

511-2018-10-03-evo-devo

Rick Gilmore

Gentle Arms of Eden.

Prelude



Today's Topics

- **No class** on Friday.
- Wrap-up on [hormonal communication](#)
- The evolution and development of the nervous system

Which of these hormones is released directly into the bloodstream by the brain?

- Oxytocin
- Vasopressin
- Cortisol
- Adrenocorticotrophic hormone

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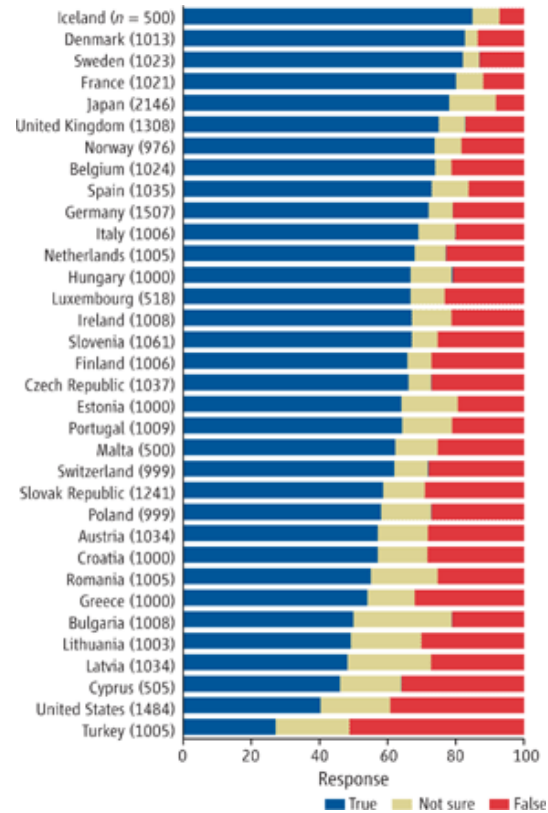
Where are they released?

- Oxytocin (anterior pituitary/posterior pituitary)
- Vasopressin (anterior pituitary/posterior pituitary)
- Adrenocorticotrophic hormone (anterior pituitary/posterior pituitary)

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Public acceptance of evolution



(Miller, Scott, & Okamoto, 2006)

Types of evidence

- Fossil
 - Fossil dating
- Geological
 - Where fossils are found relative to one another
 - How long it takes to form layers
- Genetic
 - Rates of mutation
- Anatomical

Dobzhansky

Nothing in Biology Makes Sense Except in the Light of Evolution

"Seen in the light of evolution, biology is, perhaps, intellectually the most satisfying and inspiring science. Without that light, it becomes a pile of sundry facts some of them interesting or curious, but making no meaningful picture as a whole."

(Dobzhansky, 1973)

Why is the theory so controversial (in the U.S.)?

Why Gilmore thinks it's controversial (in the U.S.)

- Contradicts verbatim/non-metaphorical reading of some religious texts
- Makes humans seem less special
- Time scales involved beyond human experience
- Scientific method vs. other ways of knowing
- Found in nature \neq good for human society

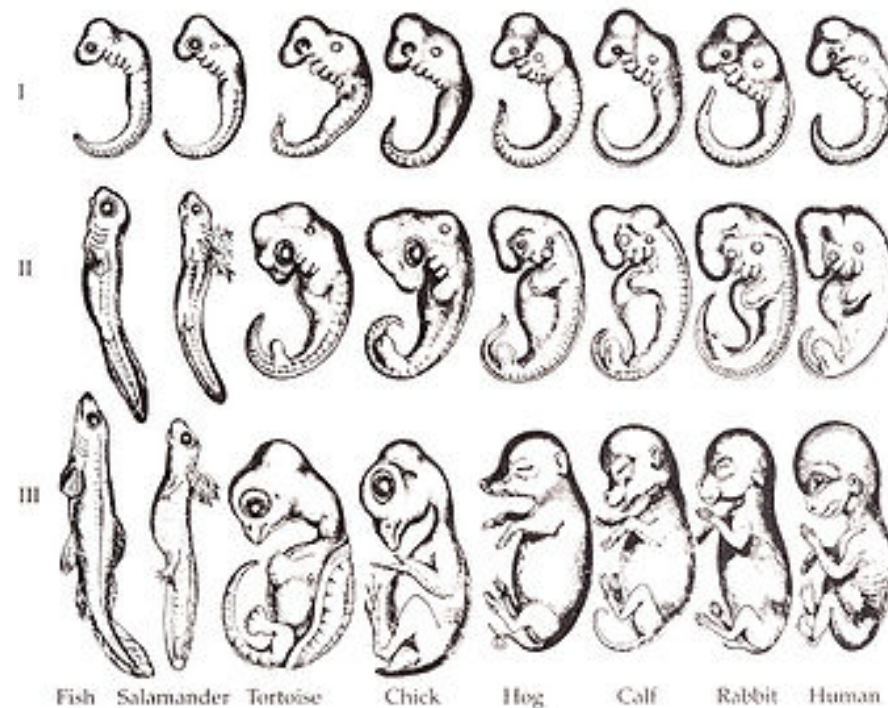
Why Gilmore thinks it's controversial (in the U.S.)

- Few negative consequences of 'disbelief'
- U.S. culture individualistic, skeptical, anti-elitist/anti-intellectual
- Lower levels of religious belief among U.S. scientists
- Politics
- A minority of citizens support teaching evolution-only
- Majority of classroom teachers aren't strong advocates

