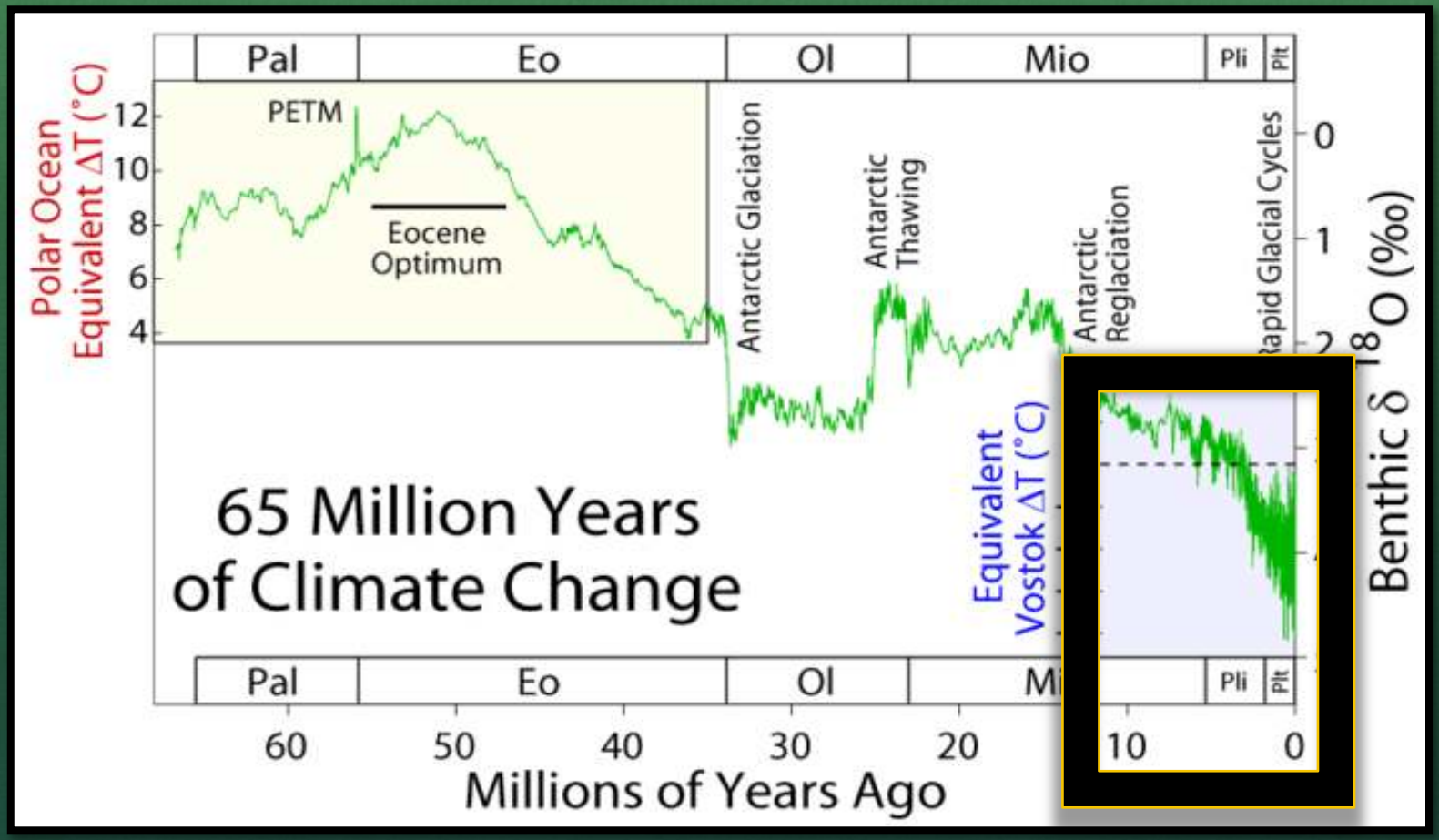
Nicholas Cappon

Bipedalism, tool use & language as the primary influences of brain development between *Australopithecus & Homo erectus*



