L·I·T EXPERT
L'AVENIR DES FILIÈRES D'ÉLEVAGE

Alain Prochiantz

Professeur

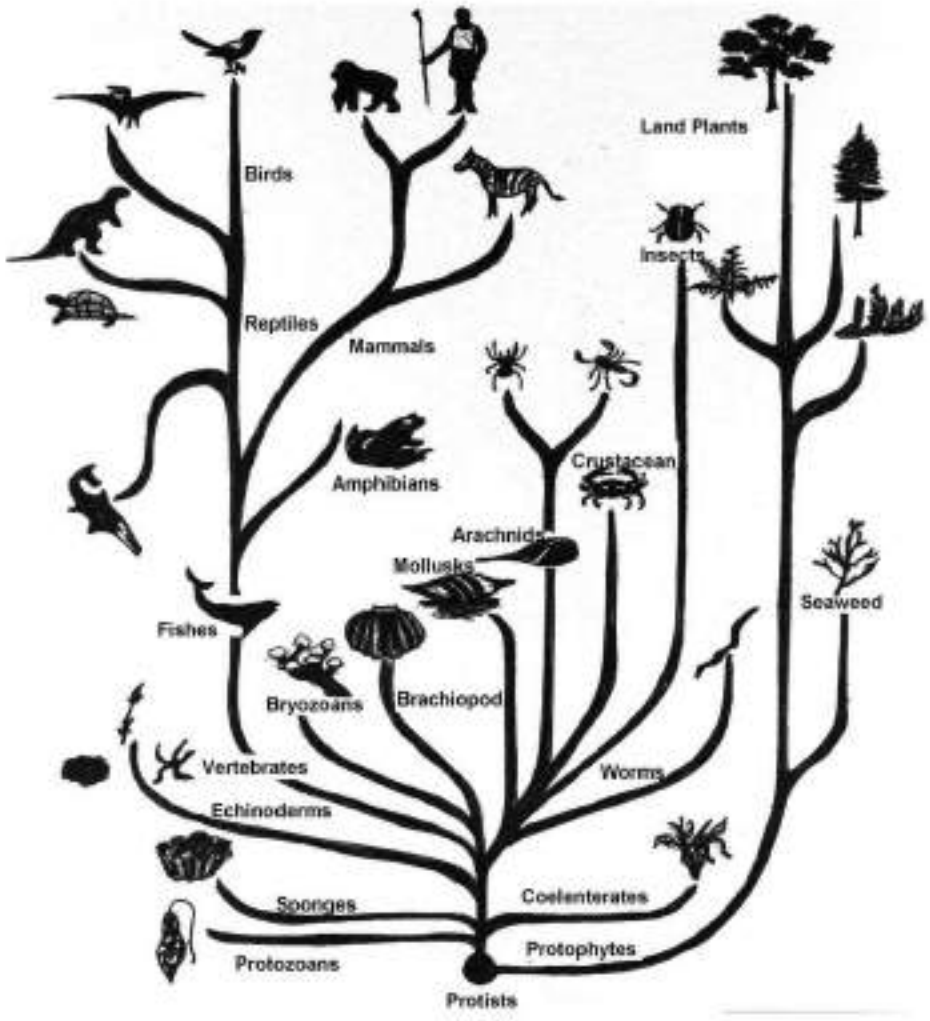
Evolution du cerveau : les singularités de l'animal humain

Journées LIT Expert

Jeudi 13 octobre 2022

Région BRETAGNE · RÉGION NORMANDIE · Région PAYS de la LOIRE · UNION EUROPÉENNE · FRANCE 2030 TERRITOIRES D'INNOVATION · BANQUE des TERRITOIRES · GOUVERNEMENT Liberté Égalité Fraternité

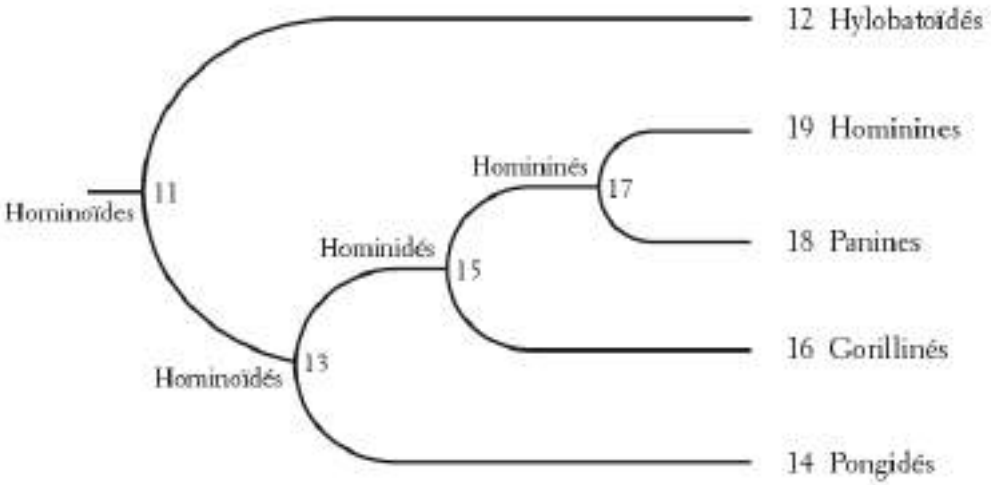
Evolution du cerveau: les singularités de l'animal humain

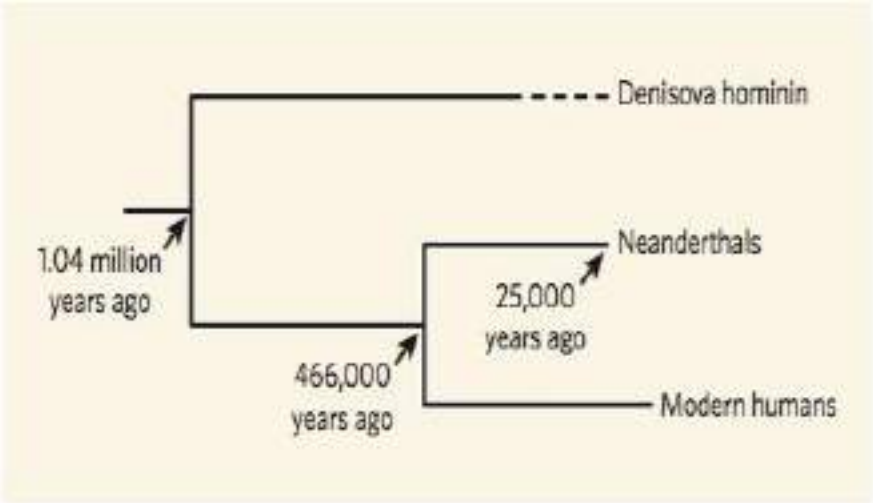


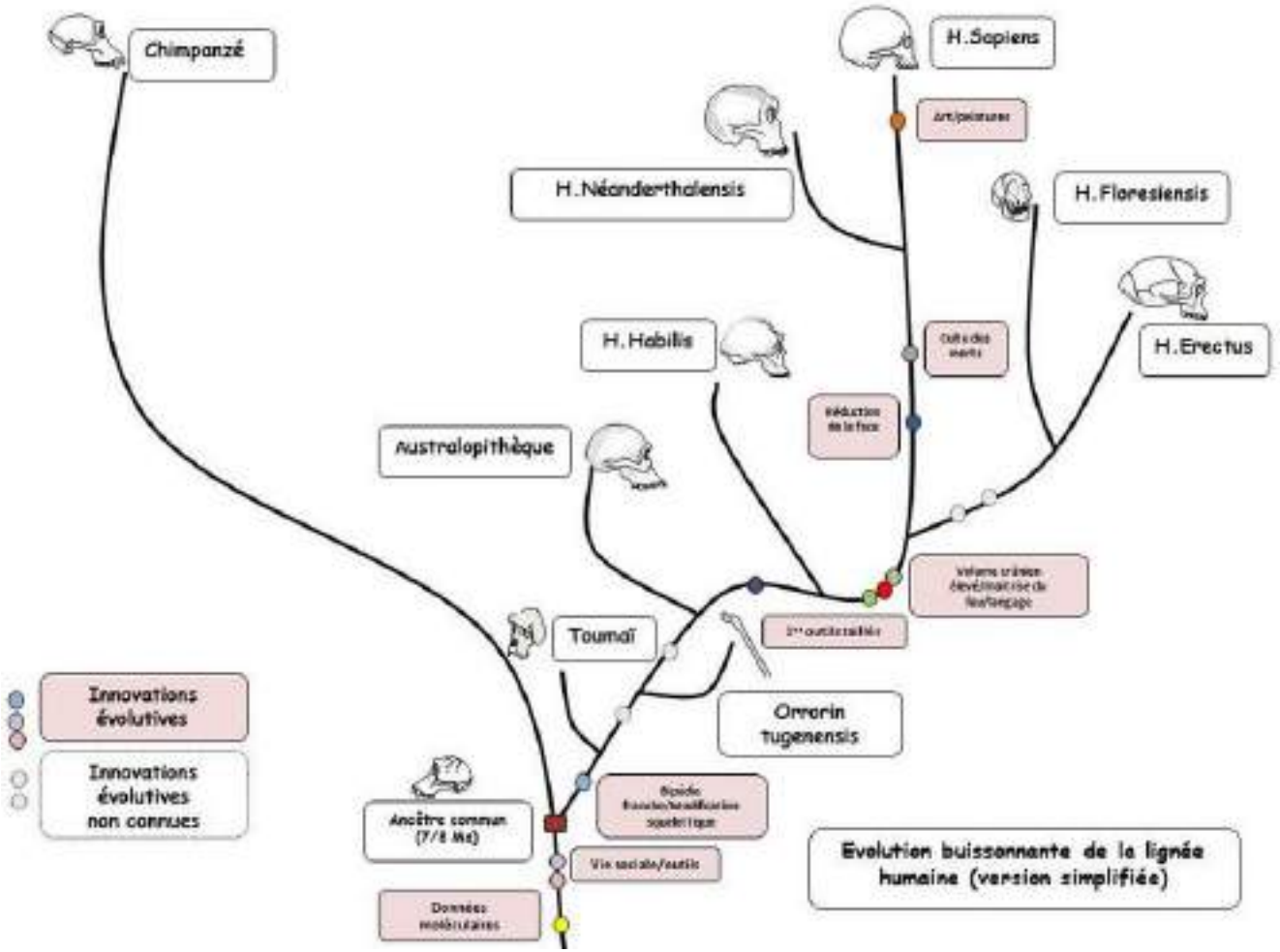
Ère	Époque	Âge (années)	Événements
Quaternaire	Holocène		Agriculture
	Pléistocène	126 000 2,6 millions	Évolution des humains modernes
Tertiaire	Pliocène	3,6 millions 5,3 millions	Lucy
	Miocène	7 millions 23 millions	Séparations des lignées humaines et chimpanzés/bonobos
	Oligocène	28 millions 34 millions	Isolement du continent antarctique
	Éocène	38 millions 56 millions	Nombreuses nouvelles espèces de petits mammifères
	Paléocène	59 millions 66 millions	Premiers primates

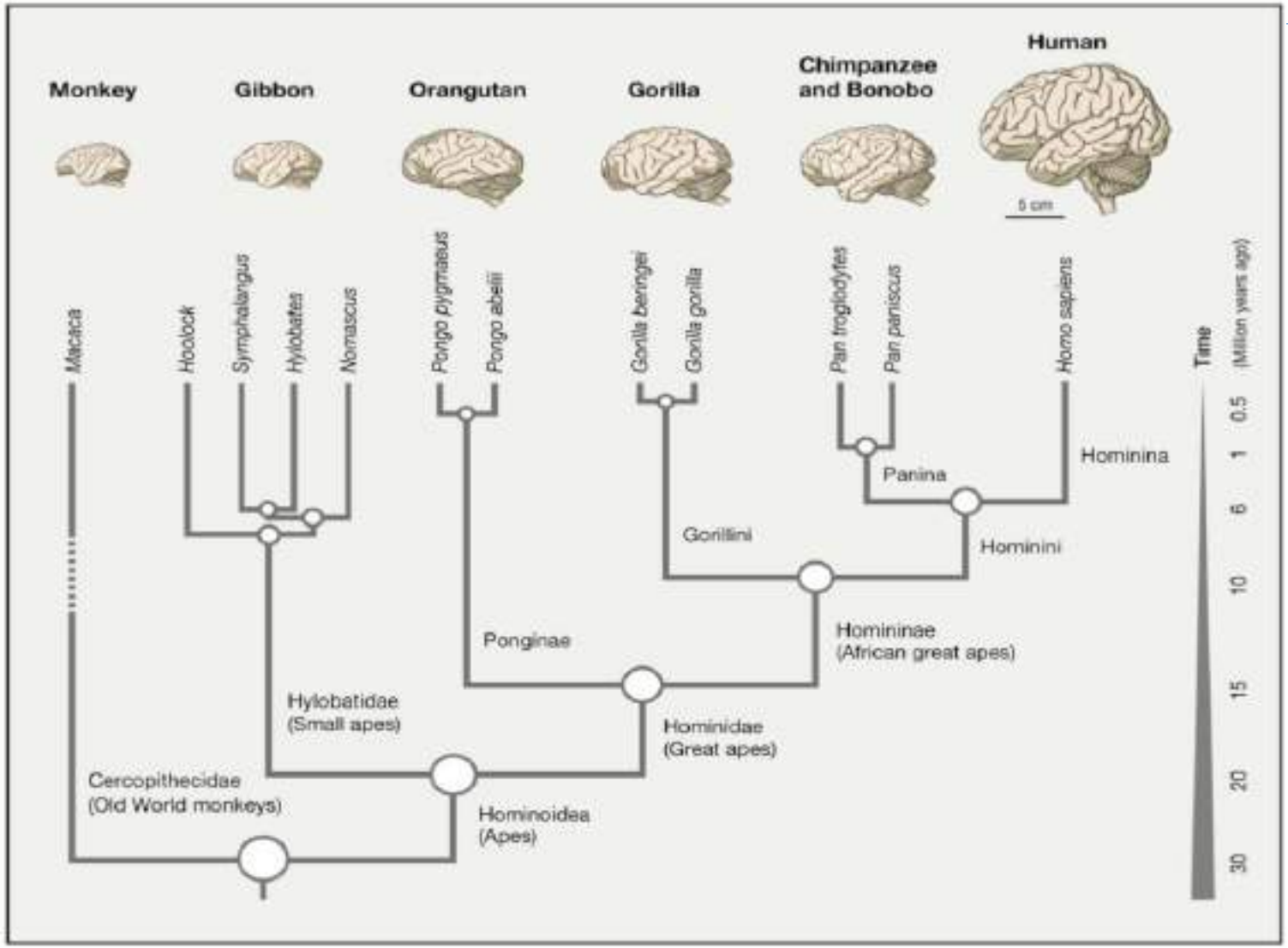
« Donc nous avons attribué à l'homme un pedigree d'une longueur prodigieuse, mais pas, pourrait-on dire, de noble qualité. Le monde, cela a souvent été dit, semble s'être préparé de longue main à la venue de l'homme ; et cela, en un sens est strictement vrai, car il doit sa naissance à une longue lignée de progéniteurs. Si un seul des liens de cette chaîne n'avait jamais existé, l'homme n'aurait pas été exactement ce qu'il est aujourd'hui. A moins que nous ne nous aveuglions volontairement, nous pouvons, avec nos connaissances actuelles, reconnaître approximativement notre parenté ; et nous n'avons nulle raison d'en concevoir de la honte. L'organisme le plus humble est une chose très supérieure à la poussière inorganique sous nos pieds ; et personne avec un esprit non biaisé ne peut étudier une créature vivante, quelque humble qu'elle soit, sans être frappé d'enthousiasme devant le merveilleux de sa structure et de ses propriétés. »

Darwin, The descent of Man


12 Hylobatoïdés
19 Hominines
Homininés
17
18 Panines
Hominidés
15
16 Gorillinés
Hominoïdes
11
Hominoïdés
13
14 Pongidés


Denisova hominin
1.04 million
years ago
Neanderthals
25,000
years ago
466,000
years ago
Modern humans