Ontogenesis and phylogenesis

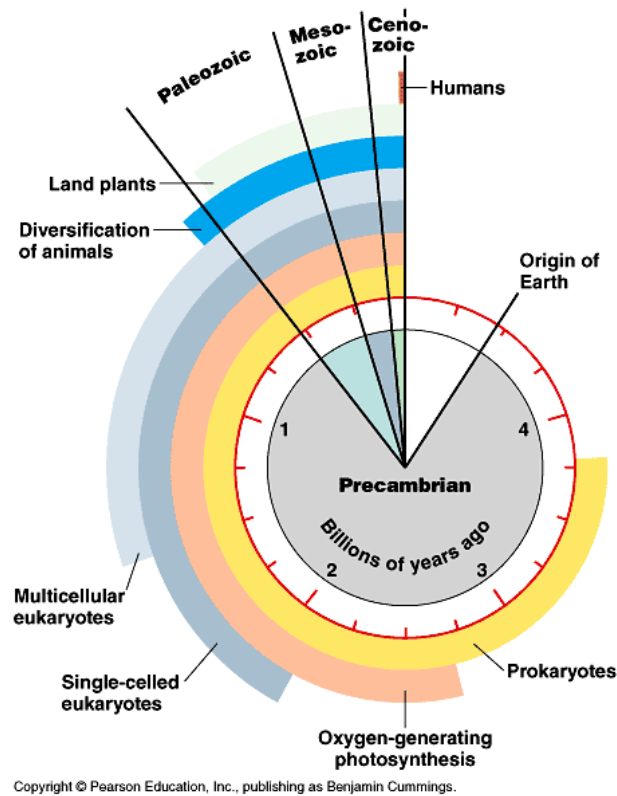
- *Ontogenesis*
 - Development within lifetimes, history of individuals
- *Phylogenesis*
 - Change across lifetimes, history of species

Ontogeny does not recapitulate phylogeny (Haeckel), but...



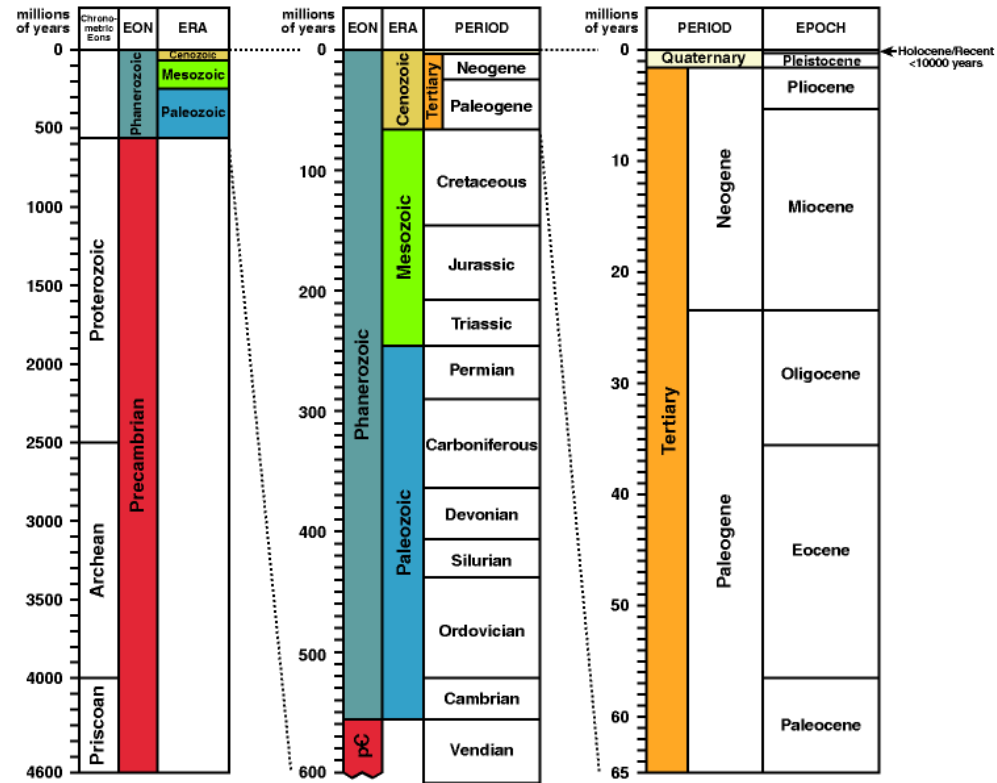
https://upload.wikimedia.org/wikipedia/commons/thumb/0/08/Haeckel_dr_Haeckel_drawings.jpg

Complex multicellular life emerged "recently"



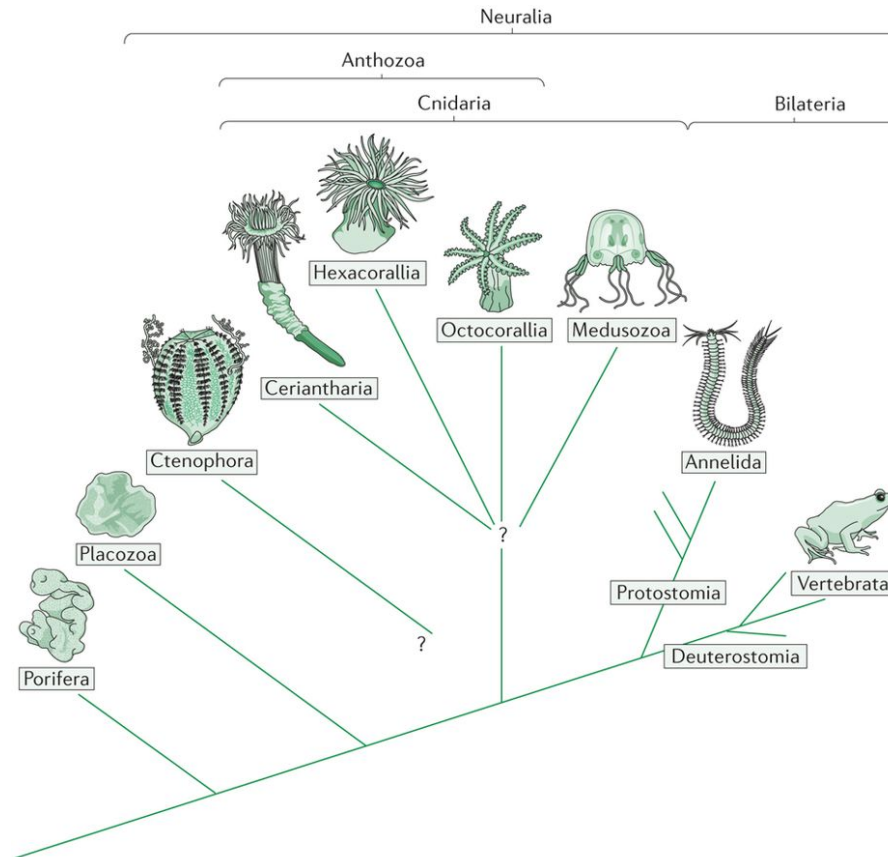
<http://www.zo.utexas.edu/faculty/sjasper/images/26.2.gif>