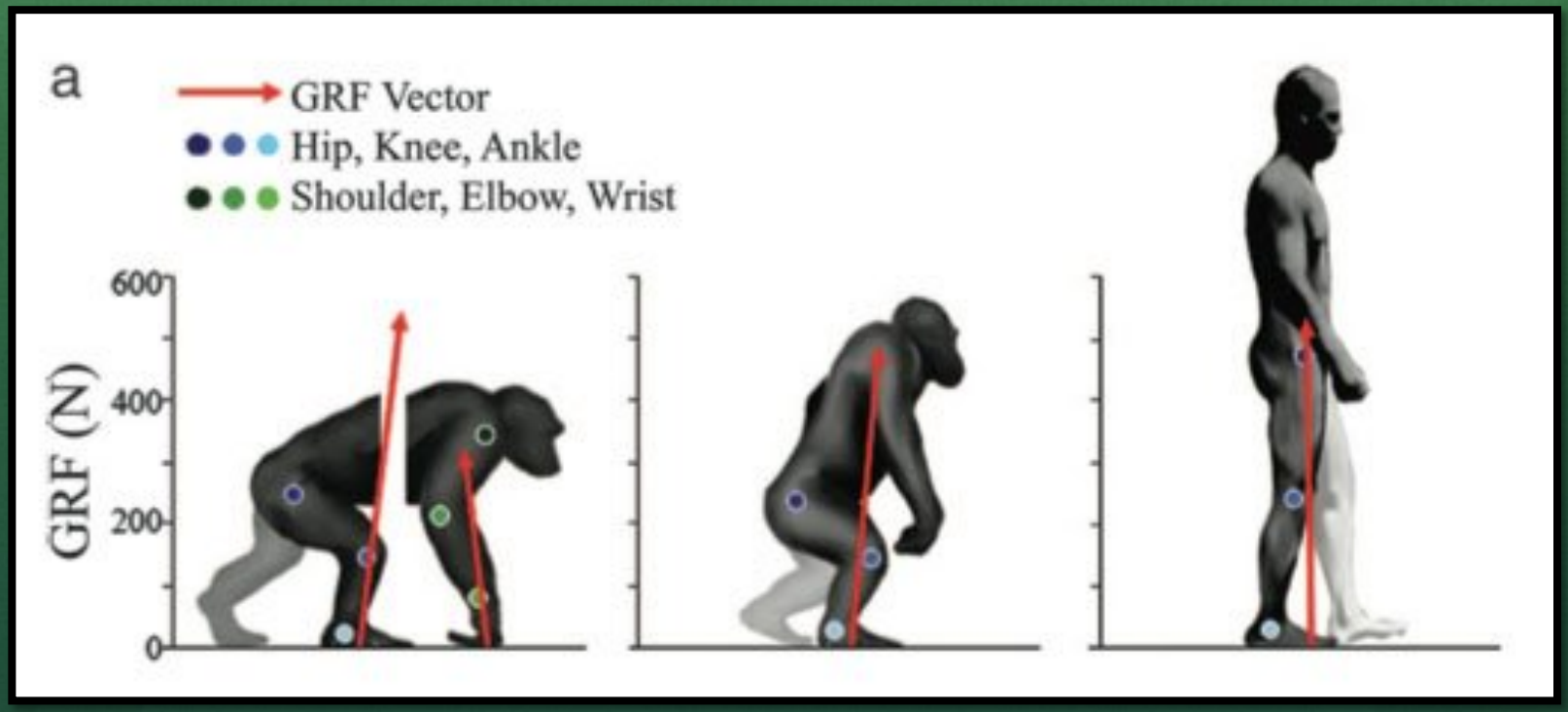
Climate Shift



Climate Shift

- ~16 mya global cooling trend began to occur (Zachos et al. 2001, Elton 2008)
- Came in flares such as the one 7-9 mya at Miocene-Pliocene boundary when early hominids lived
- At this time primates had to either adapt or face extinction like many other species
- The loss of the normal jungle habitat forced primates out of the trees and onto the grasslands, exposing them to new predators and challenges

Bipedalism



http://einekleinenachtblog.blogspot.com/2007/07/evolution-of-bipedalism.html

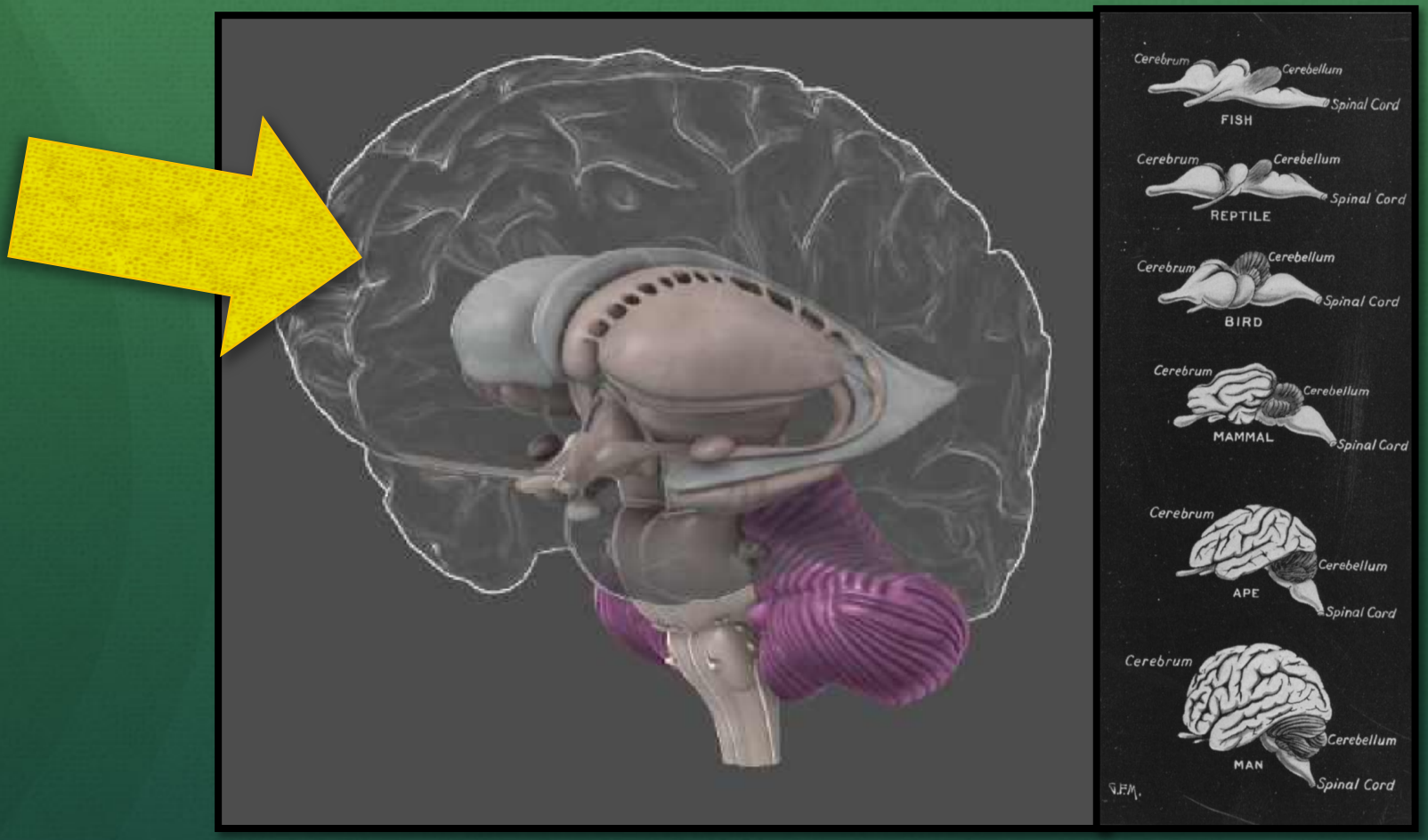
Bipedalism

- Response to the loss of jungle (arboreal locomotion), early primate ancestors adopted bipedalism
- Developed in last common ancestor (LCA)
- Possibly S. *Tchadensis* (6-7) mya (Brunet et al. 2002)
- Allowed standing up right on two feet
- This freed the hands for grasping and tool use
- Bipedalism and brain development separate process

Australopithecus

- Appeared ~3.6 mya (*A. afarensis*)
- Relatively larger brain, but still 1/3 of modern human
- Modified hand (lacks opposable thumb) shows tool use
- Bipedal locomotion (foramen magnum forward position)
- Increased tool use ~3.2 mya
- Replaced about ~2.0 mya
- Increasing diet weather by scavenging or hunting (no fire)

Cerebral Cortex Rewiring



Cerebral Cortex Rewiring

- Tool use and bipedalism had tremendous impacts on the brain and its development
- Symbiotic processes occurred ~2-3 mya
- Cerebral cortex (outer layer of the brain) saw increased development
- Cerebral cortex is where complex mental functions related to language, voluntary movement, thought and strategic planning occur