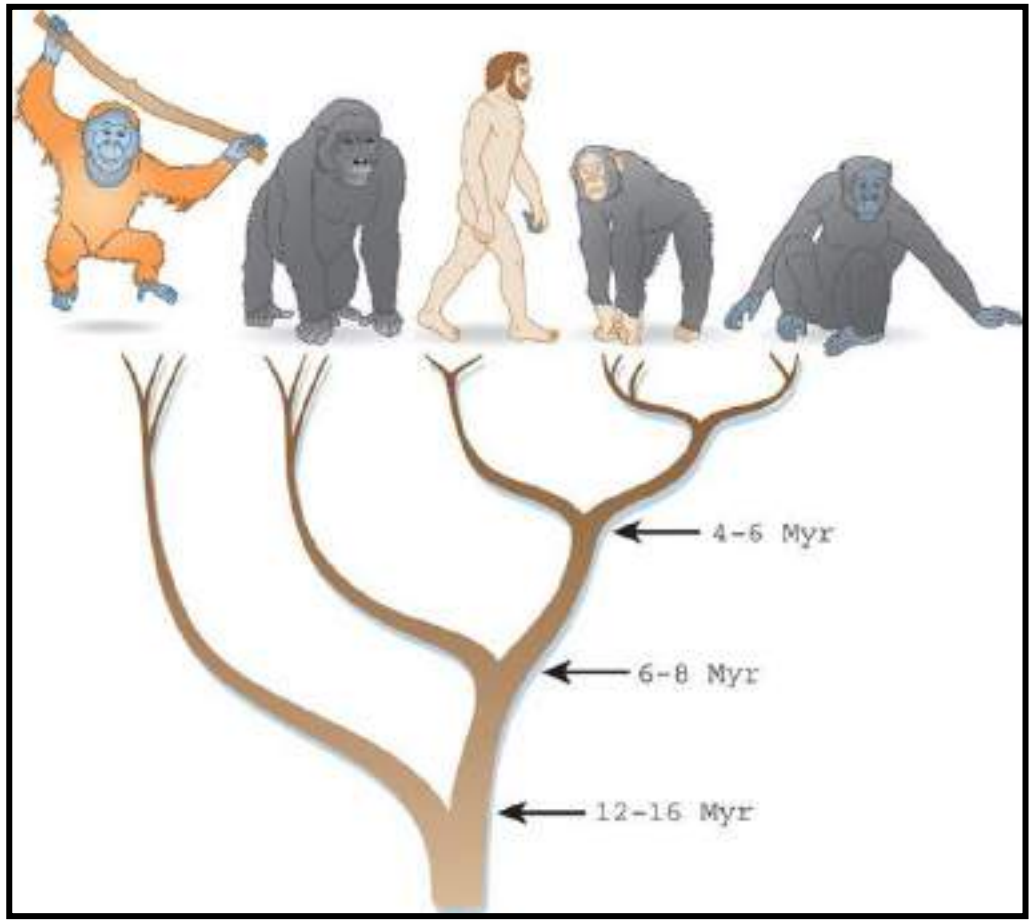

Chimpanzé
H.Sapiens
H.Néanderthalensis
H.Floresiensis
H.Habilis
H.Erectus
Australopithèque
Toumaï
Orrorin
tugenensis
Innovations
évolutives
Innovations
évolutives
non connues
Evolution buissonnante de la lignée
humaine (version simplifiée)

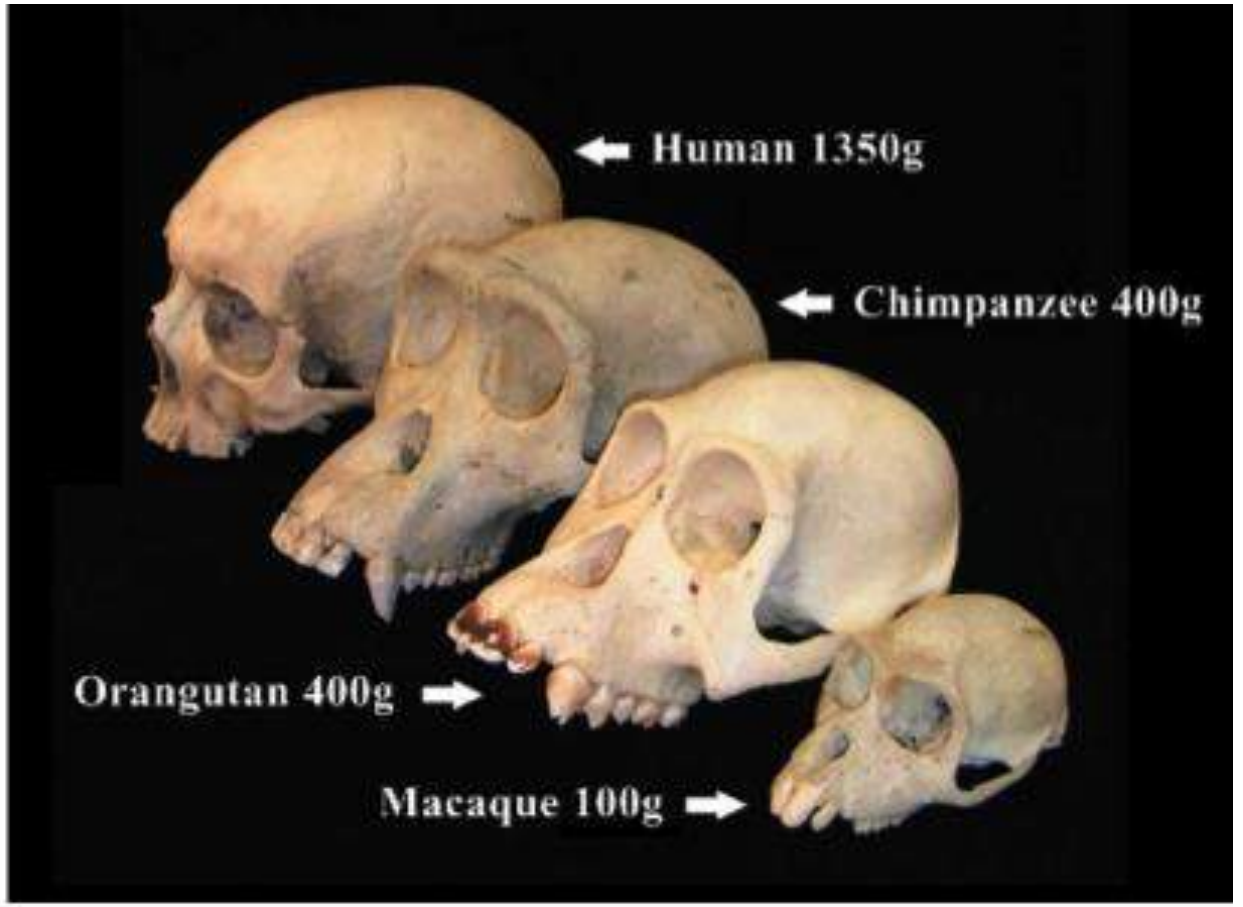


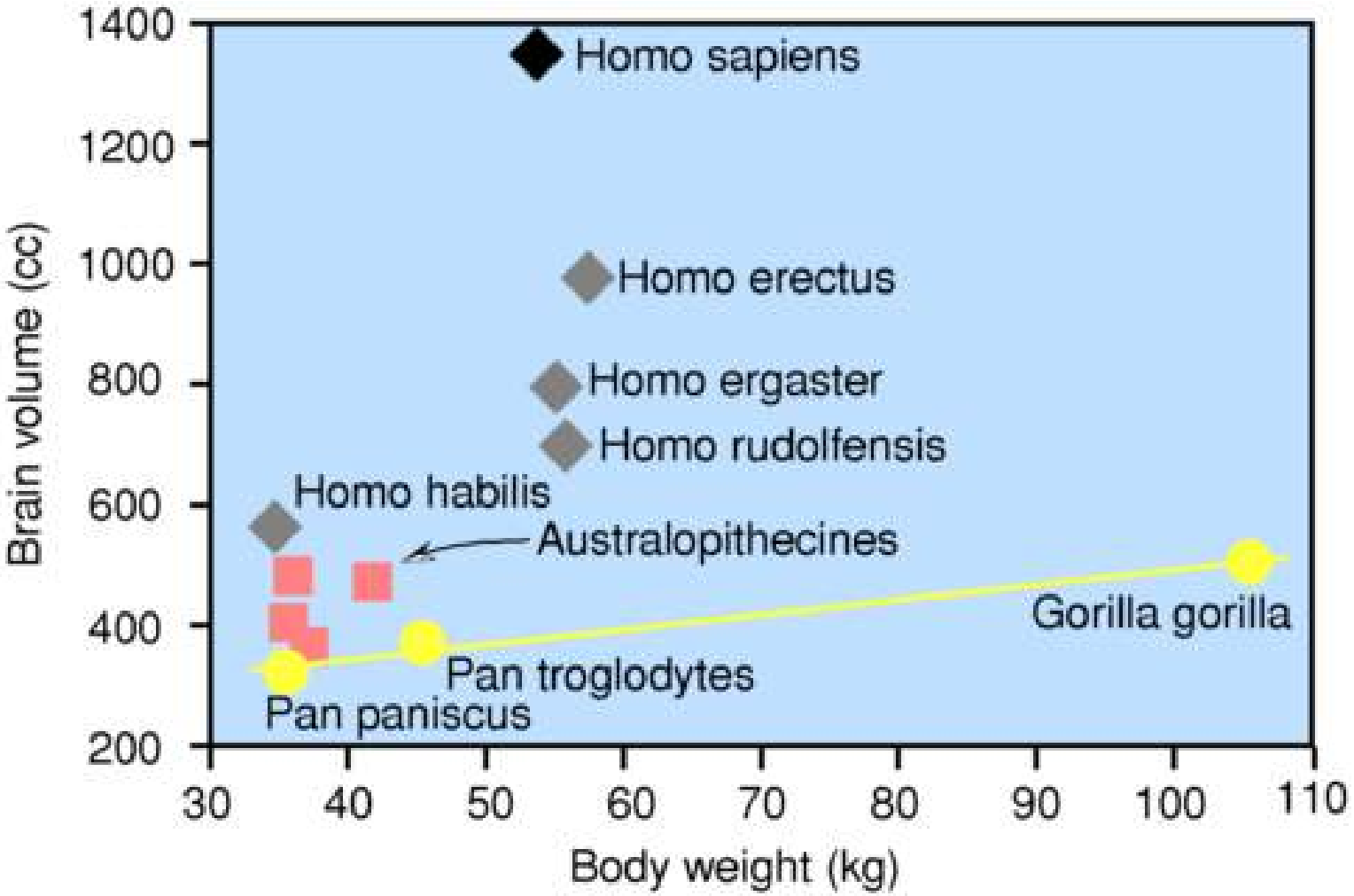
Evolution of the Human Nervous System Function, Structure, and Development.

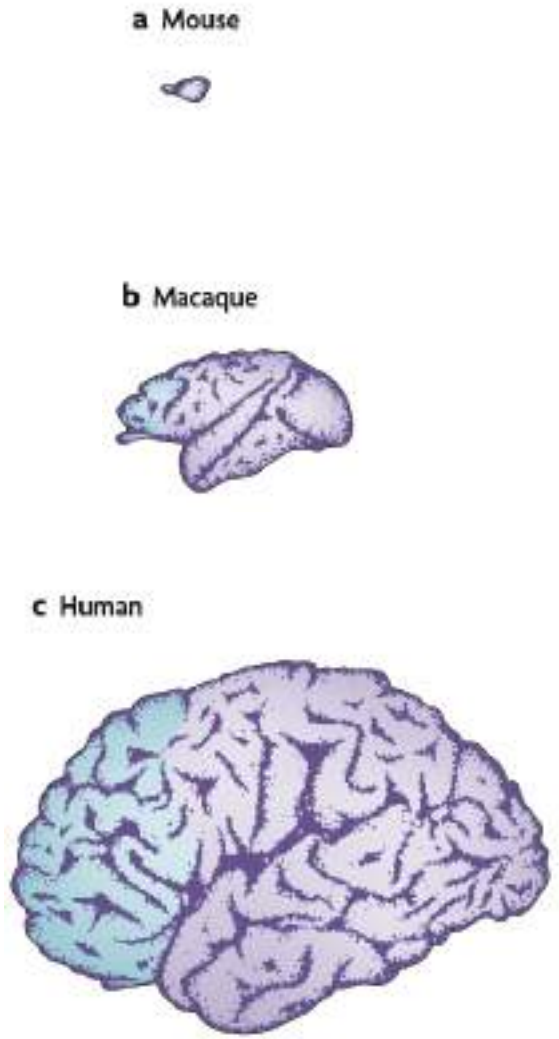
André M M Sousa et al.

Cell, 2017 vol. 170 (2) pp. 226-247


4-6 Myr
6-8 Myr
12-16 Myr


Human 1350g
Chimpanzee 400g
Orangutan 400g
Macaque 100g

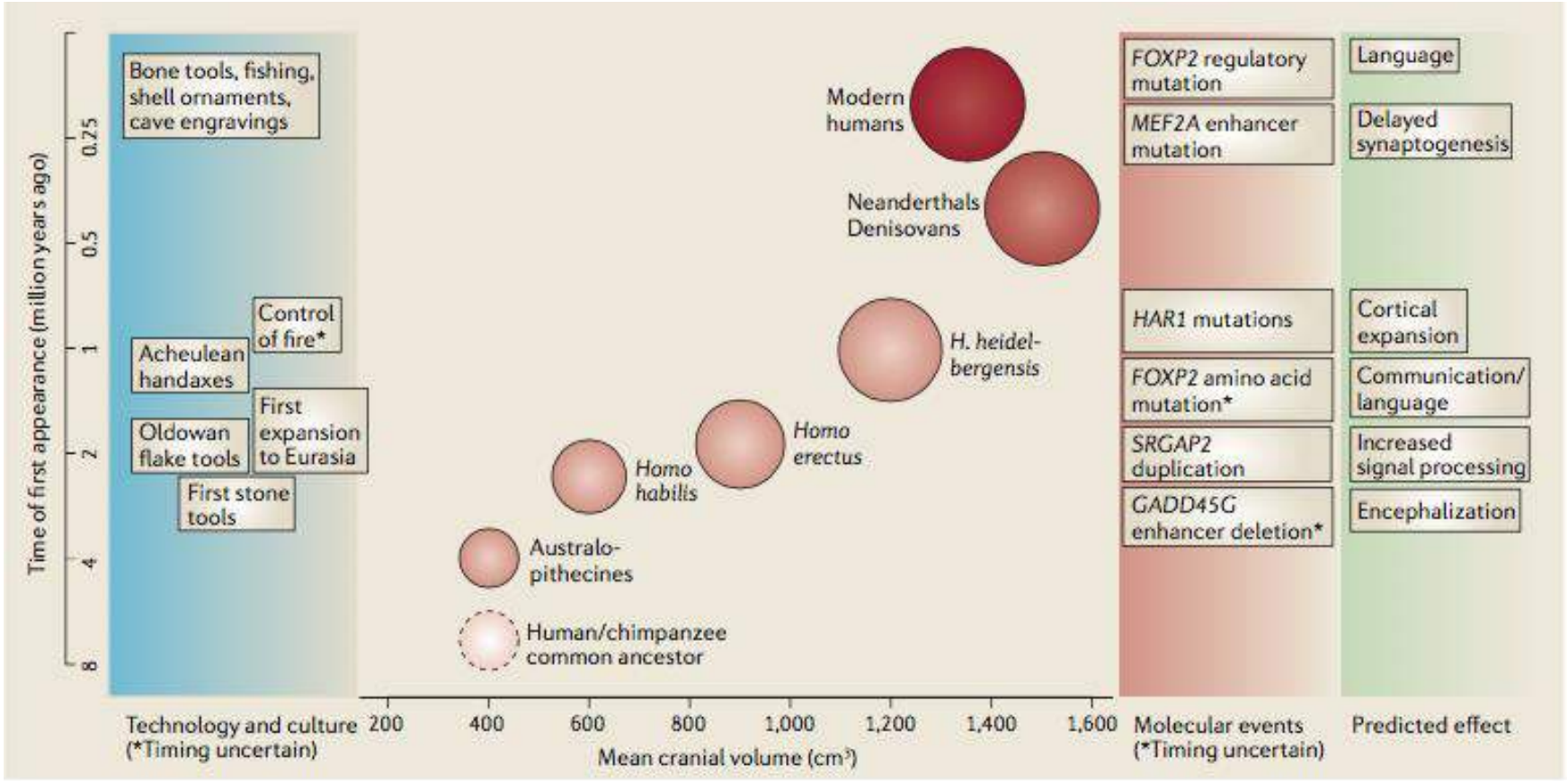

Brain volume (cc)
1400
1200
1000
800
600
400
200
30
40
50
60
70
80
90
100
110
Body weight (kg)
Homo sapiens
Homo erectus
Homo ergaster
Homo rudolfensis
Homo habilis
Australopithecines
Gorilla gorilla
Pan troglodytes
Pan paniscus