Time scales



http://www.indiana.edu/~geol105b/images/gaia_chapter_6/time_scale.gif

Nervous system architectures



Nature Reviews | Neuroscience

An animal with a nerve "net"




How nervous systems differ


- Body symmetry
 - radial
 - bilateral
- Segmentation
- Cephalization (concentration of sensory & neural structures in anterior portion of body)
- Encasement in bone (vertebrates)
- Centralized vs. distributed function


Cephalopods have "intelligent arms"





ScienceDirect





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Journal of Experimental Marine Biology and Ecology

Volume 447, September 2013, Pages 100-105

Special issue: Cephalopod Biology

Preliminary in vitro functional evidence for reflex responses to noxious stimuli in the arms of *Octopus vulgaris* ☆

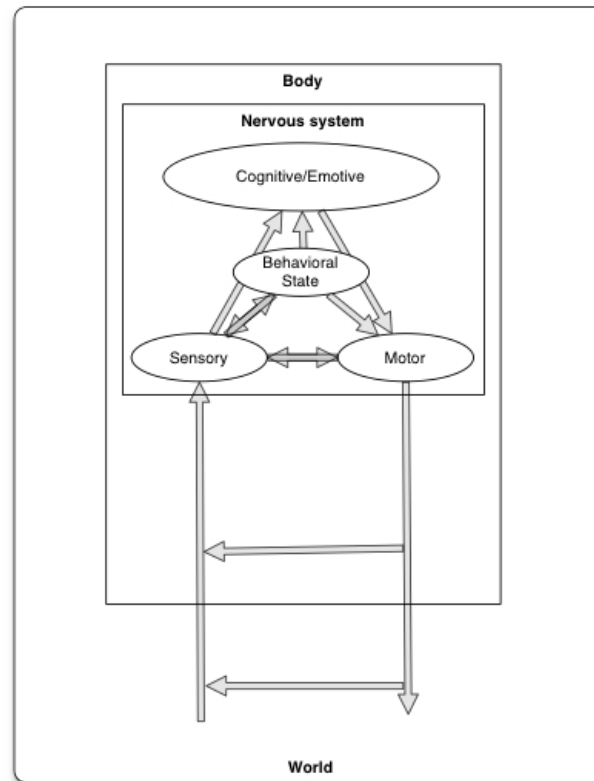
Theresa Hague ^a, Michaela Florini ^b, Paul L.R. Andrews ^{a, b}  

 Show more

Biological imperatives

- Ingestion
- Defense
- Reproduction

Information processing schematic



Information processing universals

- Sense/detect
 - Sensors
- Analyze, evaluate, decide
- Act
 - Effectors
 - e.g., approach/avoid, manipulate, ingest, signal

Sensors

- Specialize by information source/type
- Specialize by target location
 - Interoceptive
 - Exteroceptive

Analysis, evaluation, decision

- Current state
 - World
 - Organism
- Current goals
- Past state(s)

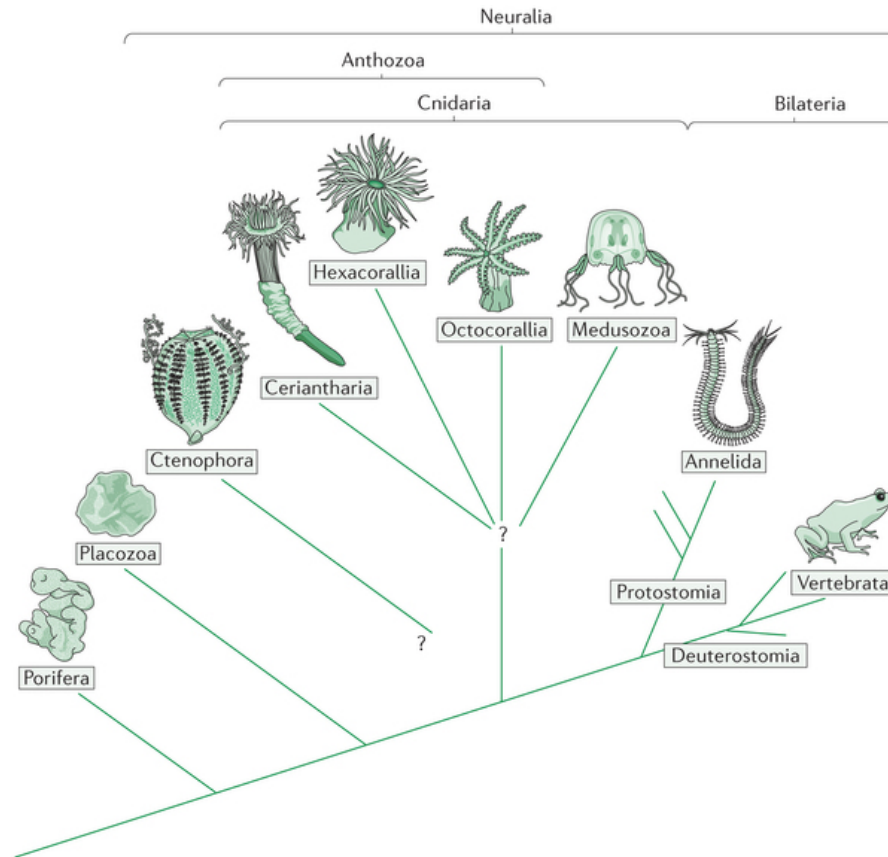
Effectors

- Move body
- Send signals
- Change physiological state

From nerve net to nerve ring, nerve cord and brain — evolution of the nervous system