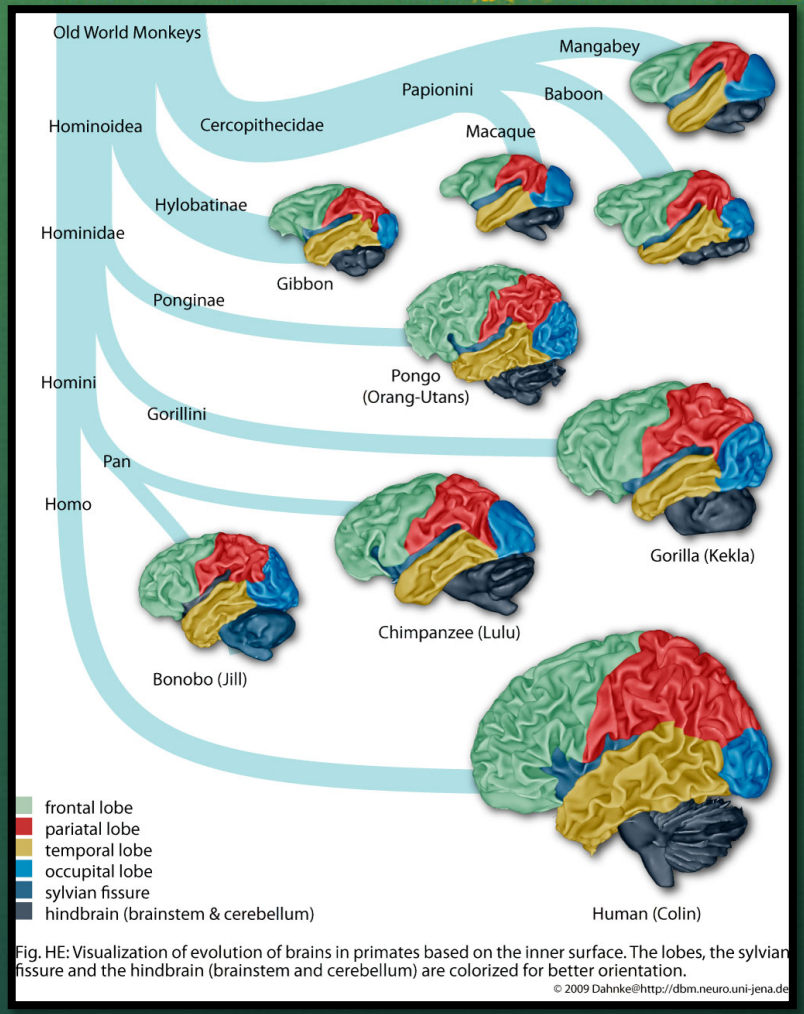
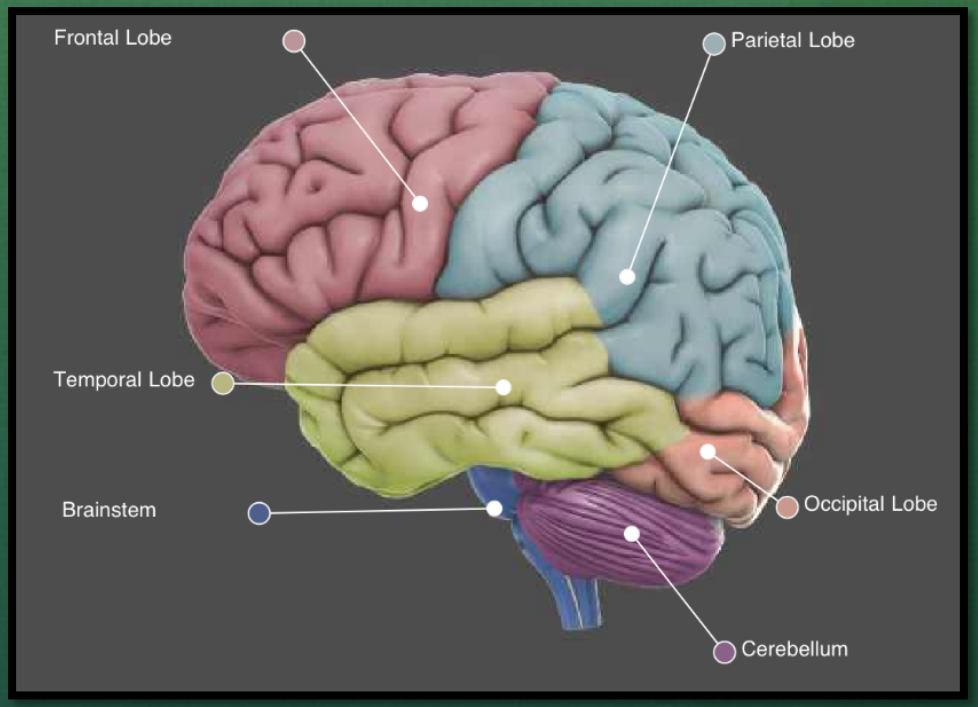


Fig. HE: Visualization of evolution of brains in primates based on the inner surface. The lobes, the sylvian fissure and the hindbrain (brainstem and cerebellum) are colorized for better orientation.

