

Chapter 2 : Brain Origins and Evolution

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Issues re: Evolution

- Philosophical Issues
 - humans vs. animals - qualitative vs. quantitative difference?
- Scientific issues
 - conflicting & rare evidence
- Religious issues
 - ancient texts
 - contrary teachings
 - literal vs. symbolic interpretation
 - “7 days” vs “4.5 billion years”
 - modern ideas

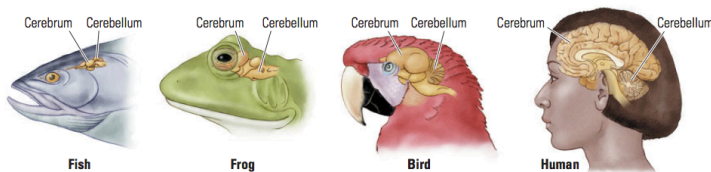
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Brain Evolution

- General increase in brain size & complexity across species



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Why study animal brains?

- Understanding basic brain mechanisms
 - neurons, synapses, neural tracts & systems
 - genetic similarities are high
- Designing animal models
 - ethical issues with human research
- Evolutionary perspectives
 - similarities
 - differences in brain --> differences in behaviors?

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Evolution

- Big Picture
 - Multicellular life - 650 MYA
 - Mammals - 150 MYA
 - Homo Sapiens - 250 KYA
- Research Methods
 - Archeological
 - Biochemical & Genetic
 - Behavioral

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Genetics : Species Differences

organism	estimated size (base pairs)	# genes	gene size	# chromosomes
Homo sapiens (human)	3.2 billion	~25,000	1 gene per 100,000 bases	46
Mus musculus (mouse)	2.6 billion	~25,000	1 gene per 100,000 bases	40
Drosophila melanogaster (fruit fly)	137 million	13,000	1 gene per 9,000 bases	8
Arabidopsis thaliana (plant)	100 million	25,000	1 gene per 4000 bases	10
Caenorhabditis elegans (roundworm)	97 million	19,000	1 gene per 5000 bases	12
Saccharomyces cerevisiae (yeast)	12.1 million	6000	1 gene per 2000 bases	32
Escherichia coli (bacteria)	4.6 million	3200	1 gene per 1400 bases	1
H. influenzae (bacteria)	1.8 million	1700	1 gene per 1000 bases	1

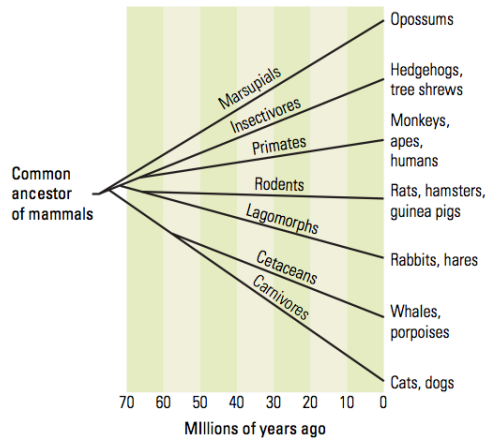
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Mammalian Evolution

- Common mammalian ancestor ~ 80 MYA



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Primate Evolution

- Best research suggests *hominids* split from *apes* 5 to 8 million years ago
 - increased height
 - longer legs
 - bipedal (walk upright), ability to walk long distances
 - jaw/teeth changes : more varied diet
 - reduced sexual dimorphism
 - longer gestations
 - opposable thumbs / tool usage
 - brain size increased (300%)

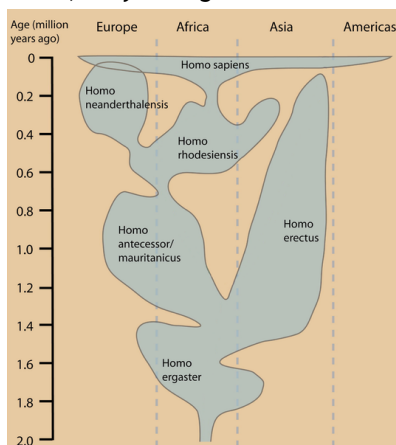
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Homo Sapiens

- Homo Sapiens ~ 250,000 years ago?

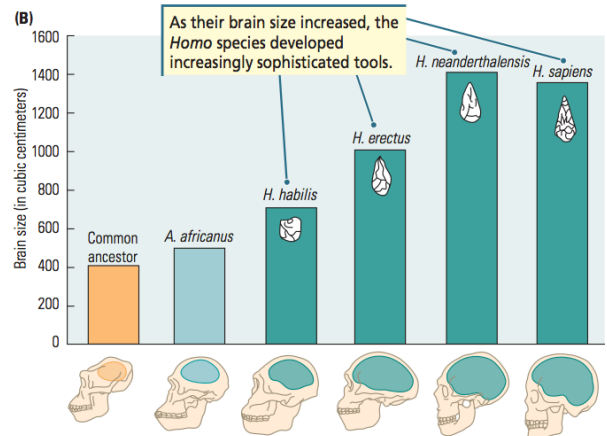


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Dramatic Brain Size Increase

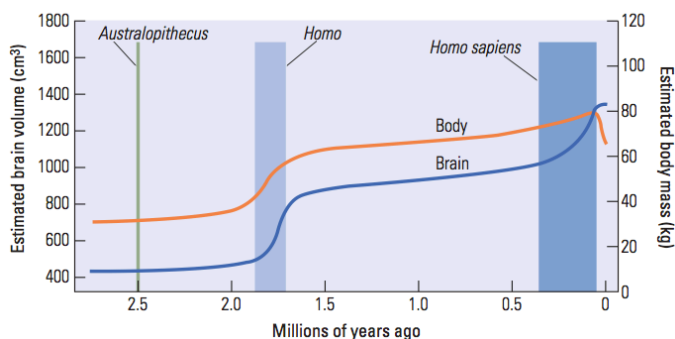


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Dramatic Brain Size Increase