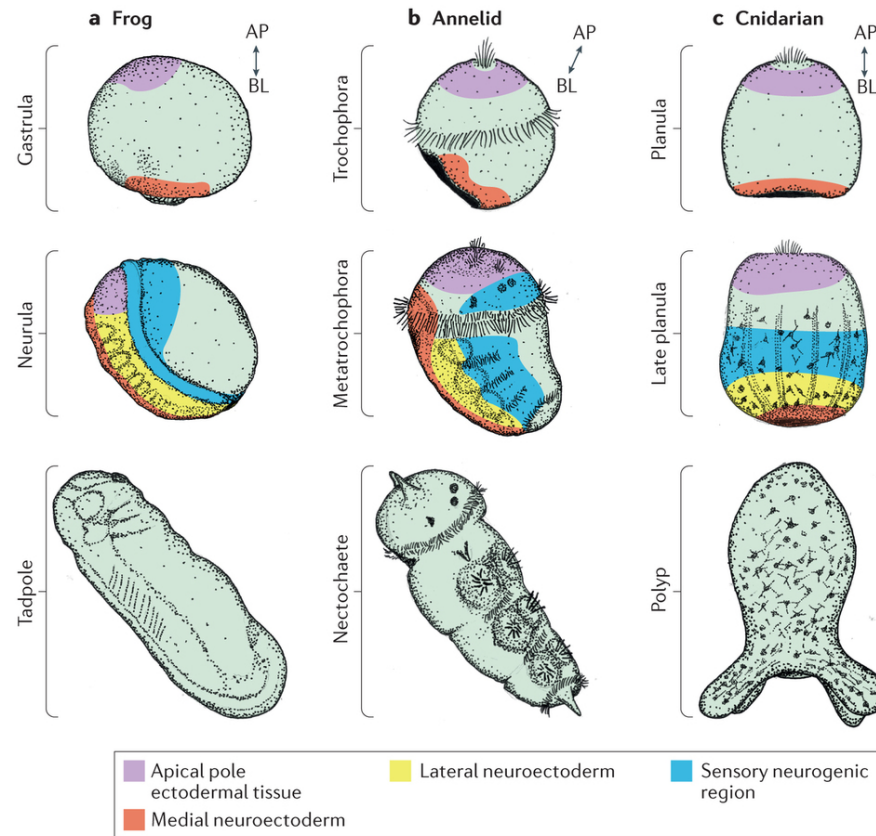
(Arendt, Tosches, & Marlow, 2016)

(Arendt et al., 2016)



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(Arendt et al., 2016)

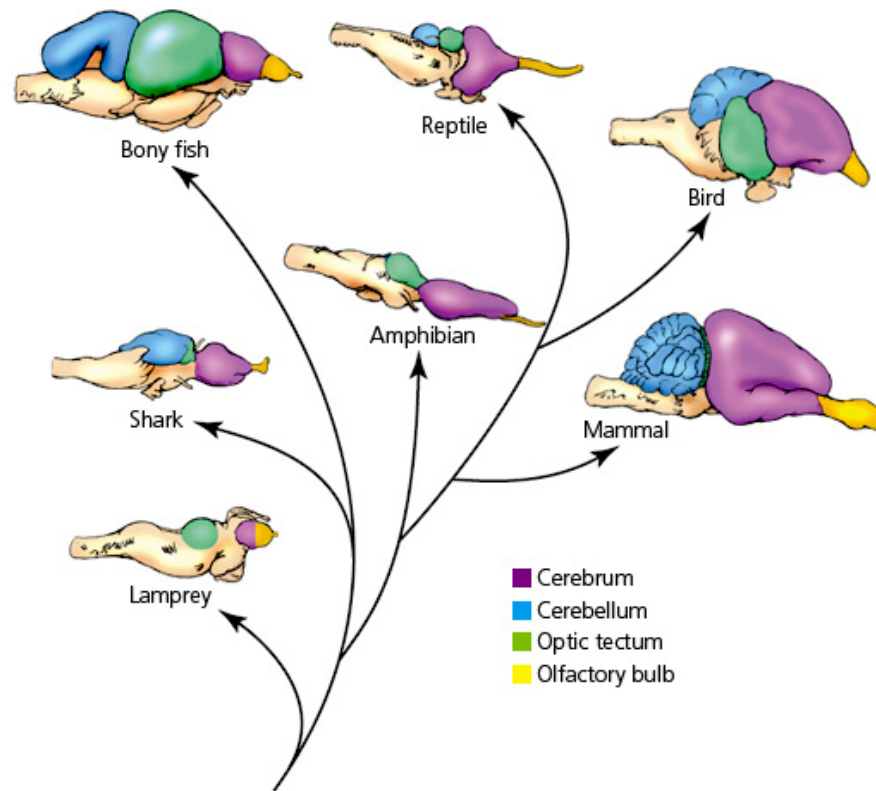


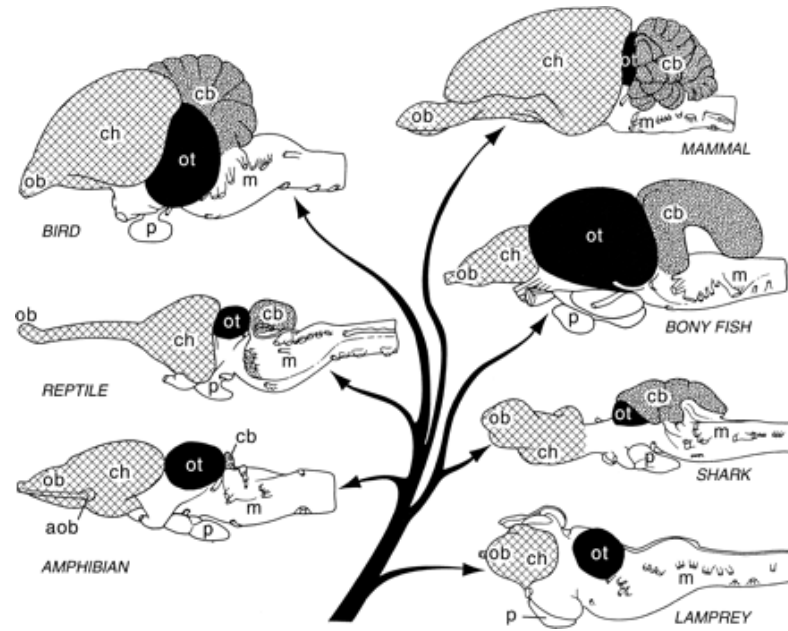
Nature Reviews | **Neuroscience**

Take homes

- Neurons and nervous systems 520-570 M years old
- Similarities at molecular level in how diverse nervous systems develop