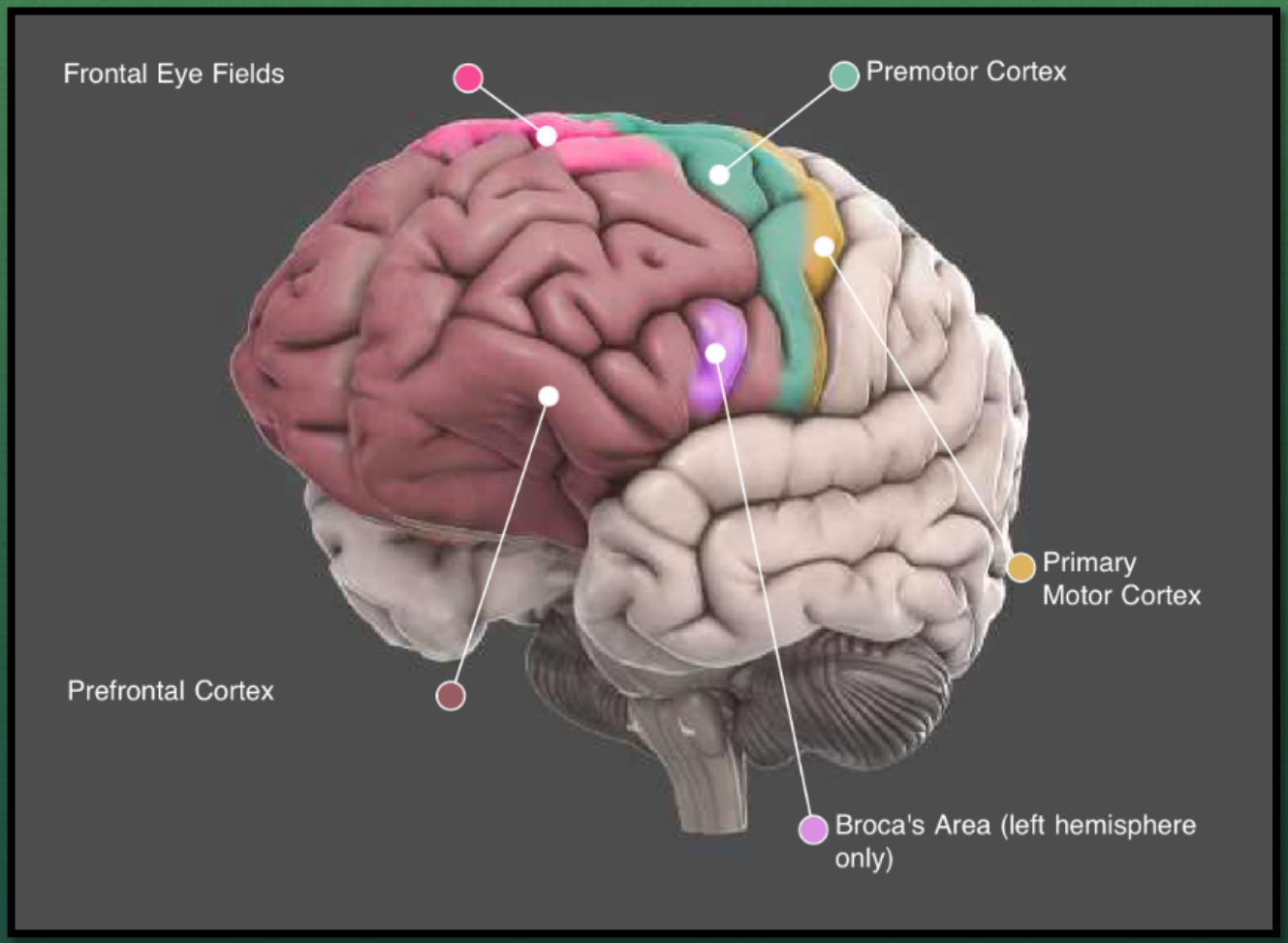
http://dbm.neuro.uni-jena.de/research/evolution-and-development/

Cerebral Cortex Rewiring

- Human-like position of the lunate sulcus proved cerebral reorganization in *Australopithecus africanus* (Dart 1925, Holloway et al. 2009)
- Gene for cerebral cortex growth duplicated multiple times 2-3 mya (Dennis et al. 2012)
- Environmental impacts on morphology of body
- Cerebral cortex subdivided into 4 lobes



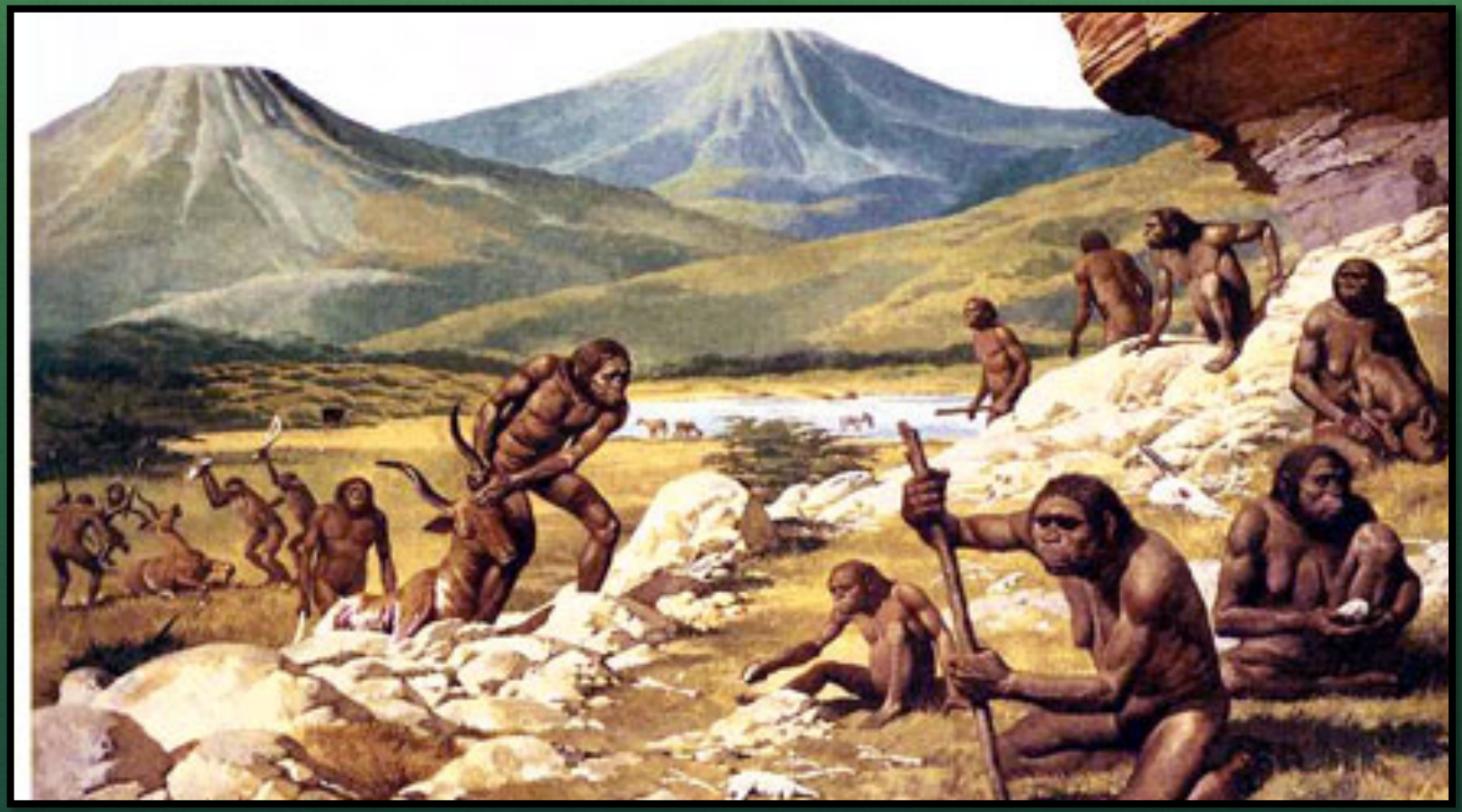
Frontal Lobe



Frontal Lobe

- *Australopithecus* saw increased frontal lobe size
- Contains primary motor and premotor cortex
- These areas responsible for voluntary movement
- Disproportionate proportion of neurons related to hand, arm and shoulder use (Meier et al. 2008)
- Contains Broca's are (2.0 – 1.8 mya), responsible for language (same region as voluntary muscle control)
- Structures seen imprinted on interior of skull upon death
- Prefrontal cortex responsible for ideas and planning (tools)