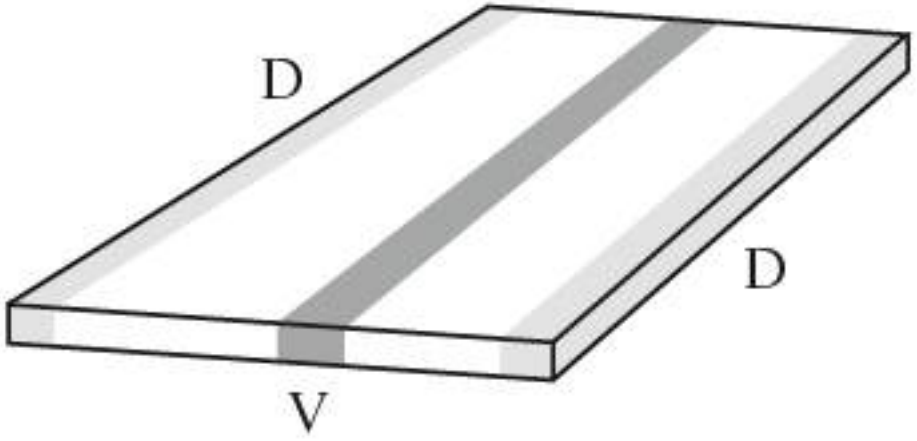

a Mouse
b Macaque
c Human

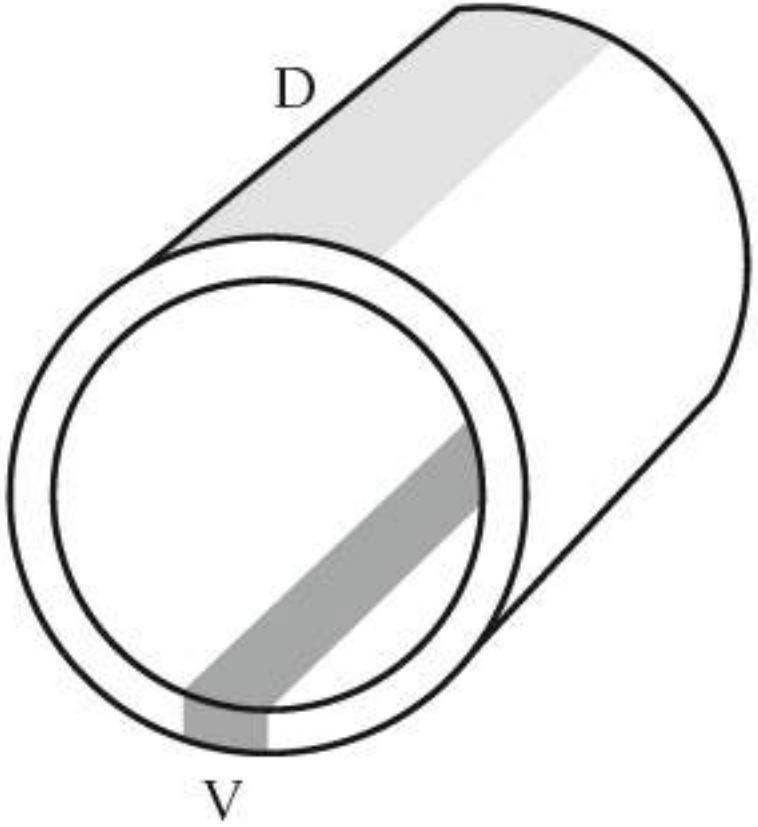
Human brain evolution: transcripts, metabolites and their regulators

Mehmet Somel[1,2], Xiling Liu[1] and Philipp Khaitovich[1,3]

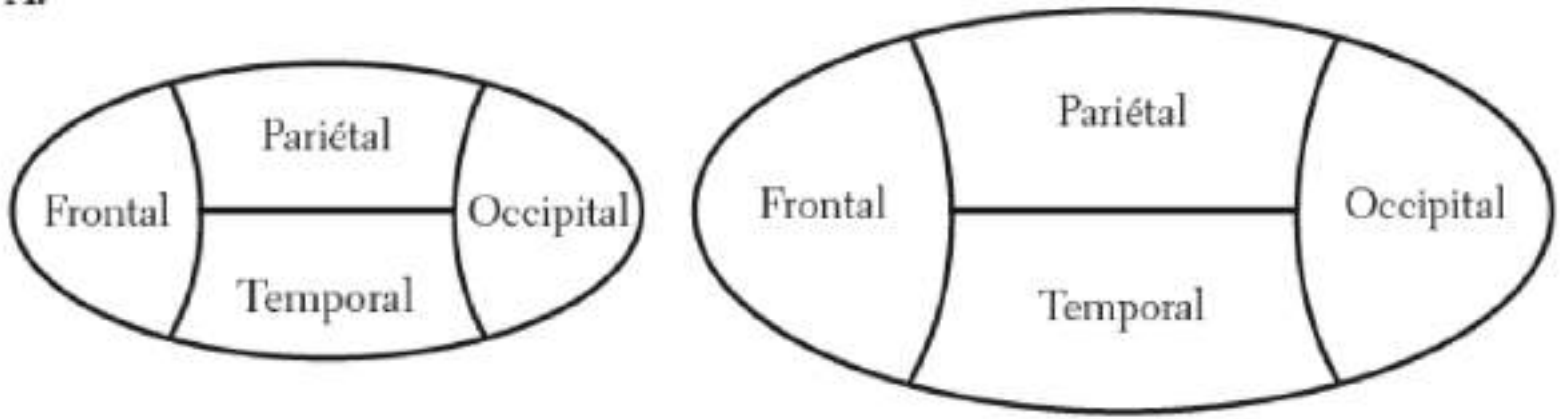
112 | FEBRUARY 2013 | VOLUME 14 www.nature.com/reviews/neuro



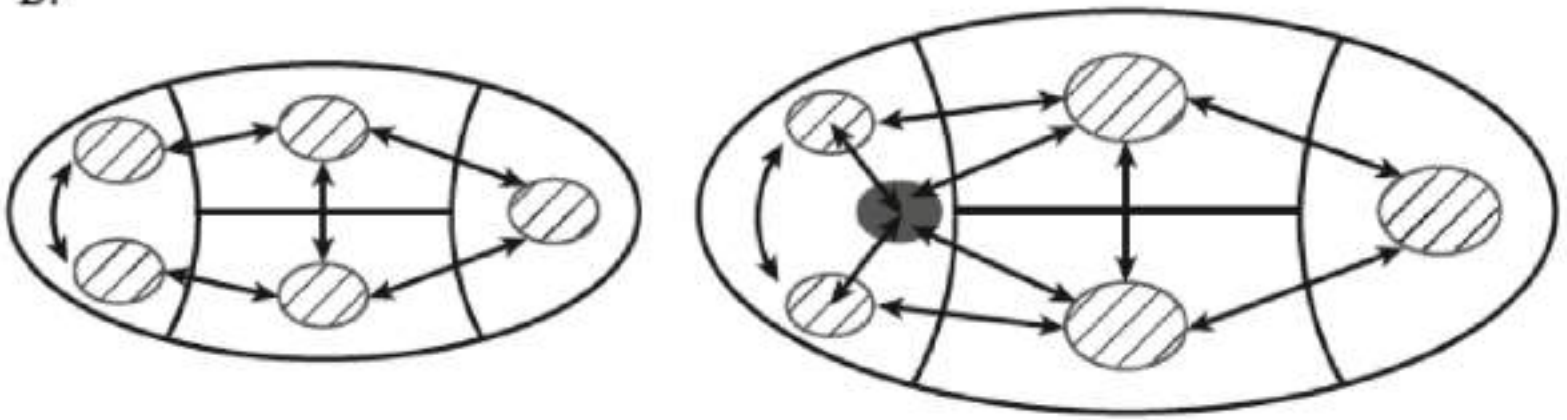

D
D
V


D
V

A.


Pariétal
Frontal
Occipital
Temporal
Pariétal
Frontal
Occipital
Temporal

B.



Evolution of the Human Nervous System Function, Structure, and Development.

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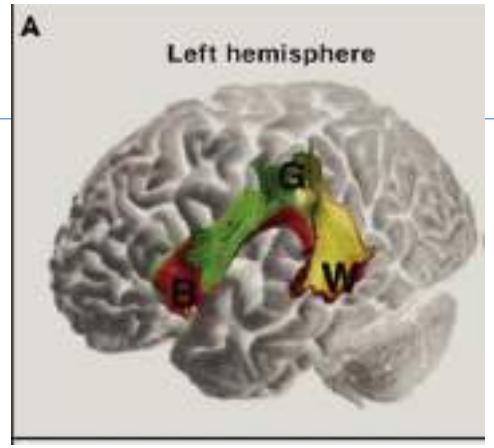
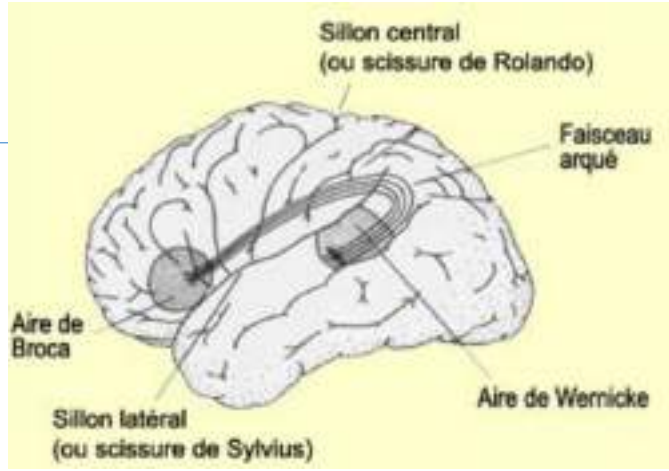
Cell, 2017 vol. 170 (2) pp. 226-247





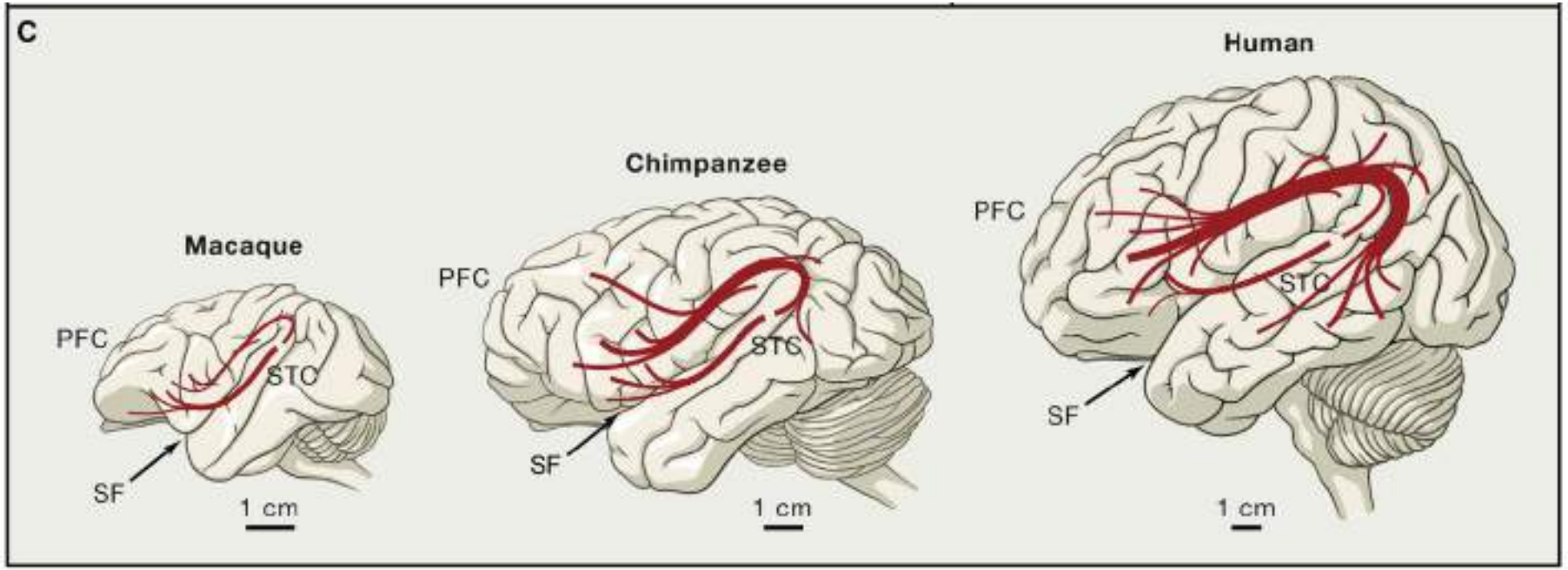


Figure 3. Language-Related Pathways Are Strongly Lateralized and Modified in Humans