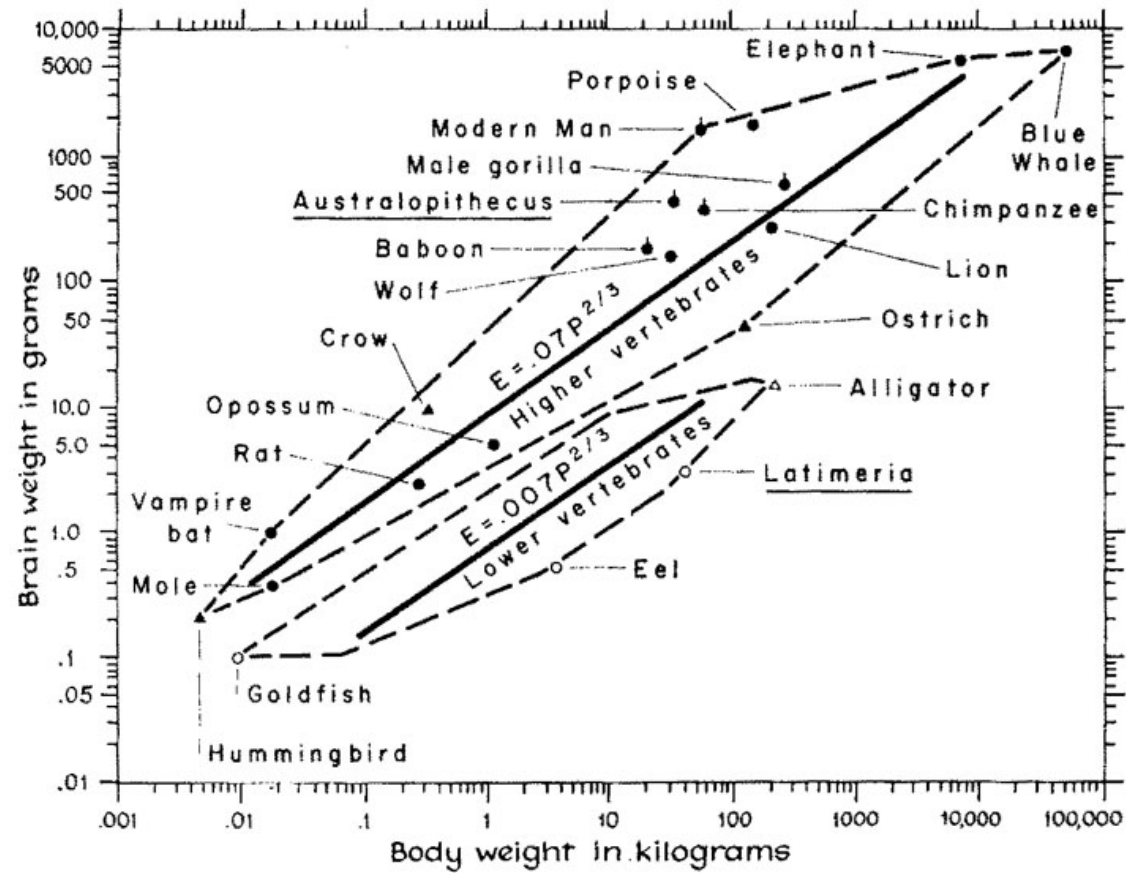
Similarities in overall vertebrate CNS organization

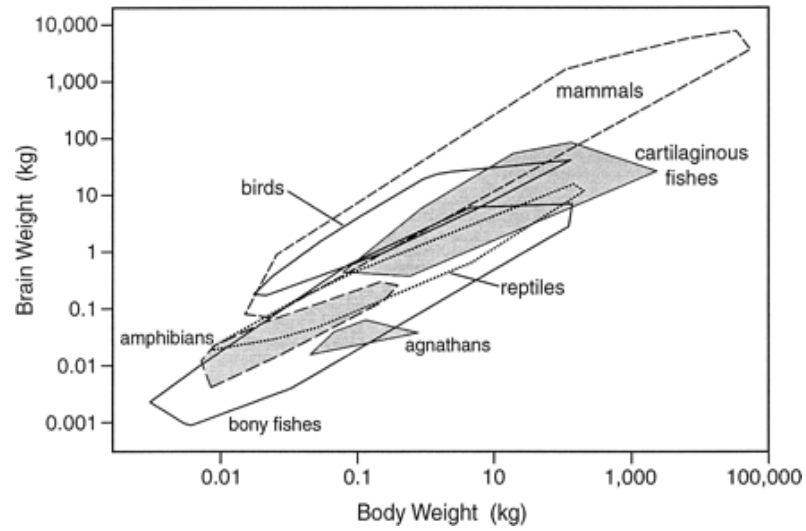




(Northcutt, 2002)

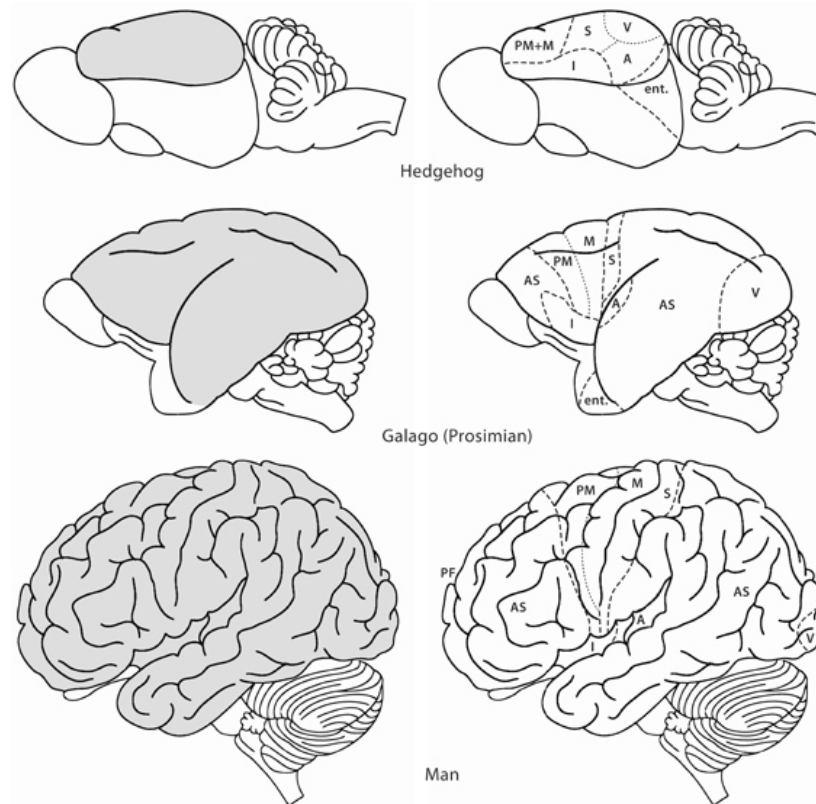
Variation in overall brain mass/body mass