Tool Use Influences

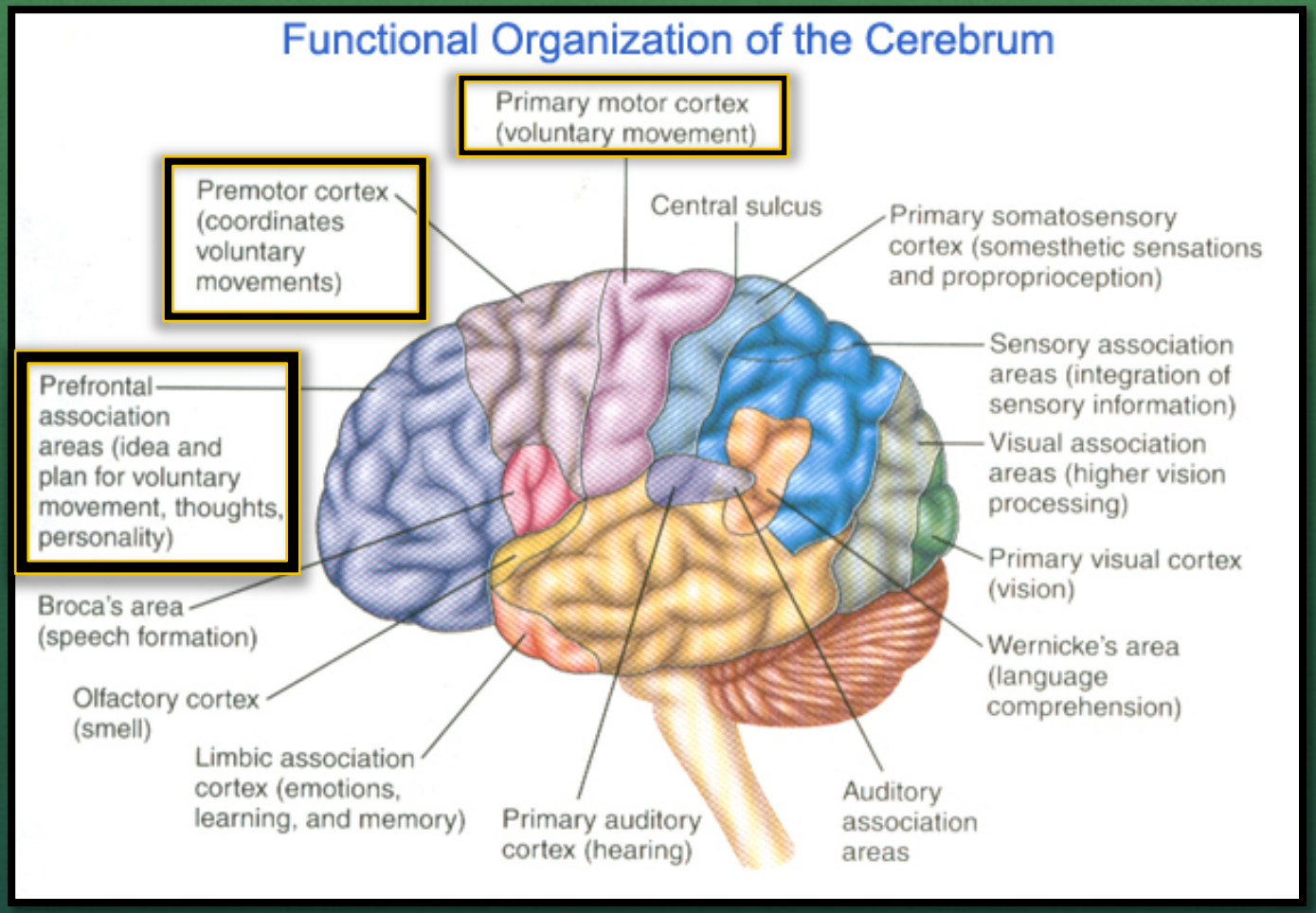


http://www.memo.fr/en/dossier.aspx?ID=550

Tool Use Influences

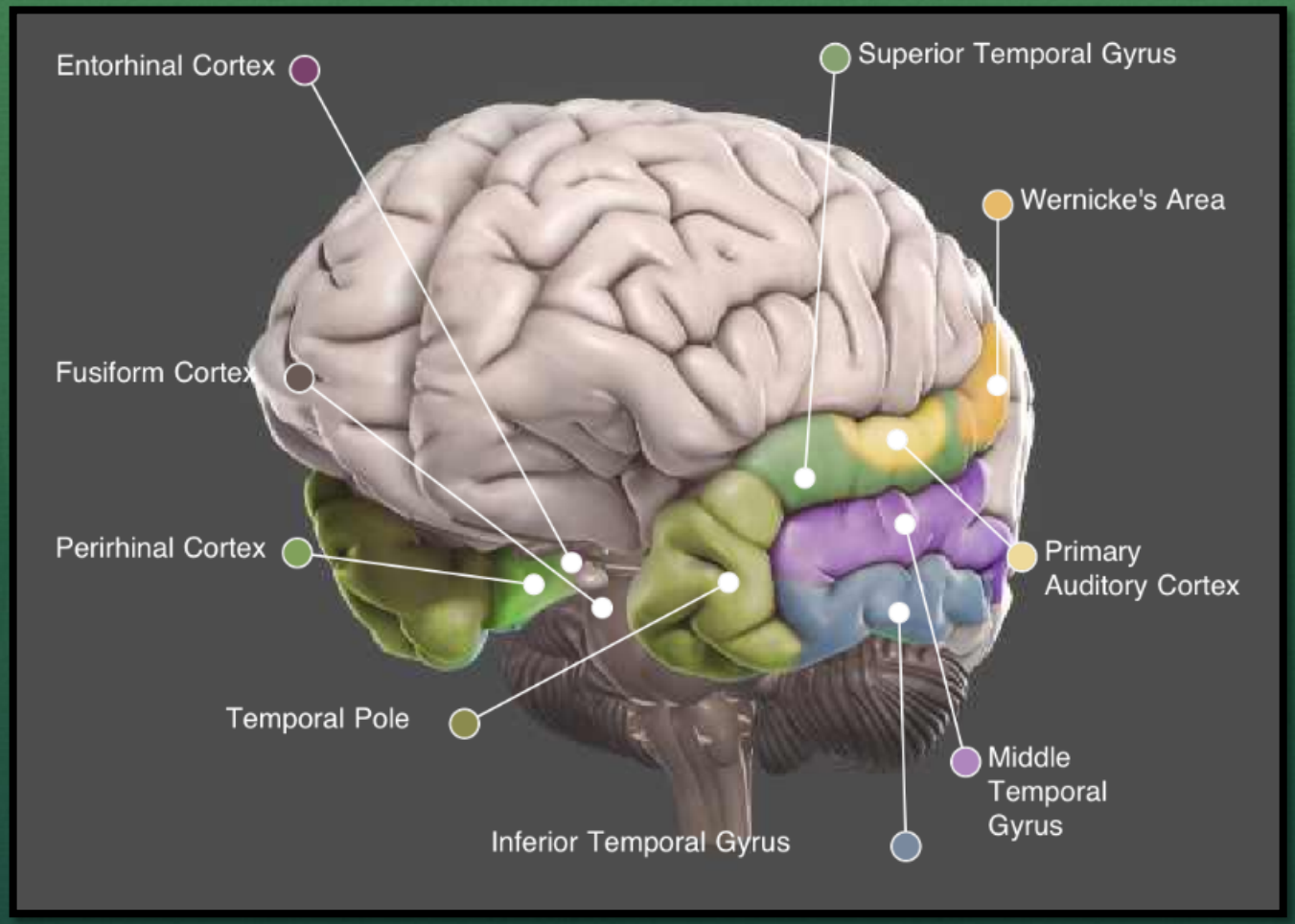
- Earliest Oldowan stone tool use dated to 3.6 mya (*Australopithecus*) – Morphological hand changes – 3.2 mya
- Tool making is a complex mental process (sustained impact on body)
- Technique vs. Technology (Gibson 1990)
- Construction of tools from mental plans
- Manipulation of the hand for different grips
- Improved dexterity of the body
- Improved control over voluntary movement allowed moving on two feet and using two hands possible in different ways than before