Establishing homology between monkey and human brains

NATURE METHODS | VOL.9 NO.3 | MARCH 2012 | 237

Tor D Wager & Tal Yarkoni

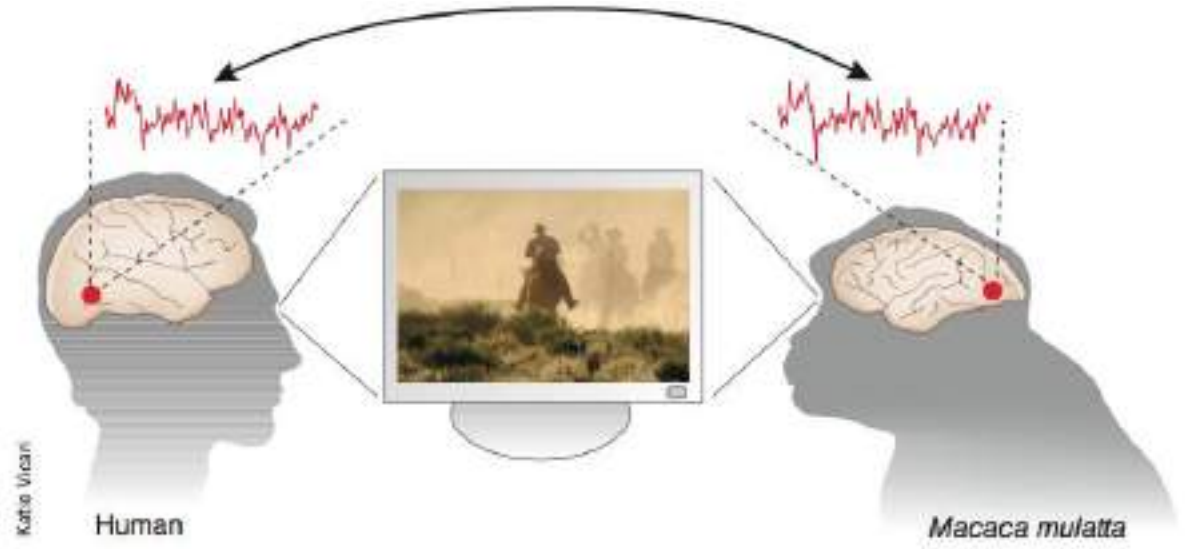
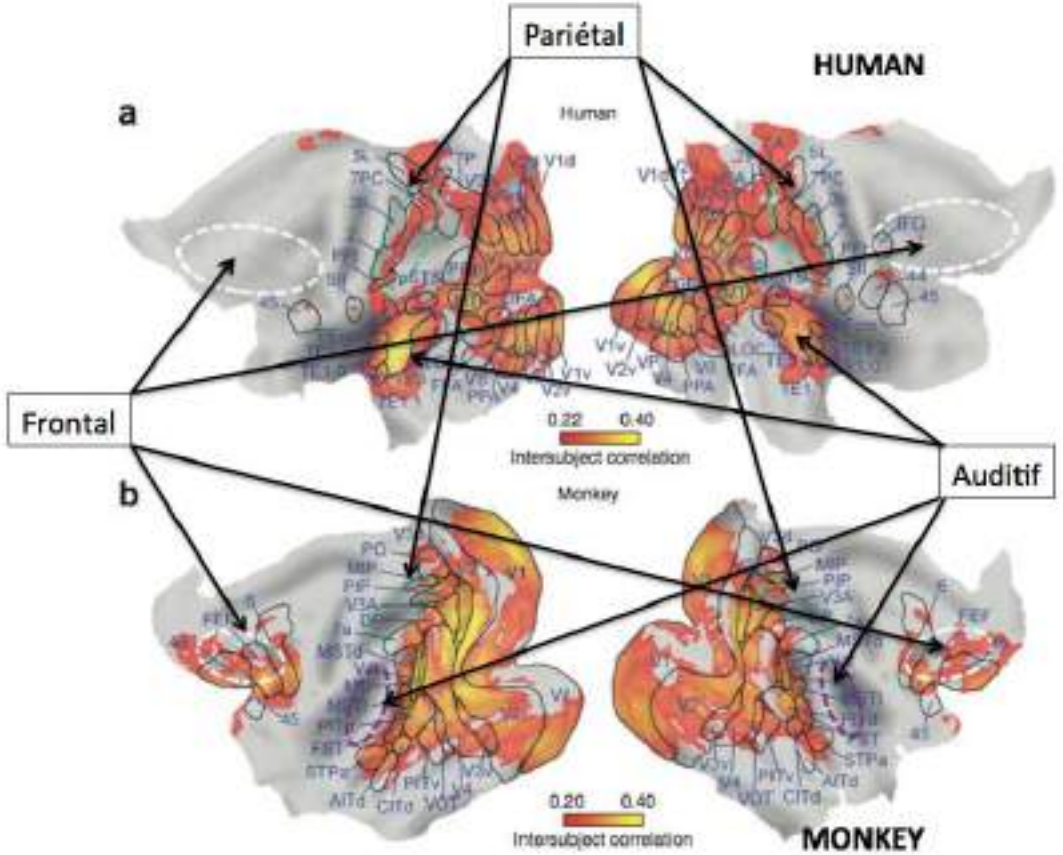
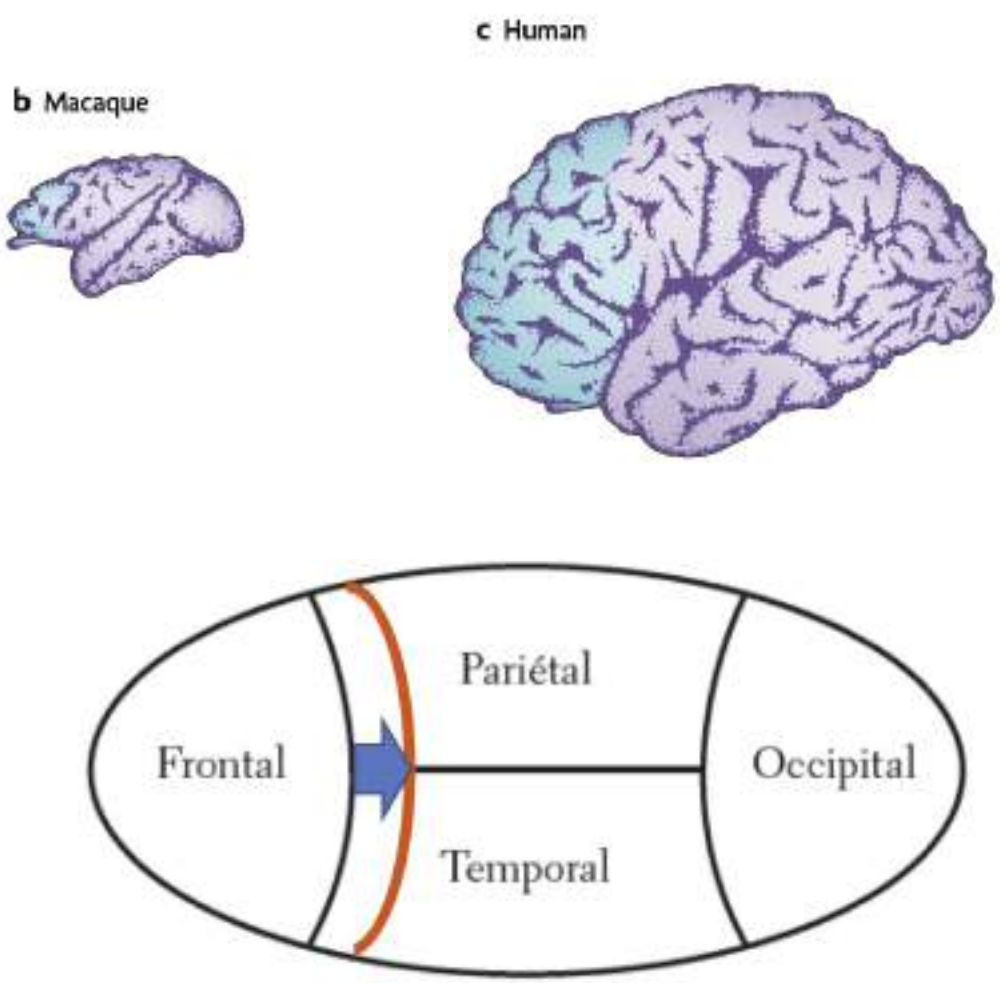
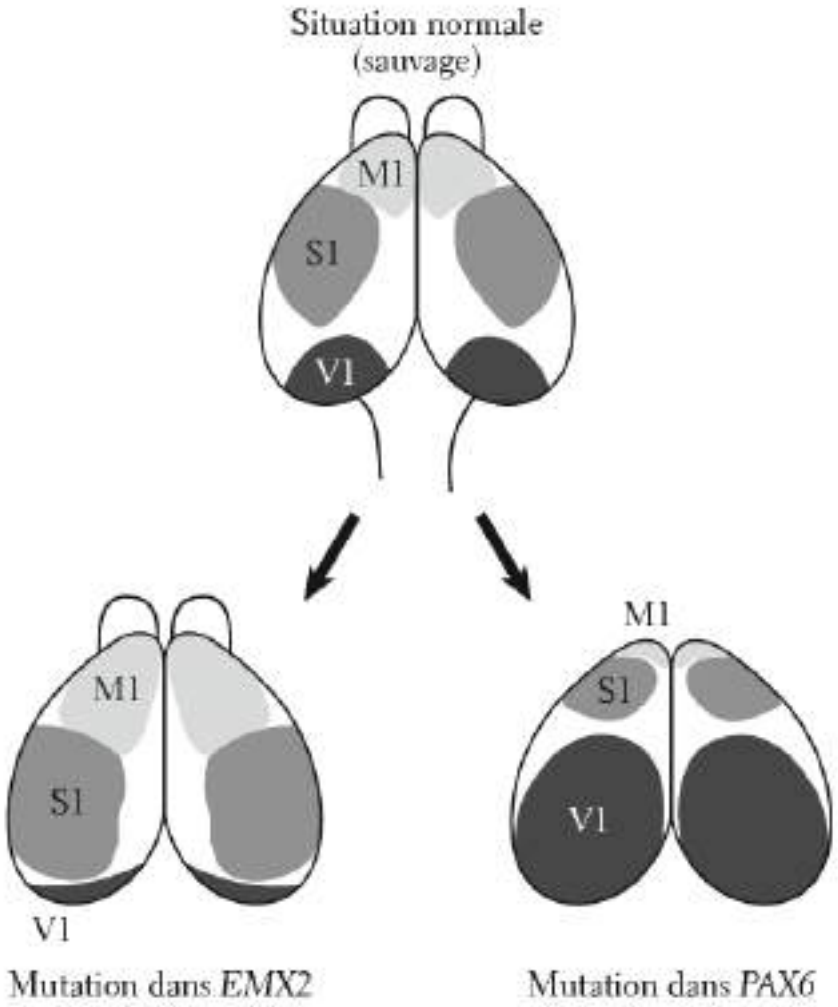


Figure 1 | The ISAC method. Humans and monkeys watch the same film as their brains are scanned with fMRI. The time course of fMRI activity during viewing is extracted from 'seed' regions in human participants and correlated with the fMRI signal in monkeys, and vice versa, with an adjustment made for interspecies differences in vascular hemodynamics. After statistical thresholding, the resulting maps in each species show areas that are potentially homologous with the targeted seed region in the other species.




b Macaque
c Human
Frontal
Pariétal
Occipital
Temporal

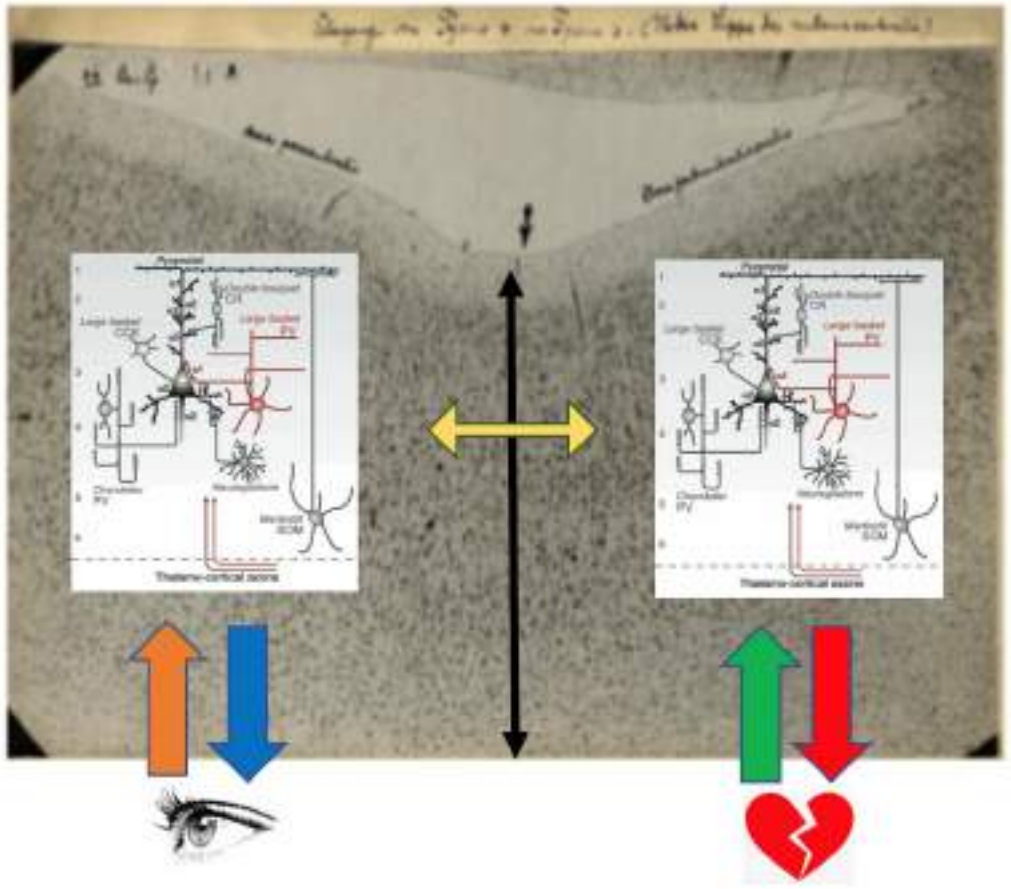

Situation normale
(sauvage)
M1
S1
V1
M1
S1
V1
Mutation dans EMX2
M1
S1
V1
Mutation dans PAX6

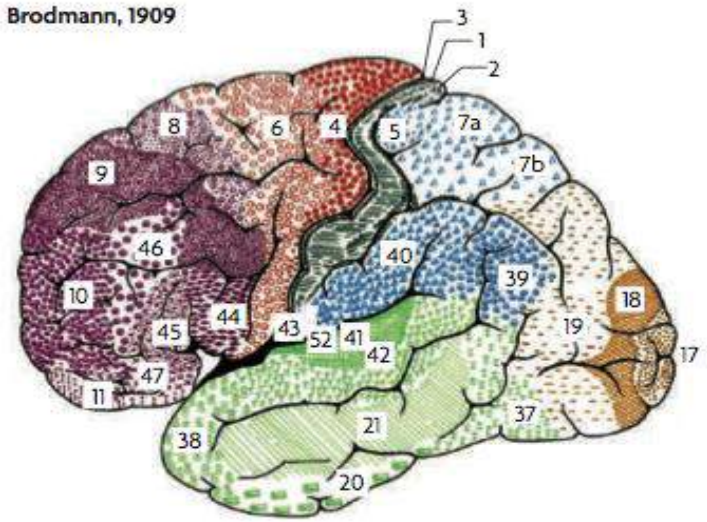
TIMELINE

Centenary of Brodmann's map — conception and fate

Karl Zilles and Katrin Amunts

NATURE REVIEWS | NEUROSCIENCE VOLUME 11 | FEBRUARY 2010 | 139





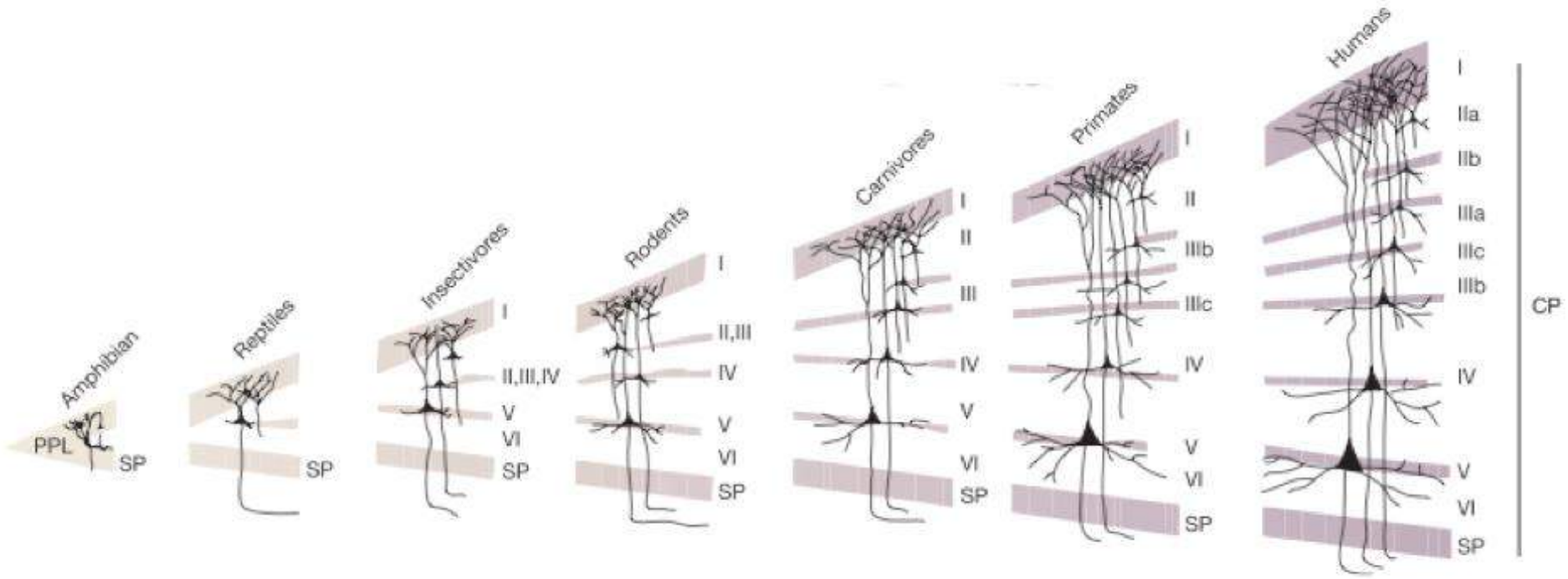
Augmentation de la taille
Augmentation du nombre des aires
Déplacement des bord
Changement des circuits

nature Vol 435 September 2005 doi:10.1038/nature04003

PROGRESS

Molecular insights into human brain evolution

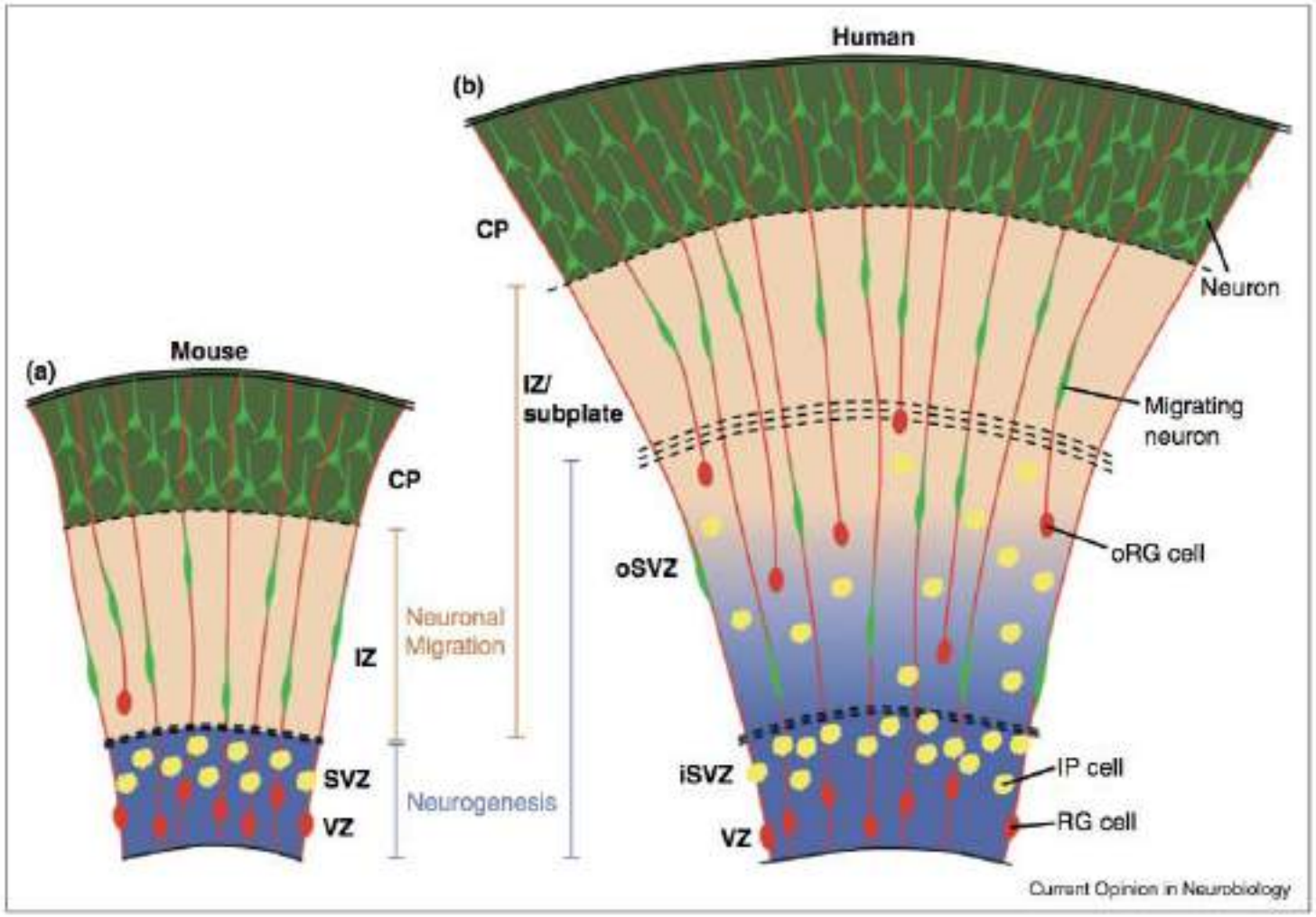
Robert Sean Hill & Christopher A. Walsh



OSVZ progenitors in the human cortex: an updated perspective on neurodevelopmental disease