(Northcutt, 2002)

Evolutionary trends in cortical size

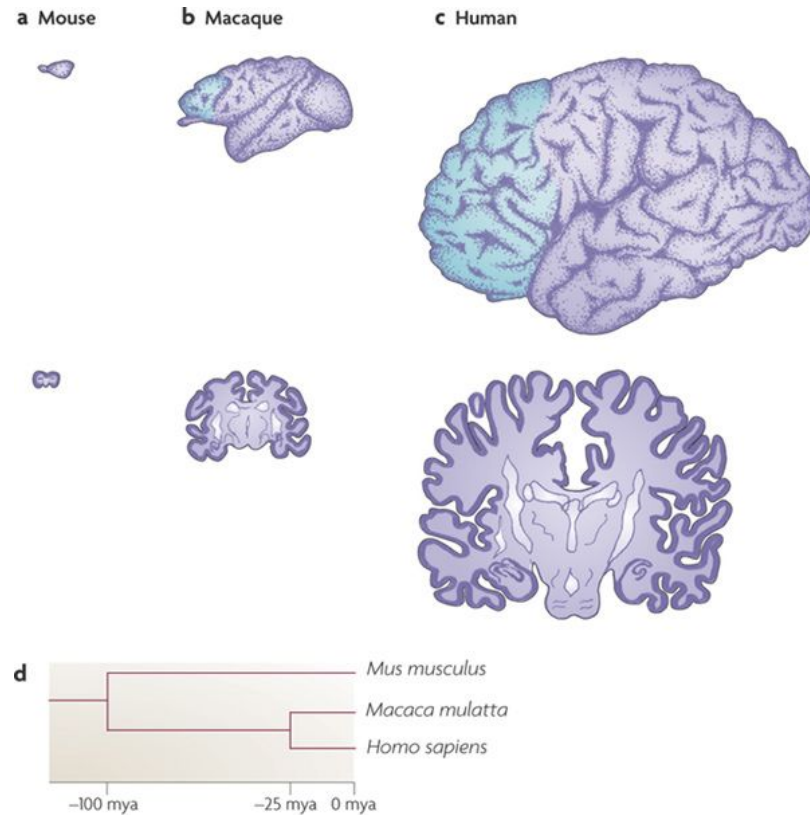


(Hofman, 2014)

Evolutionary trends in cortical size

Structural measure	Non-human comparison	Human
Cortical gray matter %/tot brain vol	insectivores 25%	50%
Cortical gray + white	mice 40%	80%
Cerebellar mass	primates, mammals 10-15%	10-15%

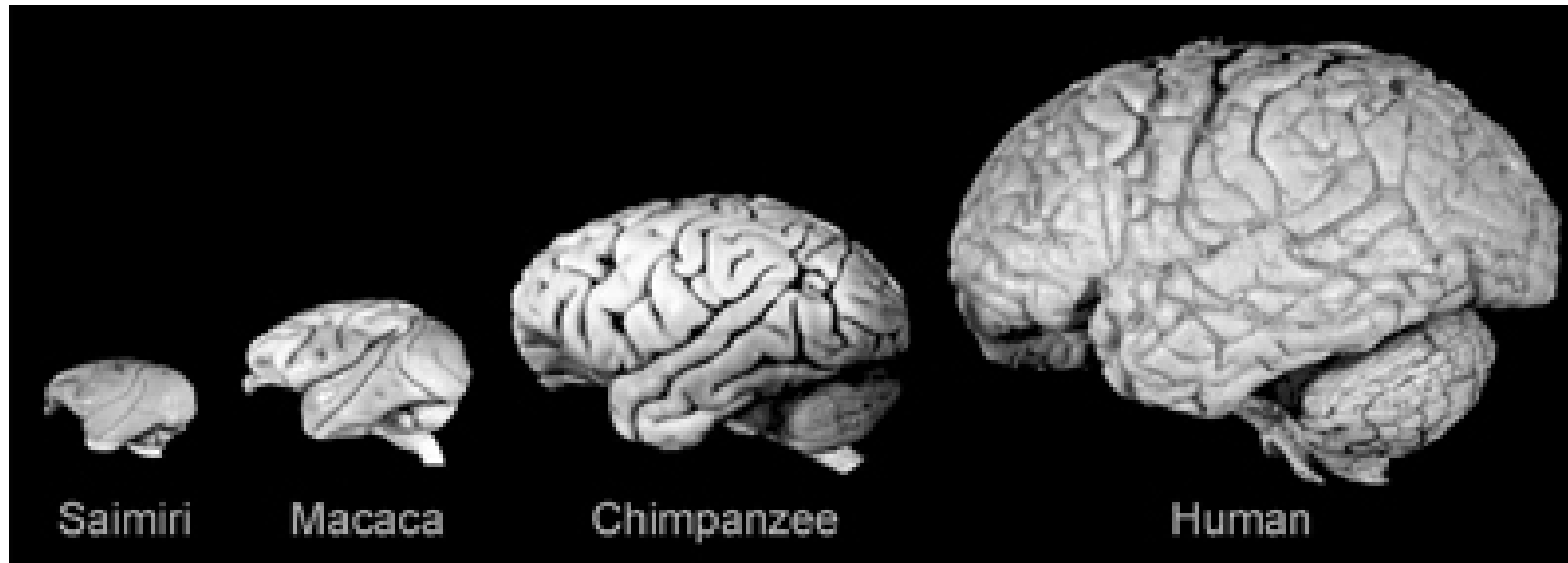
Evolutionary trends in cortical size



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(Rakic, 2009)