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Big brains : Pros & Cons

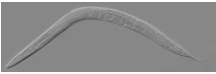
- Pros:
 - smarter
 - survival advantage
- Cons:
 - metabolic expense
 - birth canal limitations
 - neotony : slower development
 - culture & birth as adaptation

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Encephalization Quotient (EQ)

- Roundworm *C. Elegans*
 - 302 of 959 cells are neurons = 30% of body
 - Actual size: . 
- Blue whale
 - 15kg brain, but only 0.01%
- How to reconcile?
- EQ
 - ratio of actual brain size to “expected” brain size
 - Cat : “average” mammal : 1.0

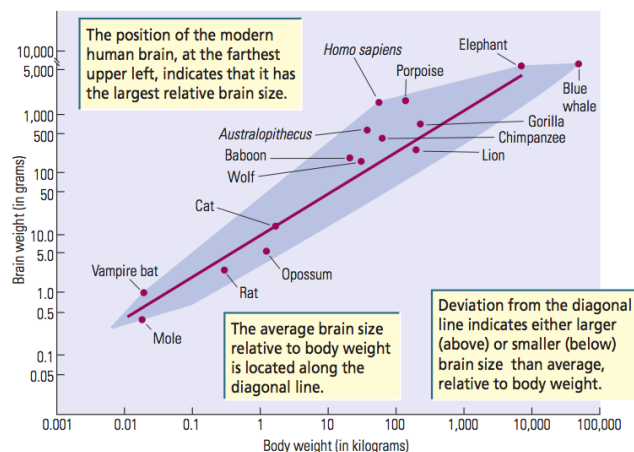


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Brain weight vs. Body weight



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Encephalization Quotient (EQ)

Species	Brain Volume (ml)	EQ
Rat	2	0.4
Cat	25	1.0
Rhesus monkey	106	2.1
Chimpanzee	440	2.5
Human	1350	7.3

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Cortical Structure

- Human brains are more specialized
- Development is slower
 - requires more parenting
- New skills/abilities can replace older ones, making room
 - e.g. color vision & depth perception reduce need for sense of smell

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Brain Size vs. Intelligence

- Interspecies:
 - strong correlation
- Intraspecies:
 - weak correlation
- Controversy:
 - The Mismeasure of Man* (Gold, 1981)
 - Faulty research, racist & nationalistic biases
 - Germans : “Germans have largest brains”
 - French : “French have largest brains”

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Intelligence Tests

- IQ tests favor left hemisphere behaviors
- How many forms of Intelligence are there?
 - One? Spearman’s *g*
 - Two? Verbal IQ, Nonverbal IQ?
 - Eight? Gardener’s multiple intelligences

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Gardner's 8 Intelligences

- logical-mathematical (*)
- verbal-linguistic (*)
- spatial (*)
- musical
- bodily-kinesthetic
- naturalist
- interpersonal
- intrapersonal

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Evolution of Culture

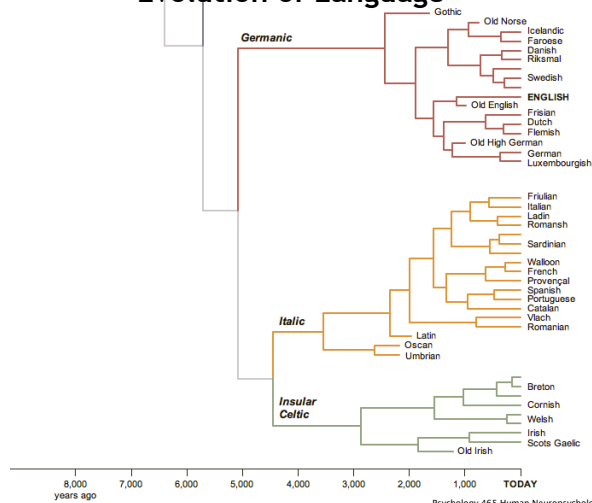
- 25,000 years ago: First art
- 9000 years ago : agriculture, animal husbandry
- 5000 years ago : written language

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Evolution of Language



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Sacks "A man of letters"

- Sacks (2010), *The Mind's Eye*, p. 53-81
- Howard Engel
 - Canadian author of Benny Cooperman detective novels
- Symptoms
 - Newspaper looked to be in foreign language
 - verbal confusion (forgot name, address, relationship to son)
 - visual field blind spot
 - object agnosia
- Diagnosis
 - Prank?
 - Stroke
 - left hemisphere, occipital lobe injury
 - could still write

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Alexia sine Agraphia

- Alexia without Agraphia
- Ability to read : gone
- Ability to write : normal
- Can read one's own writing? No
- Broca's area:
 - motor images of words (how to say a word)
- Wernicke's area:
 - auditory images of words (how to understand a word)
- Similar brain area for written words?
 - would it be on opposite hemisphere?
 - probably a disconnection syndrome similar to Conduction aphasia

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Evolution of Language : Wallace vs. Darwin

- Sacks (2010), *The Mind's Eye*, p. 71
- Background:
 - human written language ~ 5000 years ago
 - human evolution ~ 250,000 years ago
 - not enough time for biological evolution for written language
- Wallace:
 - evidence of "divine gift"
- Darwin:
 - "I hope you have not murdered too completely your own and my child"
- Modern theory:
 - "Exaptation" - redeployment / recombination of existing visual/verbal skills

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