Bridget E LaMonica[1,2,3], Jan H Lui[1,2], Xiaoqun Wang[1,2] and Arnold R Kriegstein[1,2]

Current Opinion in Neurobiology 2012, **22**:747–753



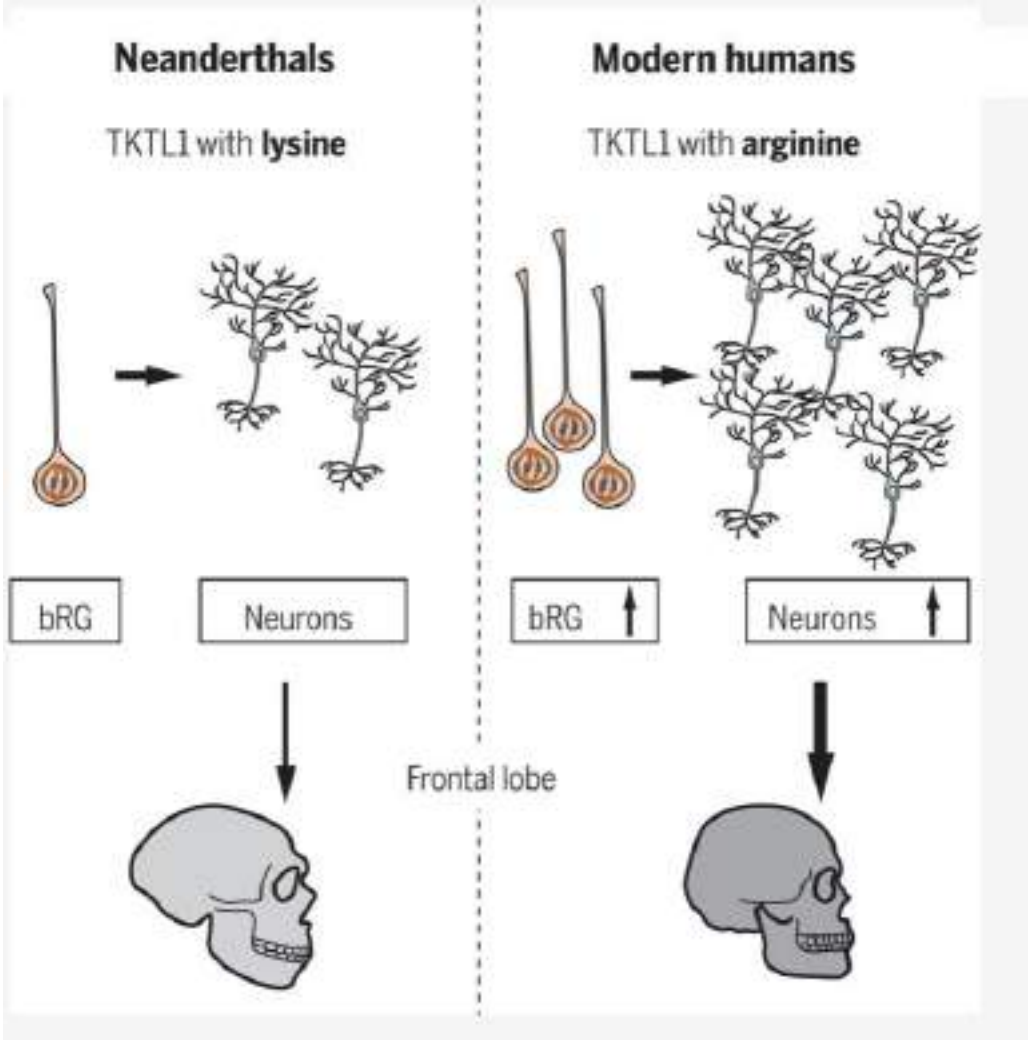
Science

SCIENCE > VOL. 377, NO. 6611 >

Human TKTL1 implies greater neurogenesis in frontal neocortex of modern humans than Neanderthals

ANNELINE PINSON, LEI XING, TAKASHI NAMBA, NEREO KALEBIC, JULA PETERS, CHRISTINA FUGSTER OEGEMA, SOFIA TRAIKOV, KATRIN REPPE, STEPHAN RIESENBERG, TOMISLAV MARICIC, BAZVAN DERIVACI, PAULINE KIMBERGER, SVANTE PÄÄBO, AND WIELAND B. HUTTNER fewer

Authors Info & Affiliations

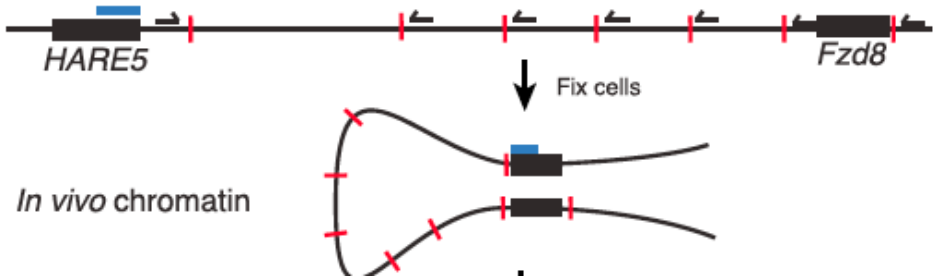


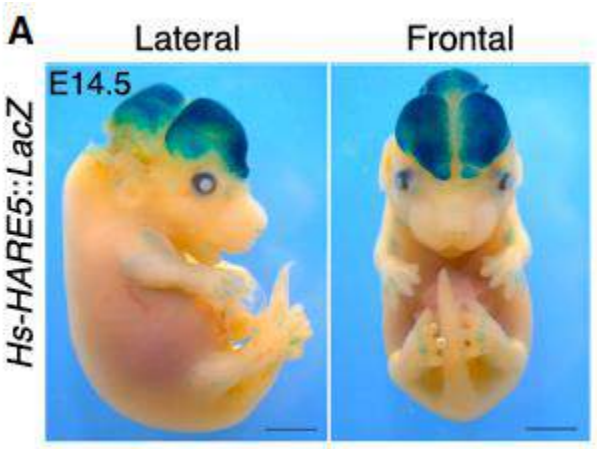
HAREs ou Régions accélées (en nombre de mutations) chez l'humain

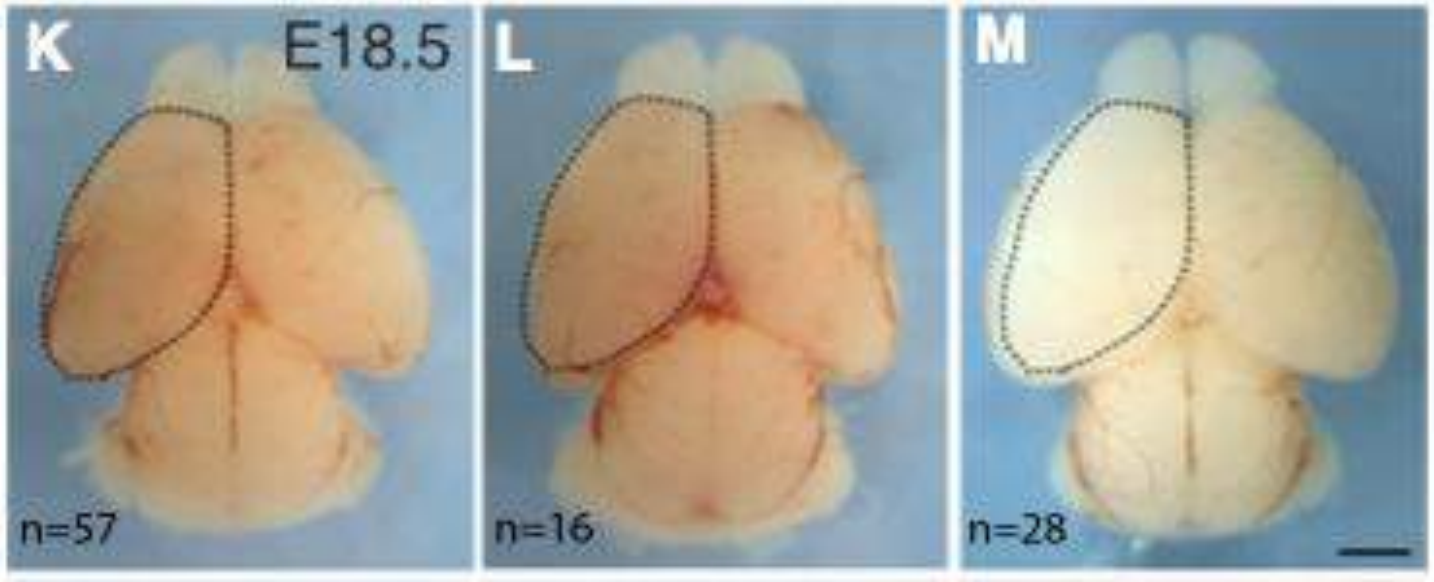
Human-chimpanzee differences in a FZD8 enhancer alter cell-cycle dynamics in the developing neocortex.

J Lomax Boyd et al.

Curr Biol, 2015 vol. 25 (6) pp. 772-779







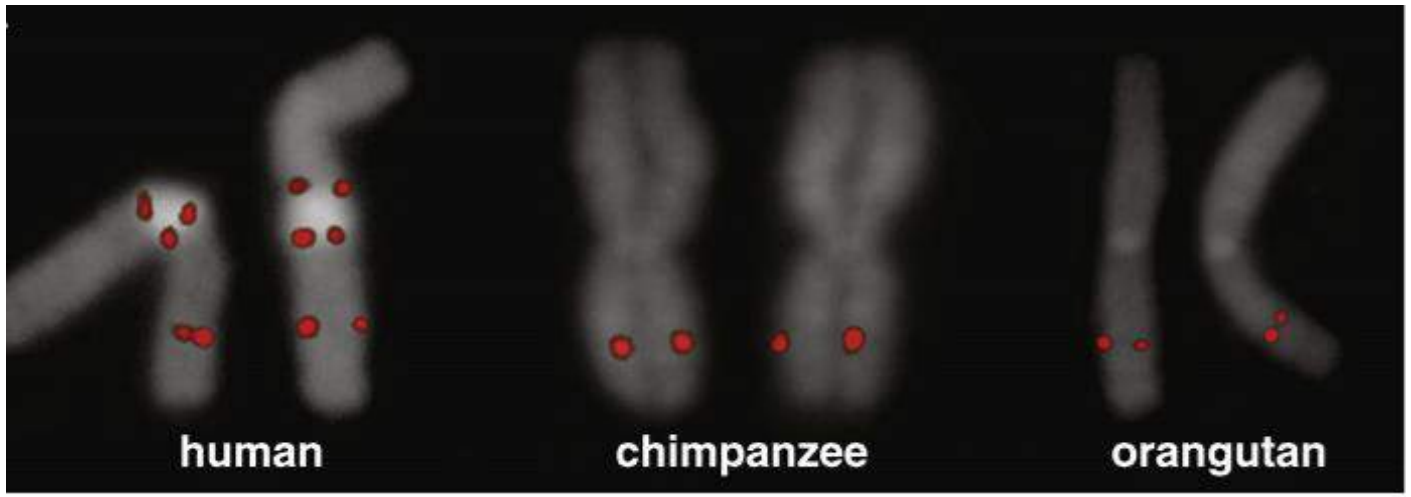
Raccoucissement du cycle cellulaire progéniteurs

Evolution of human-specific neural SRGAP2 genes by incomplete segmental duplication.

Megan Y Dennis et al.

Cell, 2012 vol. 149 (4) pp. 912-922

Duplication



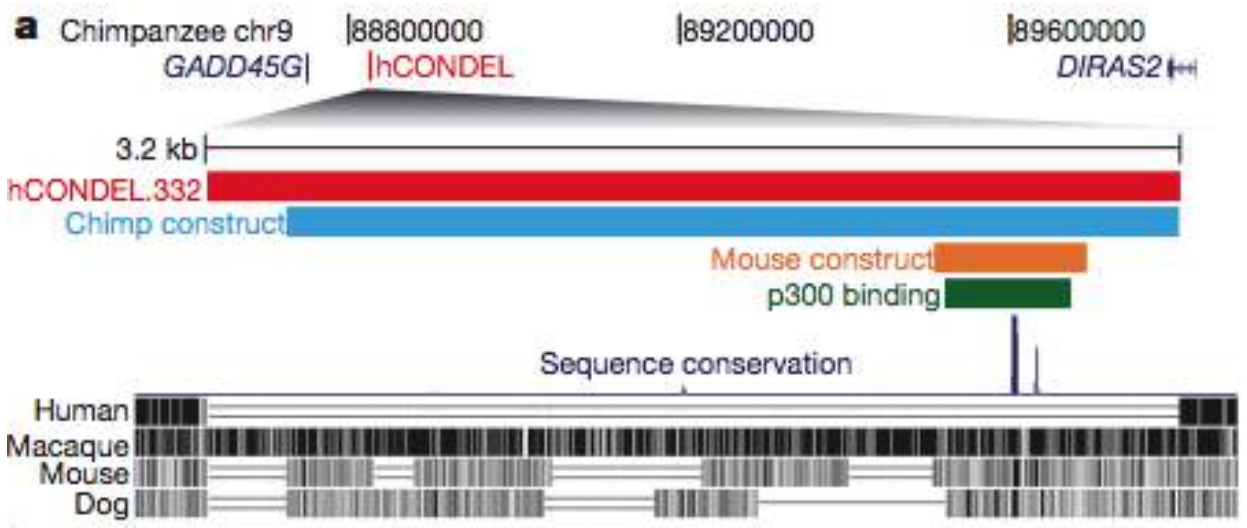
Mclean CY, Reno PL, Pollen AA, Bassan AI, Capellini TD, Guenther C, Indjeian VB, Lim X, Menke DB, Schaar BT, Wenger AM, Bejerano G, Kingsley DM

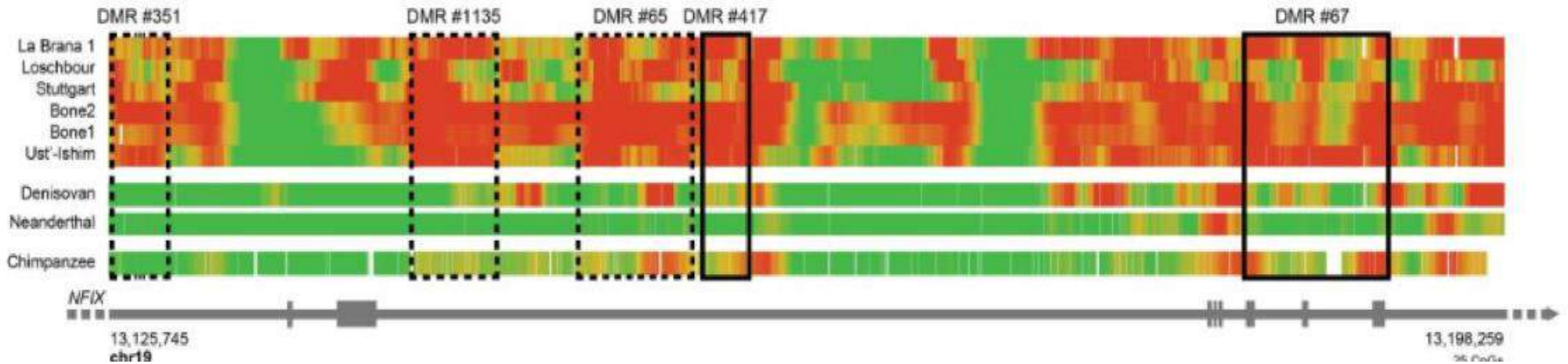
Nature

2011 vol. 471 (7337) pp. 216-9

Délétion.