Tool Use Influences



http://www.liquidarea.com/wp-content/uploads/2009/10/broca_area.jpg

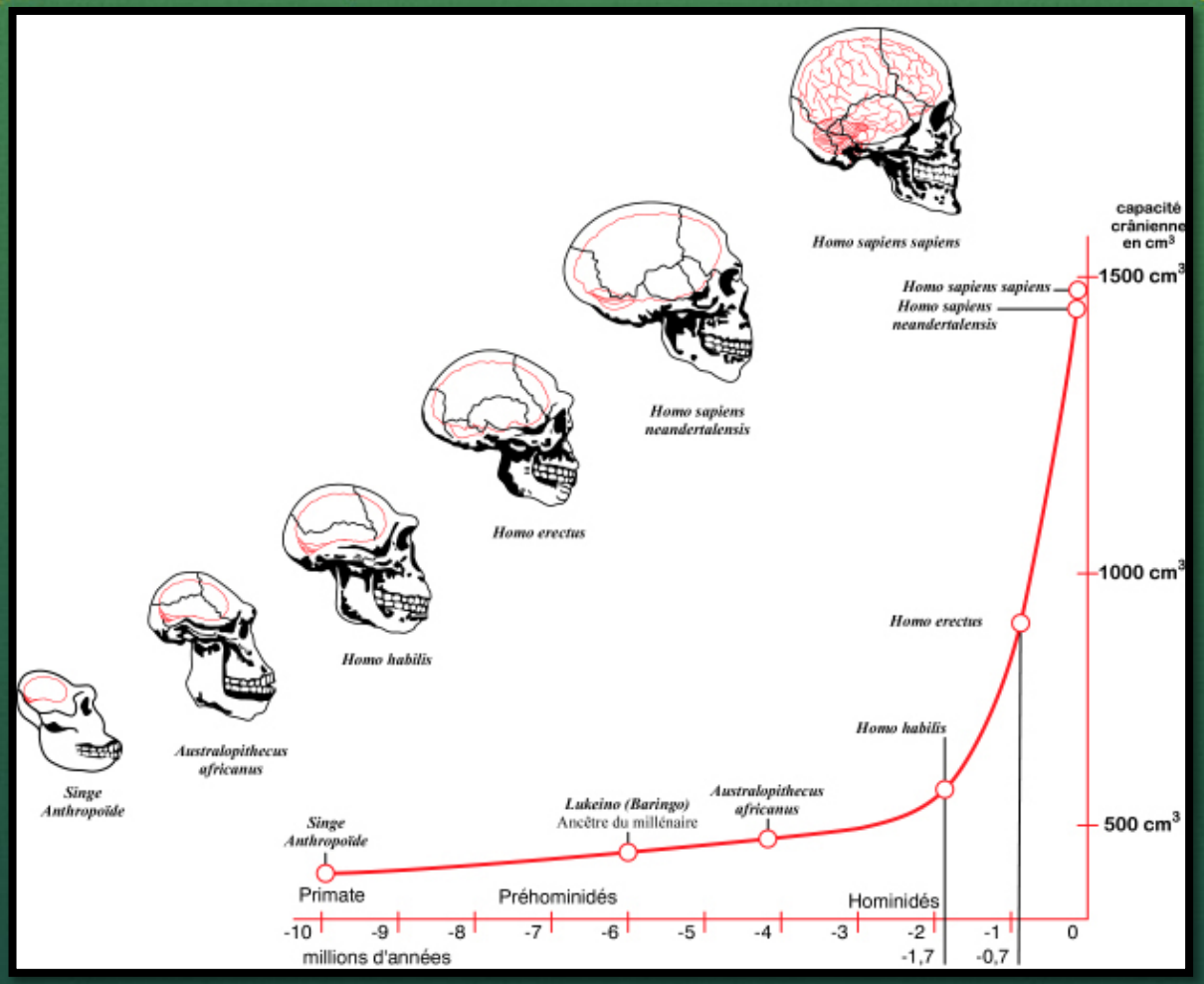
Temporal Lobe



Temporal Lobe

- Location of the primary auditory cortex and Wernicke's area (center of language)
- Wernicke area responsible for processing of spoken and written language
- Linked to Broca's area through the cerebral cortex
- Broca's and Wernicke area defined on *H. hablis* & *rudolfensis*, however possible before
- Contains limbic cortex responsible for memory