Evolutionary trends in primate brain size



(Hofman, 2014)

Take homes

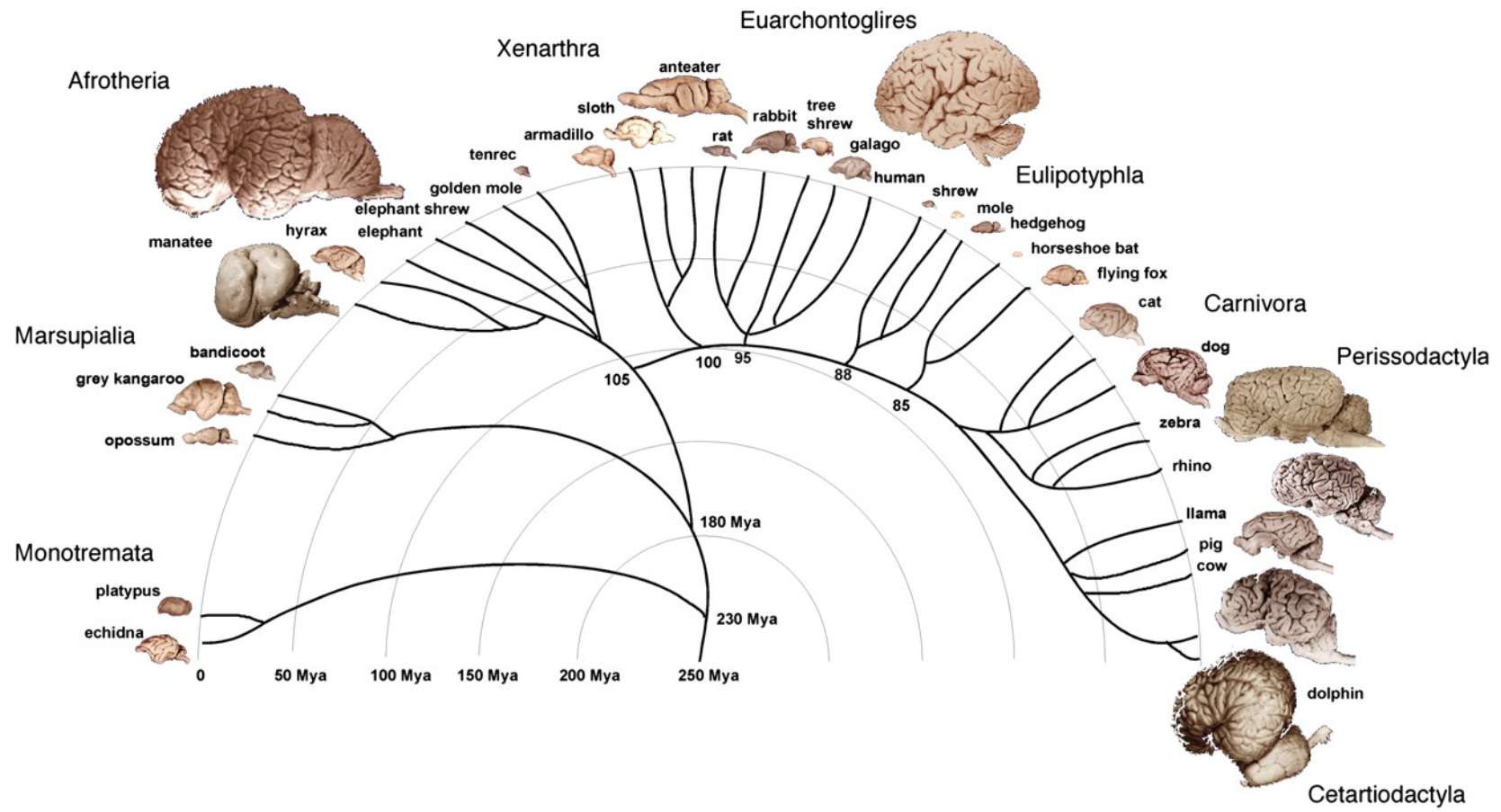
- Brain sizes scale with body size
- Brain sizes scale with animal class (more or less)

Old story

- Within mammals, human brains bigger than expected
 - Higher encephalization quotient
- Humans have larger cerebral cortical gray + white matter than comparable mammals