Human-specific loss of regulatory DNA and the evolution of human-specific traits





Extensive Regulatory Changes in Genes Affecting Vocal and Facial Anatomy Separate Modern from Archaic Humans

David Gokhman, Lily Agranat-Tamir, Genevieve Housman, Raquel Garcia-Perez, Malka Nissim-Rafinia, Swapan Mallick, Maria Nieves-Colón, Heng Li, Songül Alpaslan-Roodenberg, Mário Novak, Hongcang Gu, Manuel Fernando-Bernal, Pere Gelabert, Idil Lipende, Ivanela Kondova, Ronald Bontrop, Ellen E. Quillen, Alexander Meissner, Anne C. Stone, Anne E. Pusey, Deus Mjungu, Leonid Kandel, Meir Liebergall, Maria E. Prado, Julio M. Vidal, Kay Prüfer, Johannes Krause, Benjamin Yakir, Svante Pääbo, Ron Pinhasi, Carles Lalueza-Fox, David Reich, Tomas Marques-Bonet, Eran Meshorer, Liran Carmel

doi: https://doi.org/10.1101/106955

bioRxiv

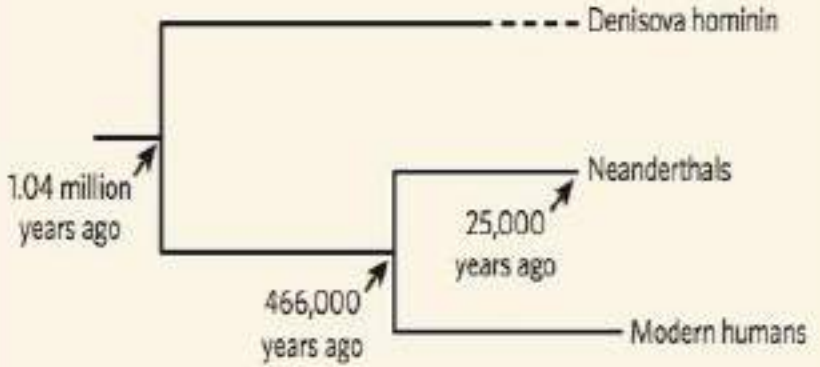
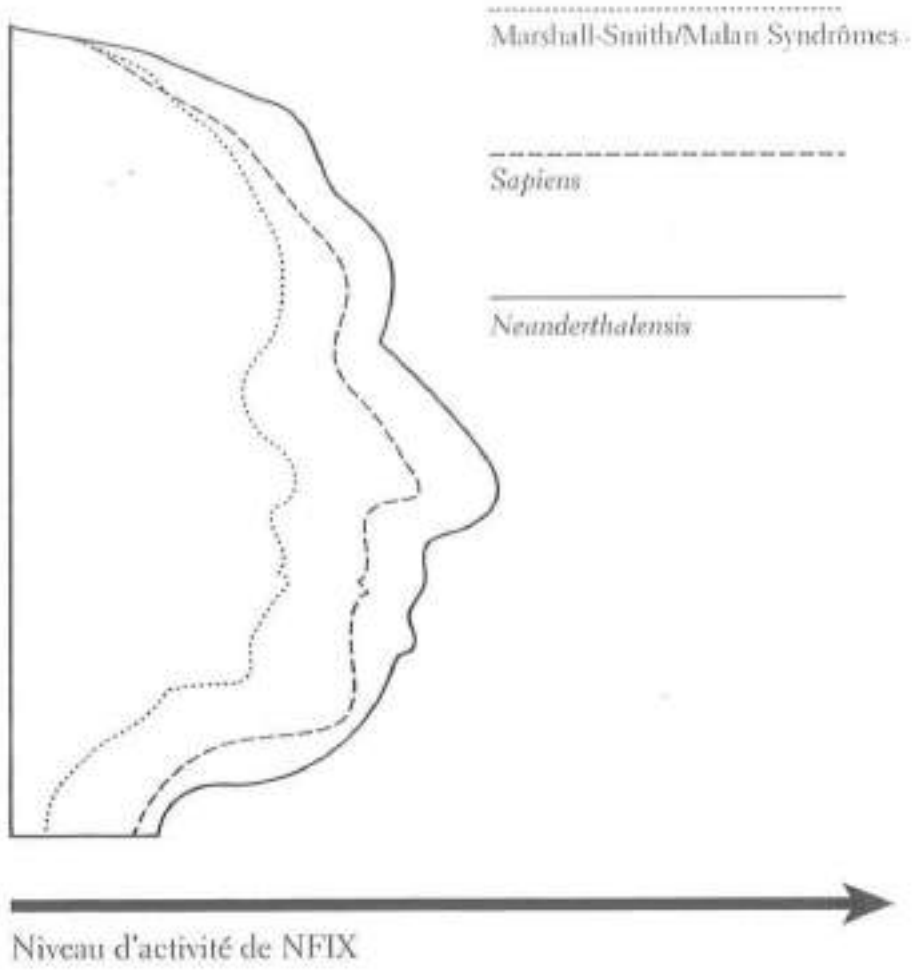


Table 1. DMGs that affect the voice and the larynx.

DMG	Associated phenotype	Chr
ALPL	Abnormality of the voice	1
AHDC1	Laryngomalacia	1
AHDC1	Laryngomalacia	1
SATB2	Abnormality of the voice	2
SPEG	Dysphonia	2
COLQ	Weak cry	3
TGFBR2	Abnormality of the voice	3
TGFBR2	Abnormality of the voice	3
TGFBR2	Abnormality of the voice	3
POC1A	High pitched voice	3
PLXND1	Abnormality of the voice	3
SH3BP2	Abnormality of the voice	4
SDHA	Hoarse voice, loss of voice, vocal cord paralysis	5
GLI3	Laryngeal cleft	7
CHD7	Abnormality of the voice, Laryngomalacia	8
HNRNPA1	Bowing of the vocal cords, hoarse voice	12
TRPV4	Vocal cord paresis	12
MEIS2	Laryngomalacia	15
ACAN	Hoarse voice	15
CREBBP	Laryngomalacia	16
CREBBP	Laryngomalacia	16
XYLT1	High-pitched voice	16
WWOX	Abnormality of the voice	16
WWOX	Abnormality of the voice	16
SOX9	Laryngomalacia	17
SOX9	Laryngomalacia	17
GNAL	Laryngeal dystonia	18
NFIX	Laryngomalacia	19
NFIX	Laryngomalacia	19
POLD1	High-pitched voice	19
RIN2	High-pitched voice	20
TBX1	Abnormality of the voice, nasal speech	22



Larynx et cordes vocales ¶

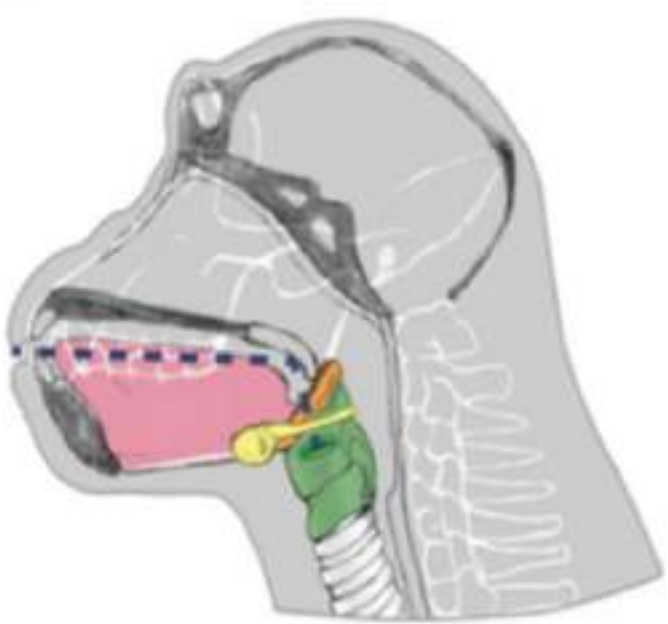
langue ¶

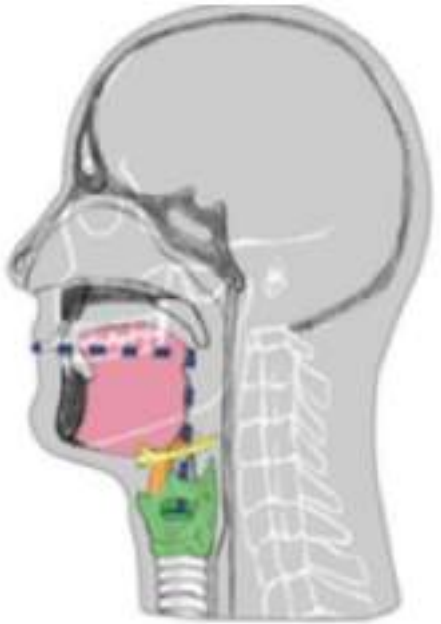
Os hyoïde ¶

épiglotte ¶

David Gokhman[1], Lily Agranat-Tamir[1,2], Genevieve Housman[3,4], Raquel García-Pérez[5], Malka Nissim-Rafinia[1], Swapan Mallick[6,7,8], Maria A. Nieves-Colón[3,4], Hongcang Gu[9], Manuel Fernando-Bernal[1], Pere Gelabert[5], Iddi Lipende[9], Ivanela Kondova[10], Ronald Bontrop[10], Ellen E. Quillen[11], Alexander Meissner[6,12,13], Anne C. Stone[3,4,14], Anne E. Pusey[15], Deus Mjungu[9], Leonid Kandel[16], Meir Liebergall[16], María E. Prada[17], Julio M. Vidal[18], Kay Prüfer[19], Johannes Krause[20], Benjamin Yakir[2], Svante Pääbo[19], David Reich[6,7,8], Carles Lalueza-Fox[5], Tomas Marques-Bonet[5,21,22], Eran Meshorer[1,23,*], Liran Carmel[1,*] ¶

¶

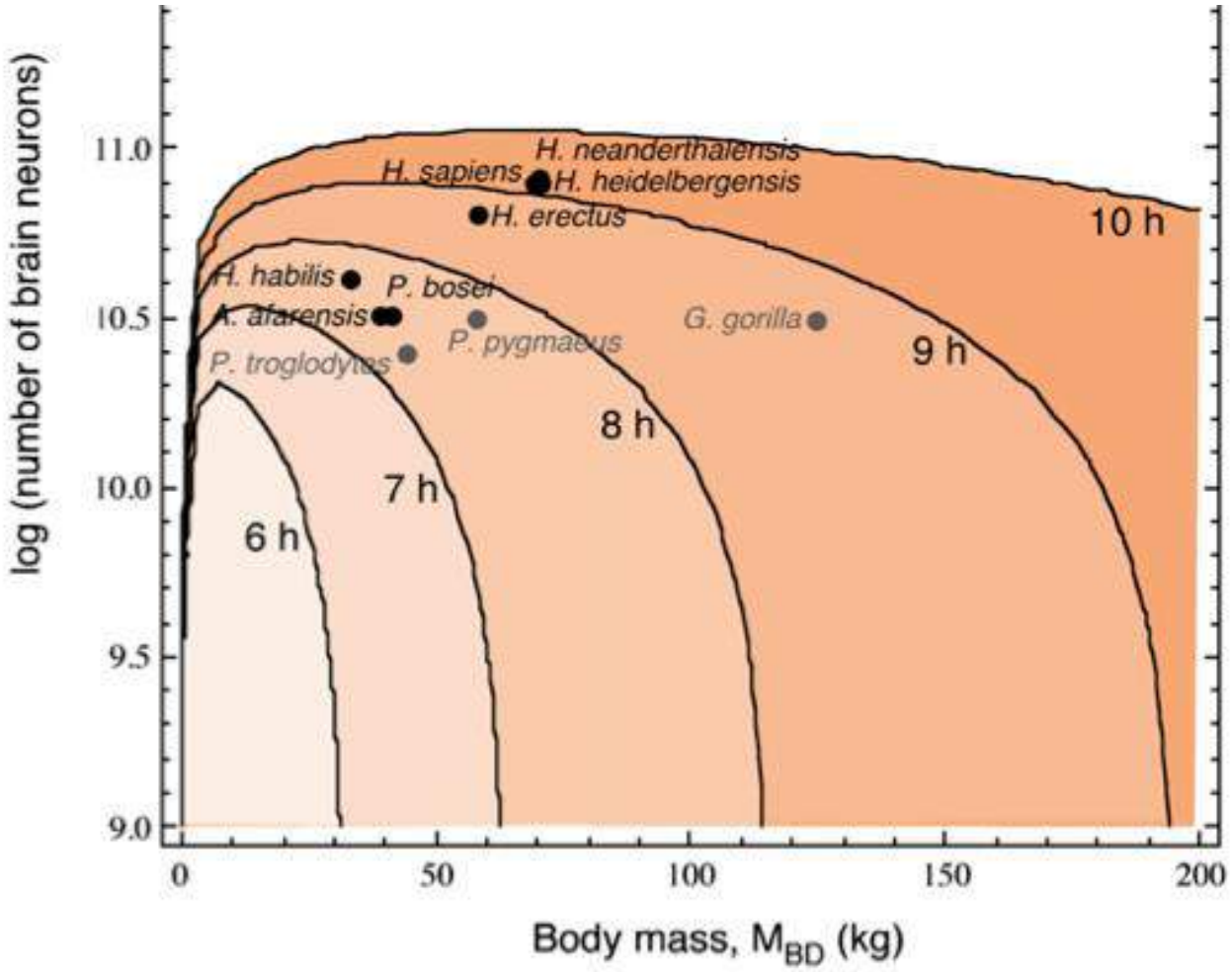


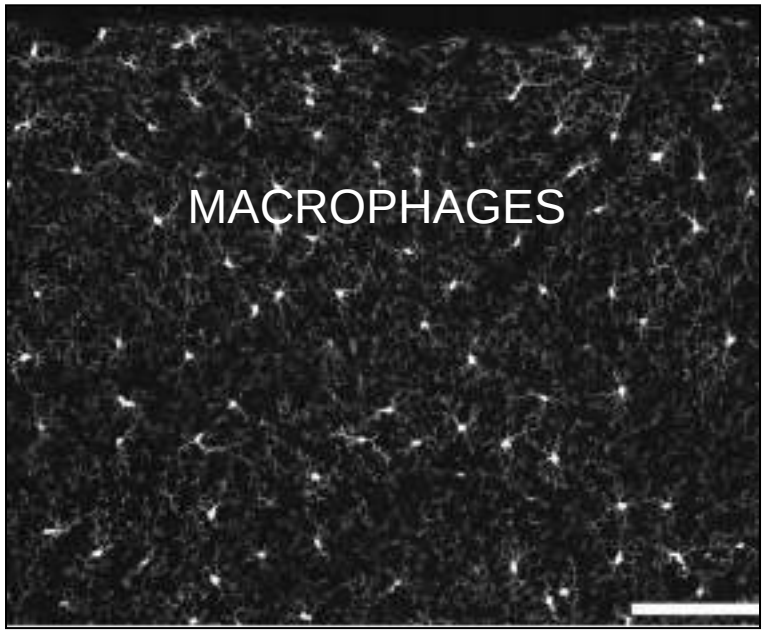


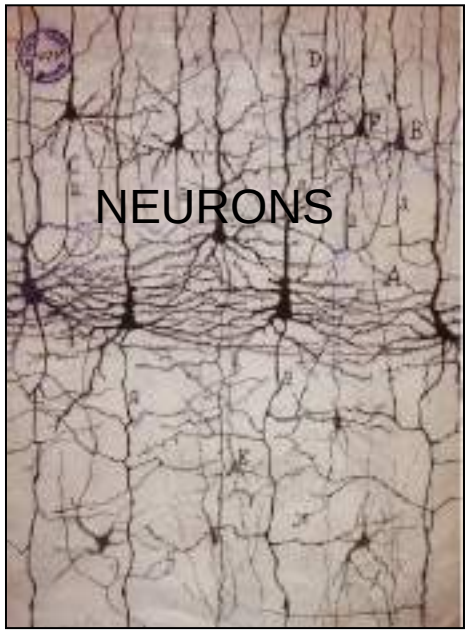
Metabolic constraint imposes tradeoff between body size and number of brain neurons in human evolution