Rapid Brain Growth



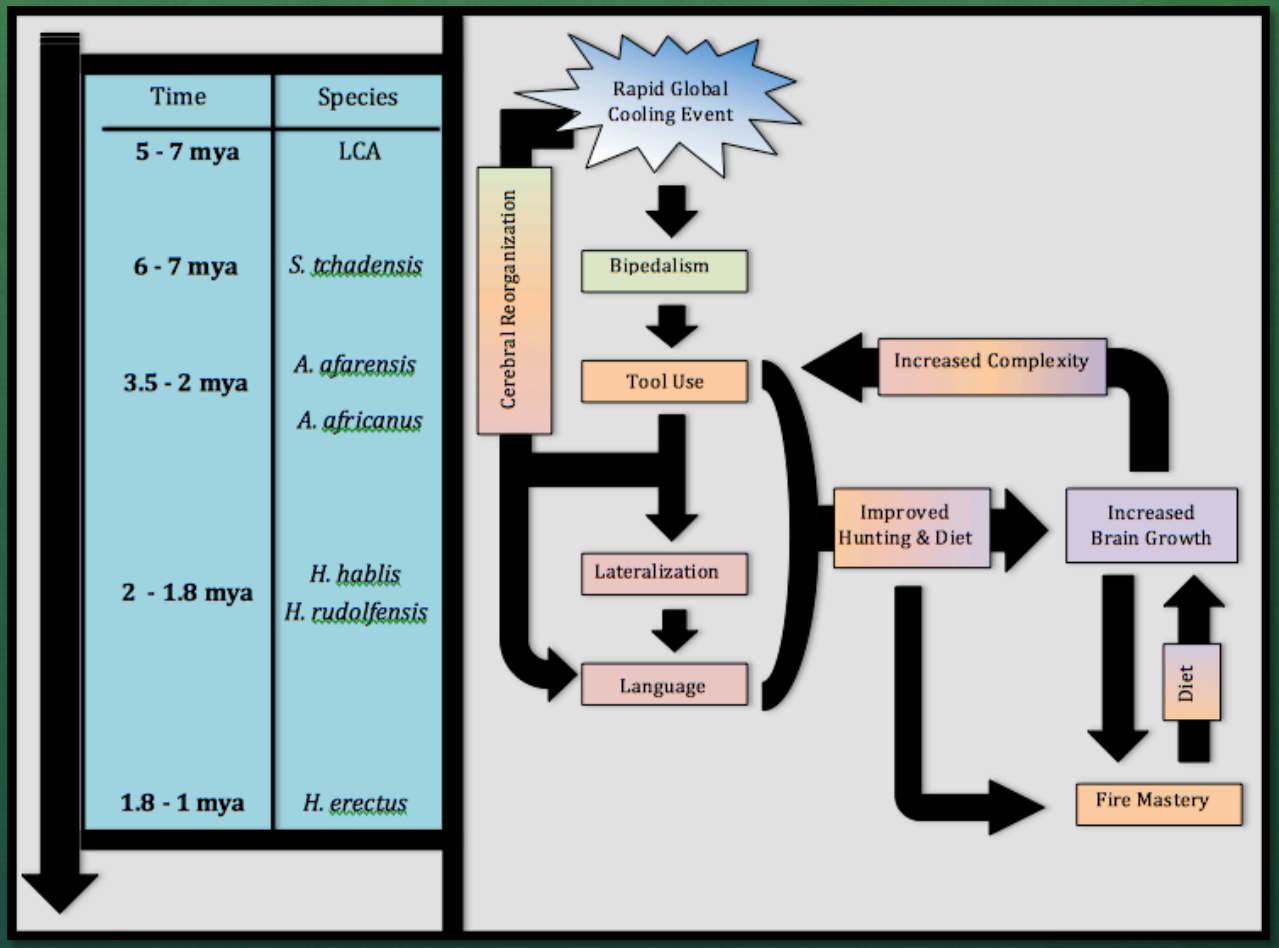
http://disjointedthinking.jeffhughes.ca/2011/02/all-about-the-brain-part-2/

Rapid Brain Growth

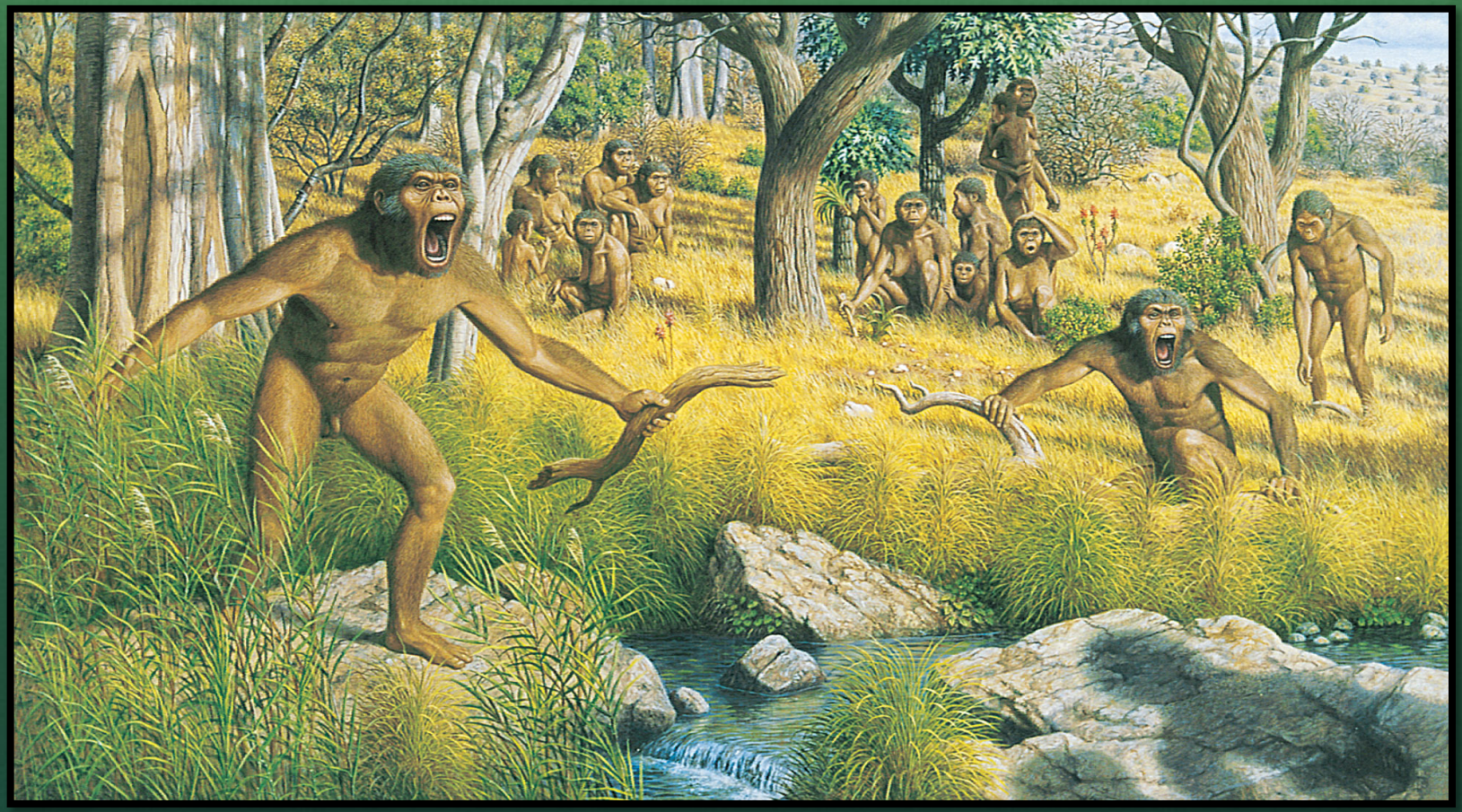
- Brain only 2% of the body, accounts for 20% of oxygen and significant amount of energy (Raichle & Gusnard 2002)
- Does not make sense with increased body size unless nutritional quality had increased
- Rapid relative brain size growth
- Occurred during the second cerebral reorganization
- Influence of improved hunting, gathering cooking and increased nutrition (Wrangham 2009)