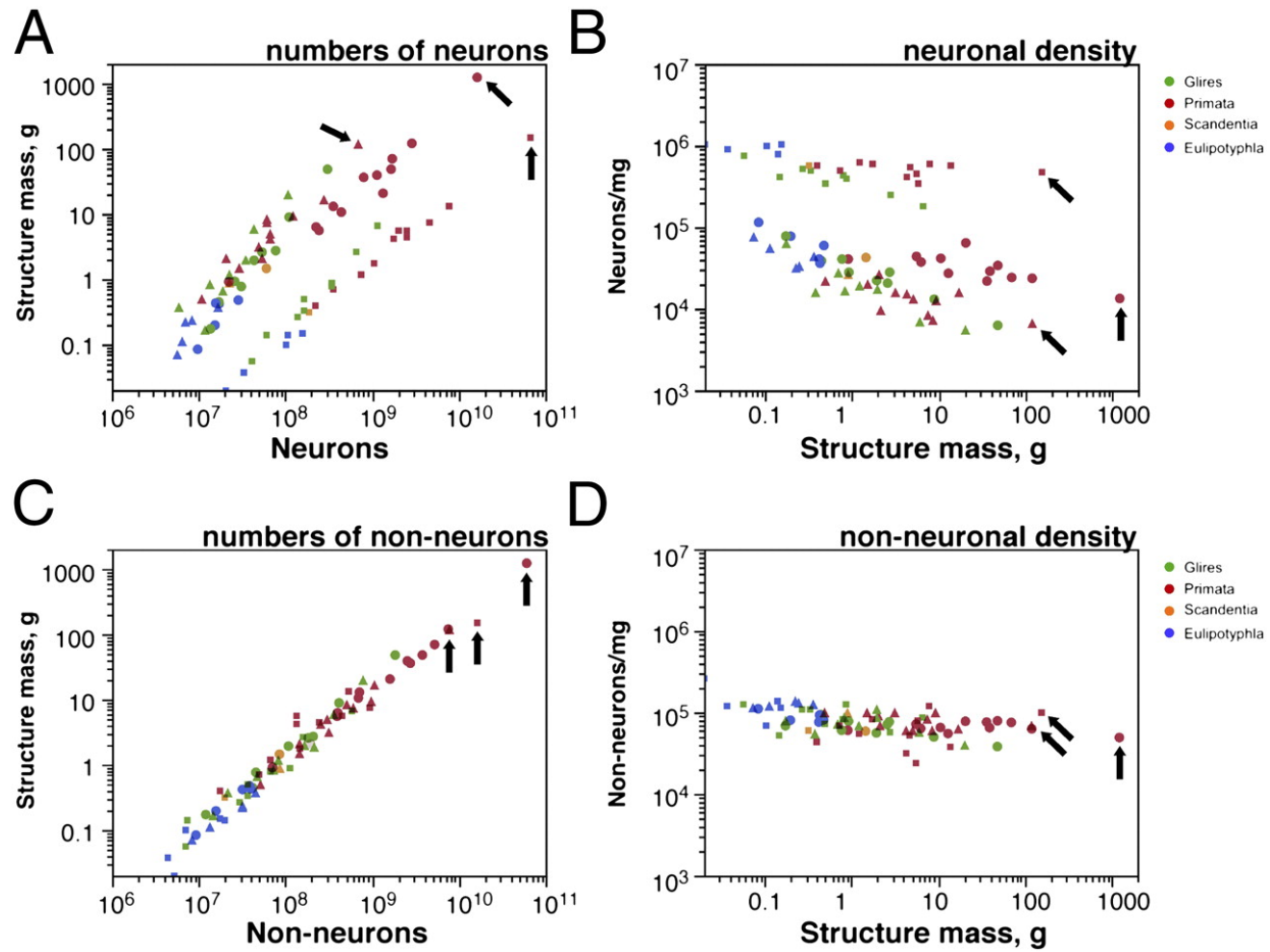
New story

- Does brain size/mass matter (that much)?
- "Size matters" (brain mass) presumes similarity among brains at micro-level
- Big (large mass) brains arise in multiple animal lineages

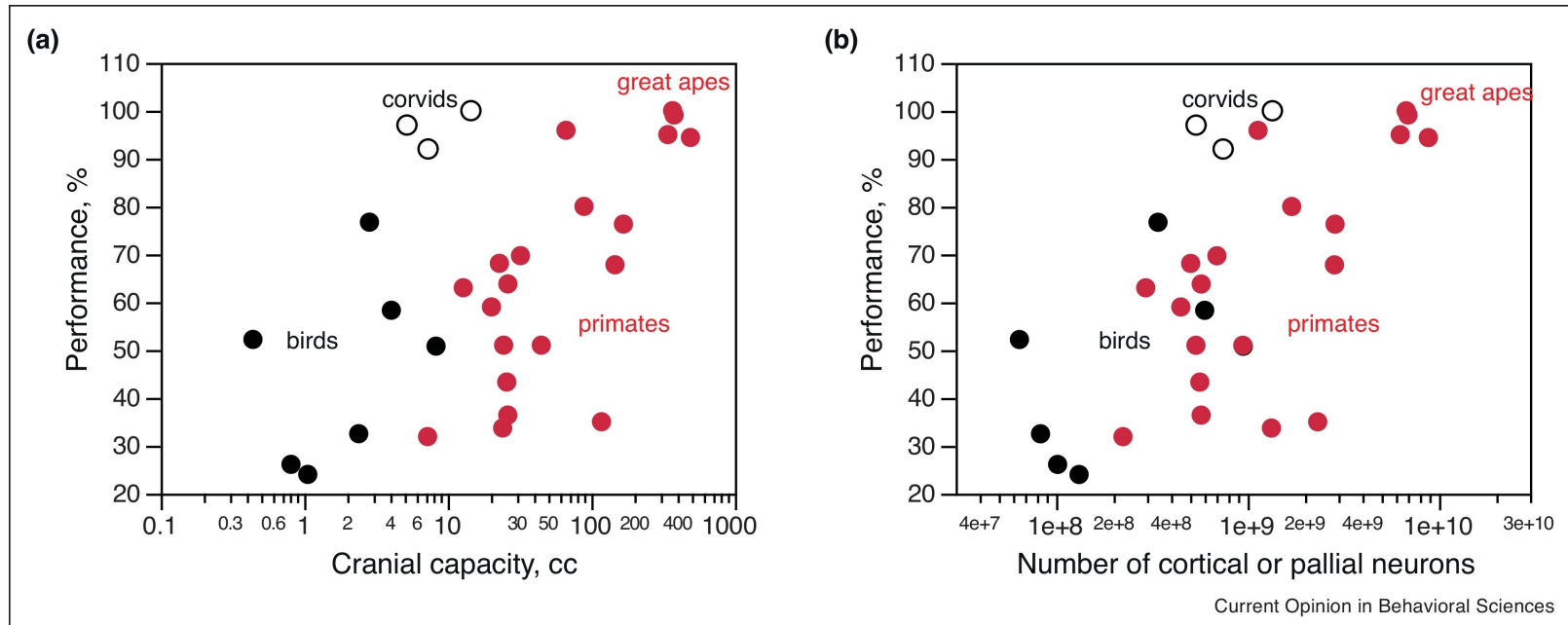


New story

- *# of cortical neurons* more important difference than brain mass
- The primate advantage -> more cortical neurons, but not larger neurons
- Human brain just scaled up (non-ape) primate brain



of cortical (or in birds, pallidum) neurons predicts "cognition"?



[\(Herculano-Houzel, 2017\)](#)

The Human Advantage (Herculano-Houzel, 2016)

- More neurons in cerebral cortex than other animals, but not disproportionately so
- Less time spent foraging
 - Higher quality/more energetically dense food
 - Higher food availability
 - Cultural factors (agriculture + cooking)
 - See also (Wrangham, 2009)

And finally, humans have an extended childhood during which those neurons are filled with vital cultural knowledge.

Next time...

- Wrap-up on brain development

References

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