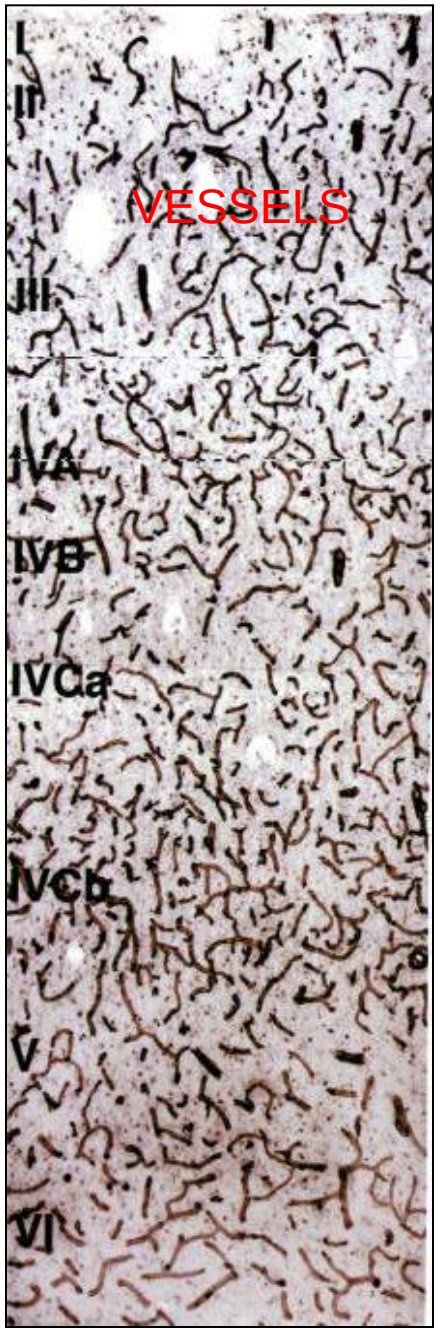
Fonseca-Azevedo K, Herculano-Houzel S

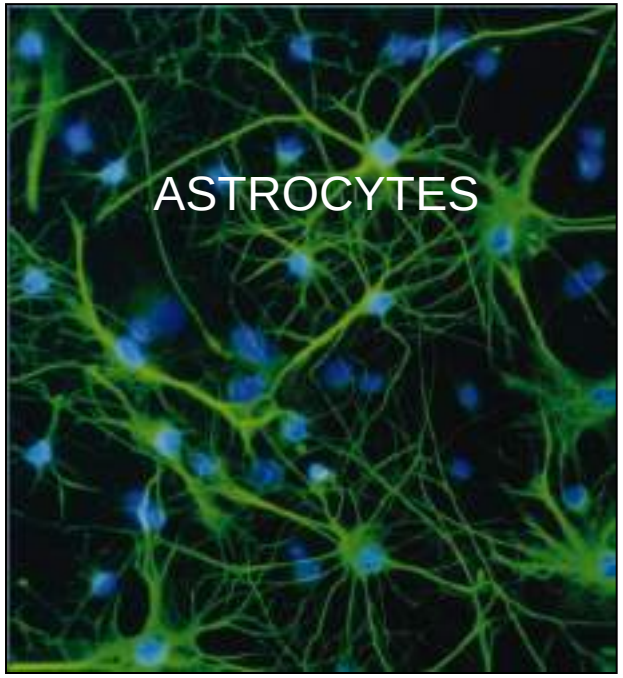
Proc Natl Acad Sci USA
2012 vol. 109 (45) pp. 18571-6

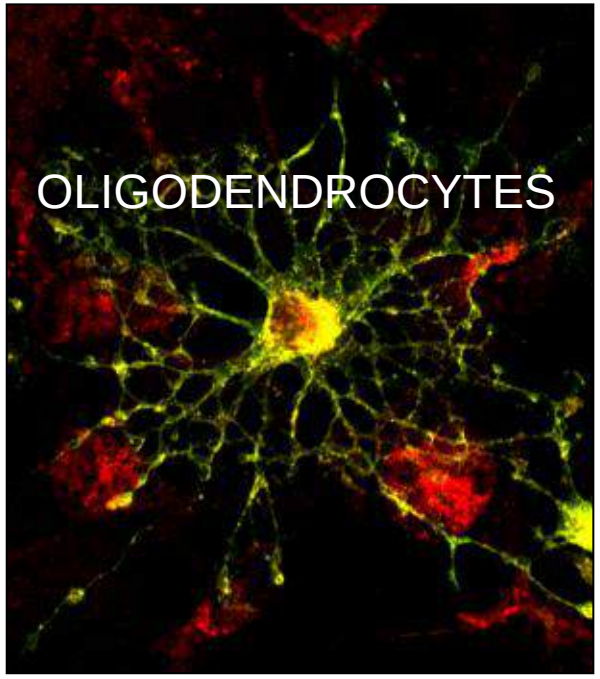



MACROPHAGES


NEURONS

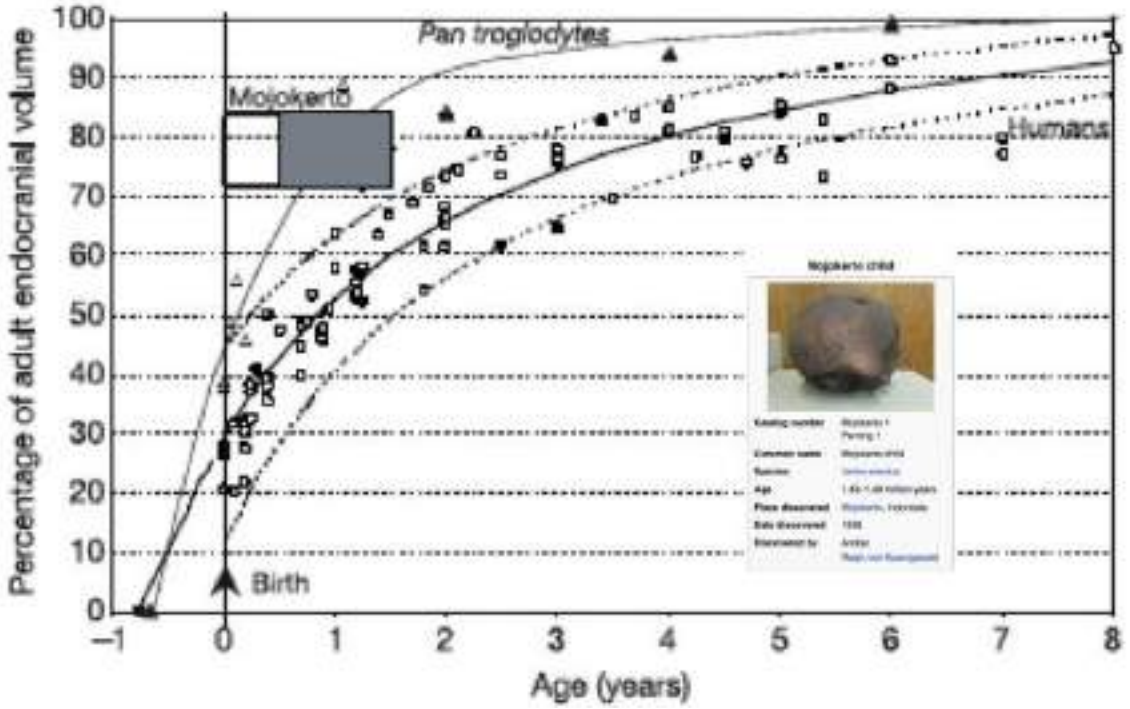

VESSELS
I
II
III
IVA
IVB
IVCa
IVCb
V
VI

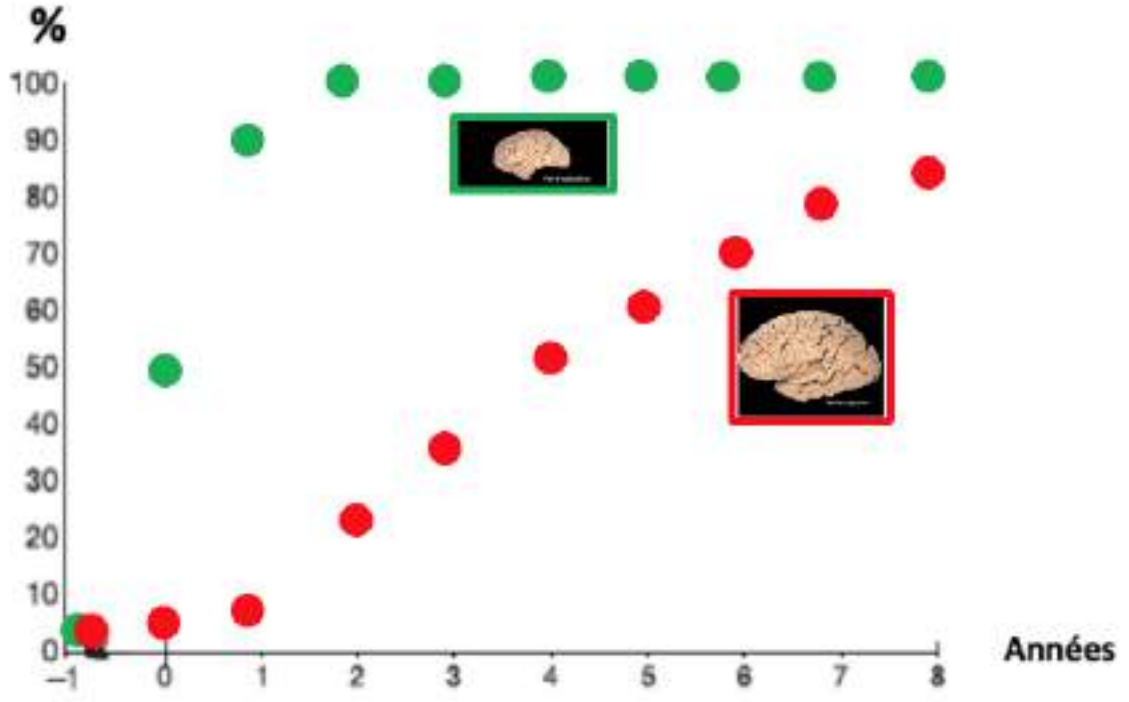

ASTROCYTES

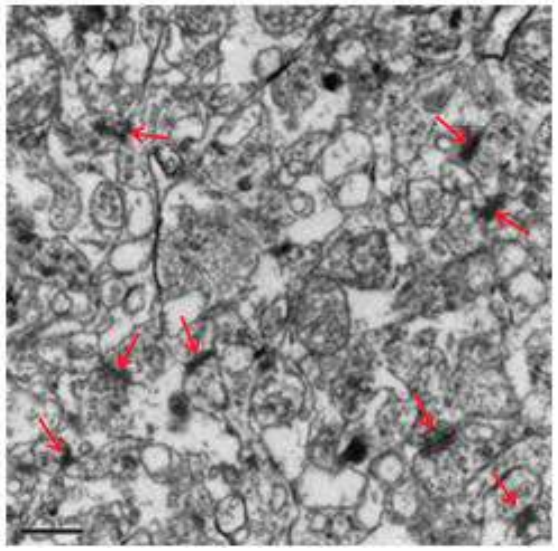

OLIGODENDROCYTES

Early brain growth in *Homo erectus* and implications for cognitive ability

H. Coqueugniot[1], J.-J. Hublin[2], F. Veillon[3], F. Houët[3] & T. Jacob[4]



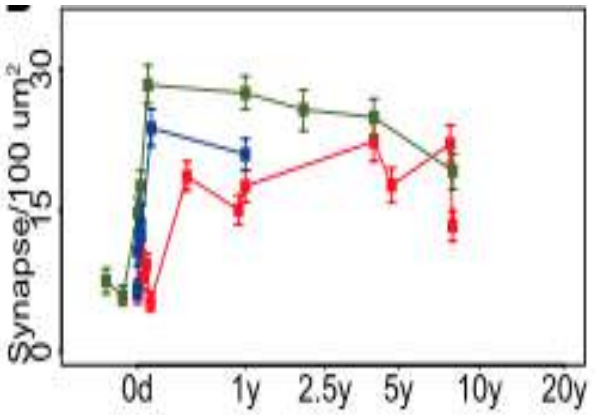




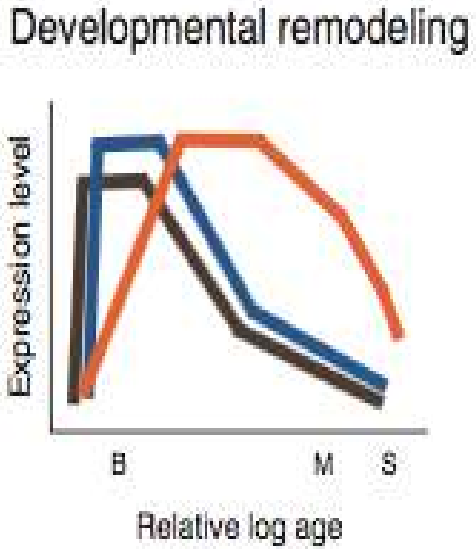
Extension of cortical synaptic development distinguishes humans from chimpanzees and macaques.

Xiling Liu et al.