Mosaic Theory of Evolution

- Multi-variable theory
- Must be understood in the context of environment, anatomy, and archaeological evidence



Language Influences

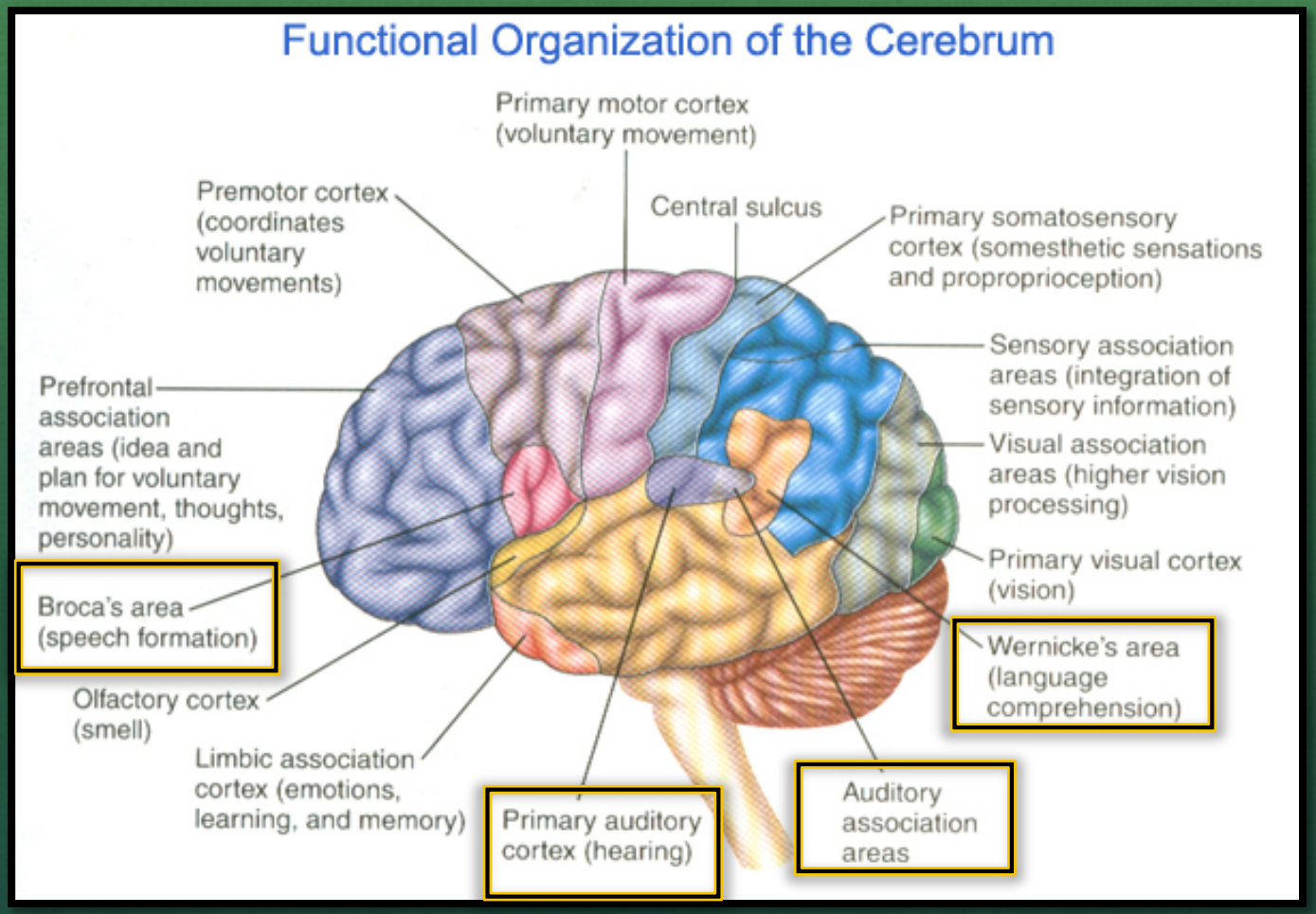


http://www.teachersnetwork.org/powertolearn/web/Prehistory%20Web%20Quest/images/australopithecus_family.jpg

Language Influences

- Language centers located on the left hemisphere in 90% of the population (right handedness) (Lonsdorf 2005)
- Right hand is the dominant hand for tool use
- No communication in *Australopithecus* beyond or slightly improved from chimpanzees. Anatomy does not allow for spoken language (small groups)
- Increased communication is shown to have positive influence on cerebral cortex growth (Dunbar 1992)
- Communicate tool making techniques and technology

Language Influences



http://www.liquidarea.com/wp-content/uploads/2009/10/broca_area.jpg

Homo erectus

http://www.teachersnetwork.org/powertolearn/web/prehistory%20web%20quest/homo_erectus.htm

Homo erectus

- Appeared ~1.8 mya after transitional species *H. hablis & rudolfensis*
- Fire mastery and improved hunting techniques
- More complex tools
- Larger brain, larger body size
- Increased group size and cooperation

http://www.independent.co.uk/migration_catalog/article5208328.ece/ALTERNATES/w620/homo-erectus.jpeg

Limitations

- Lack of preserved biological evidence (imprints)
- Argument is contextual and speculative
- Only 1 endocast per 250,000 years (falsifiable)
- Fossil evidence is largely incomplete and lacks acceptable sample size
- Human-like levels of sexual dimorphism and variation present
- Tracing direct ancestry near impossible

Implications for the Future

- Study of the human brain as it was before could lead to insight on how it functions now
- Where and why certain regions developed
- Answer questions such as what is consciousness?
- Neuroscience is one of the fields so rarely explored and so many questions are still unanswered
- New species add more pieces to the puzzle
- Questions?

Conclusion

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