Genome Research, 2012 vol. 22 (4) pp. 611-622

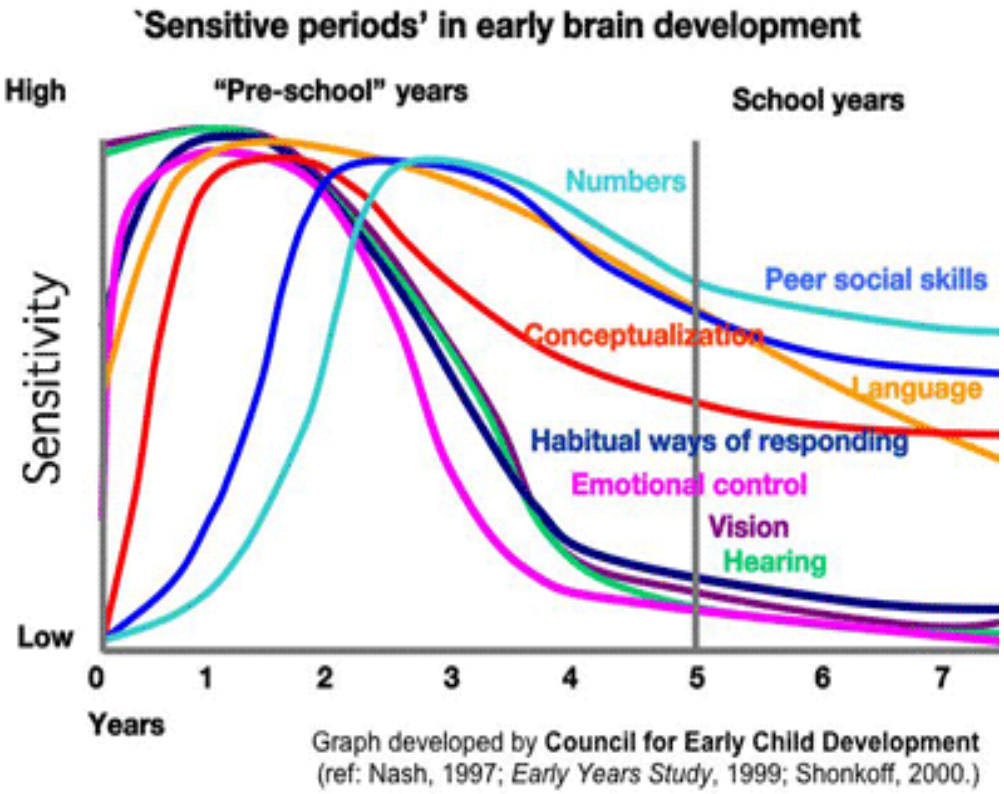


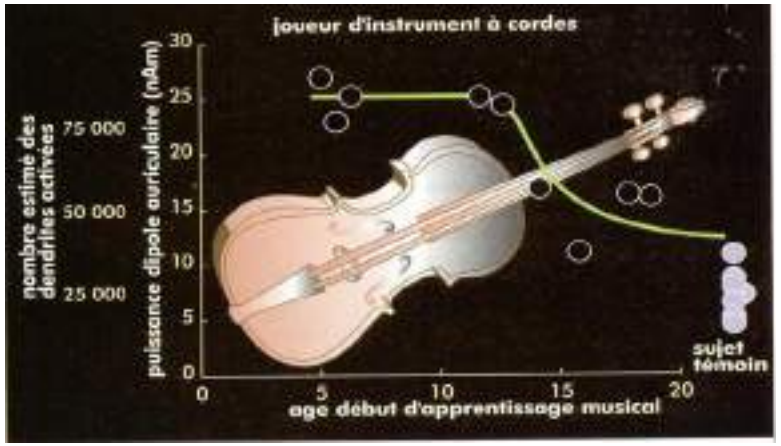
Human
Chimp
Macaque

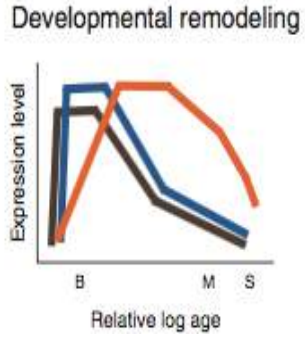


Neuroplasticity

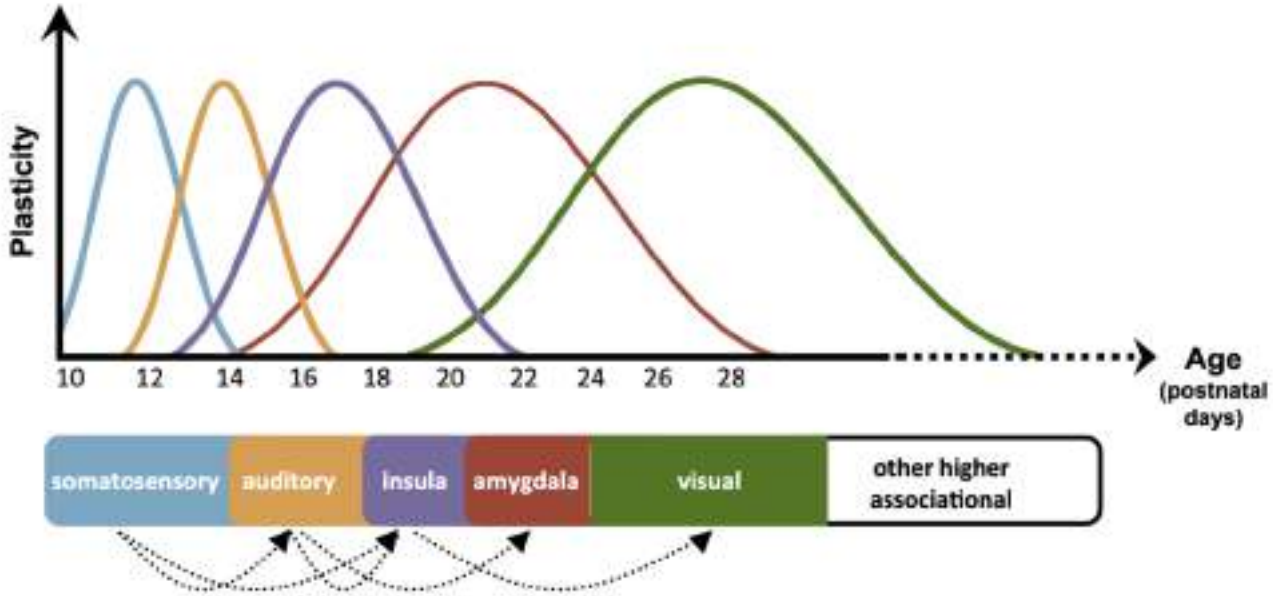
Ability to change neural pathways and synapses caused by changing behavior, environment, neural processes, thinking, emotions, as well as changes resulting from bodily injury

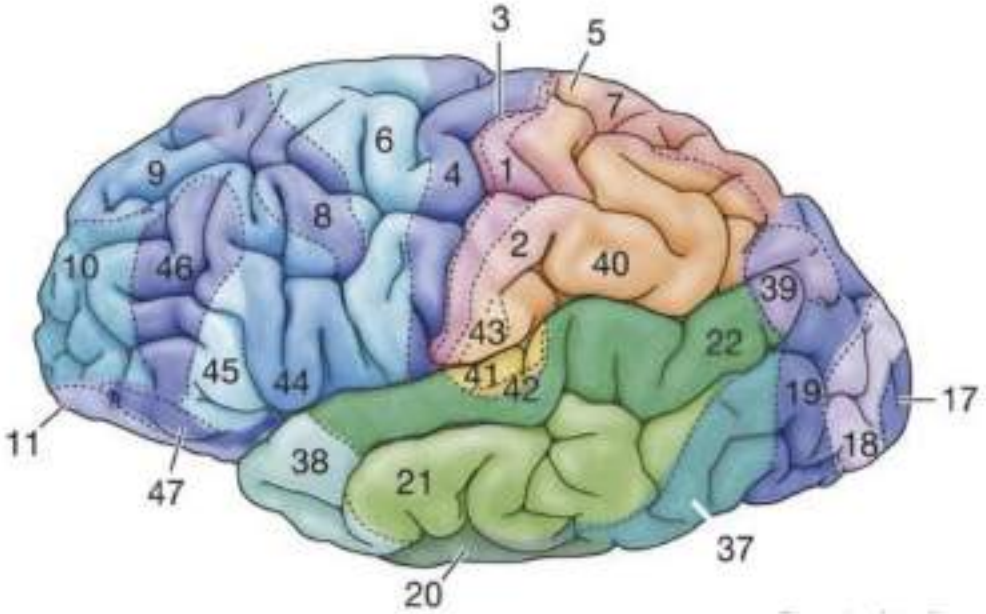






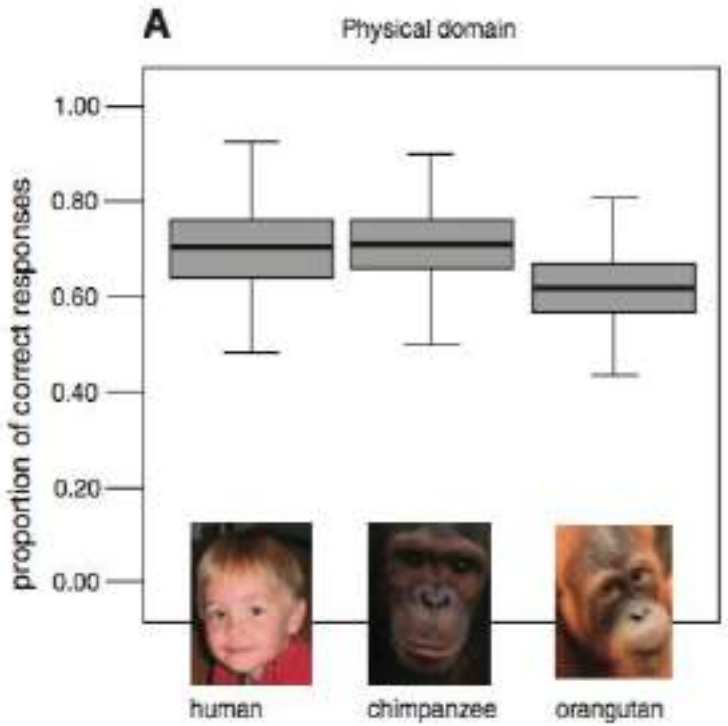
Brain adapts to environment during heightened plasticity

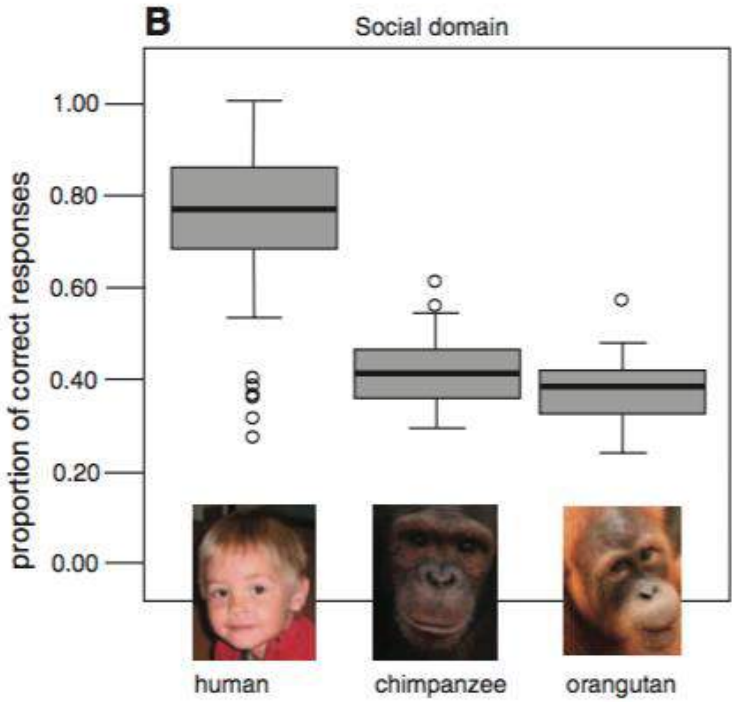


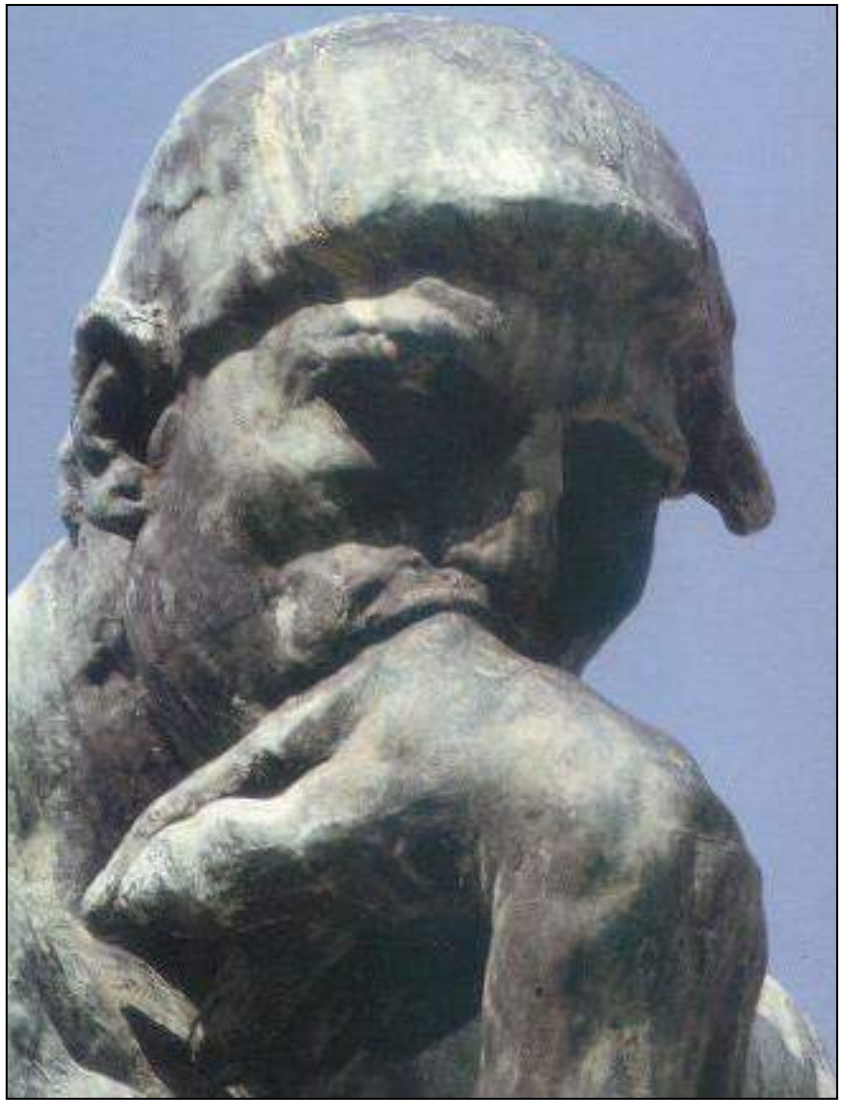


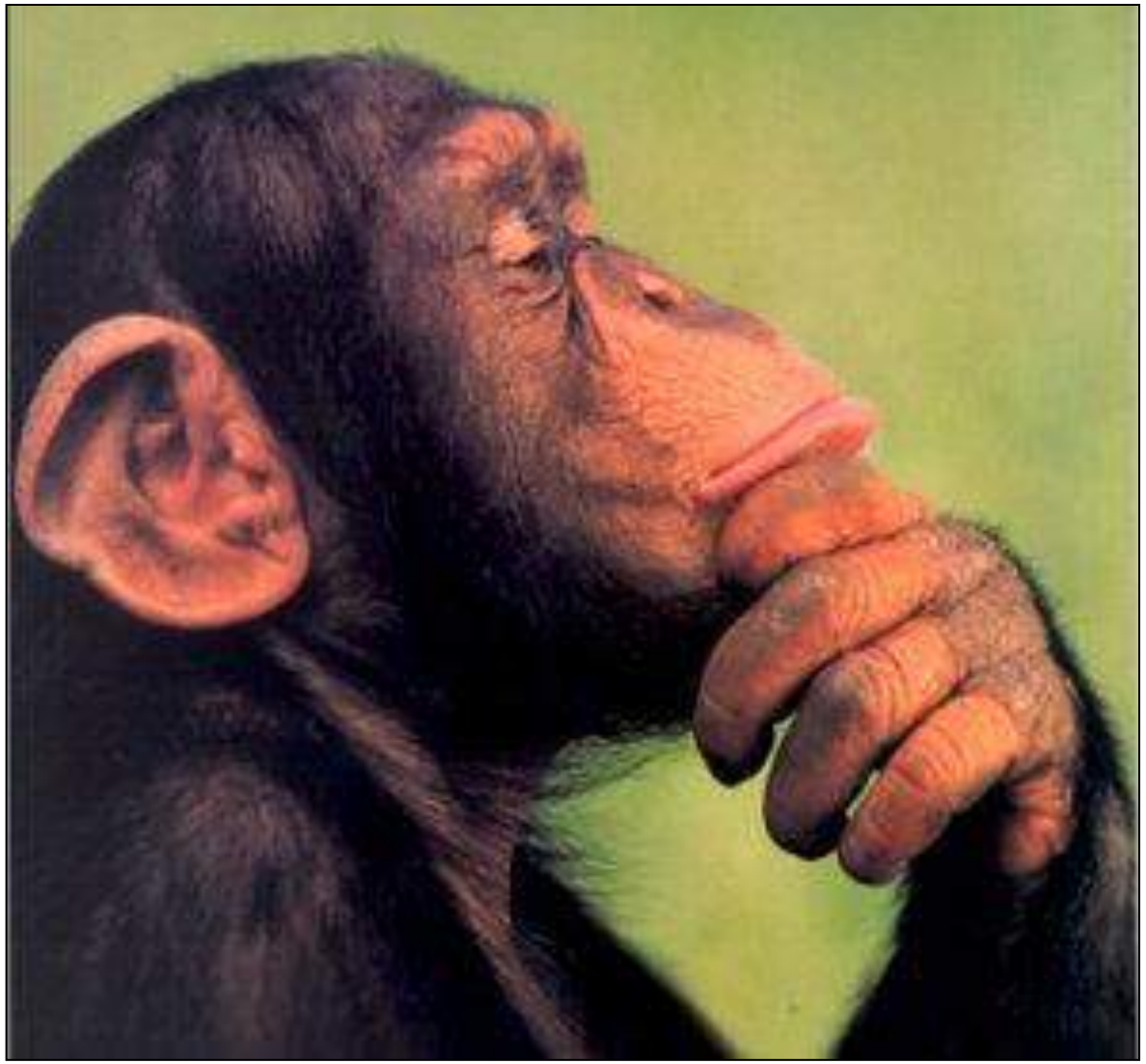
Humans Have Evolved Specialized Skills of Social Cognition: The Cultural Intelligence Hypothesis

Esther Herrmann,[1]* Josep Call,[1] María Victoria Hernández-Lloreda,[1]
Brian Hare,[1,3] Michael Tomasello[1]



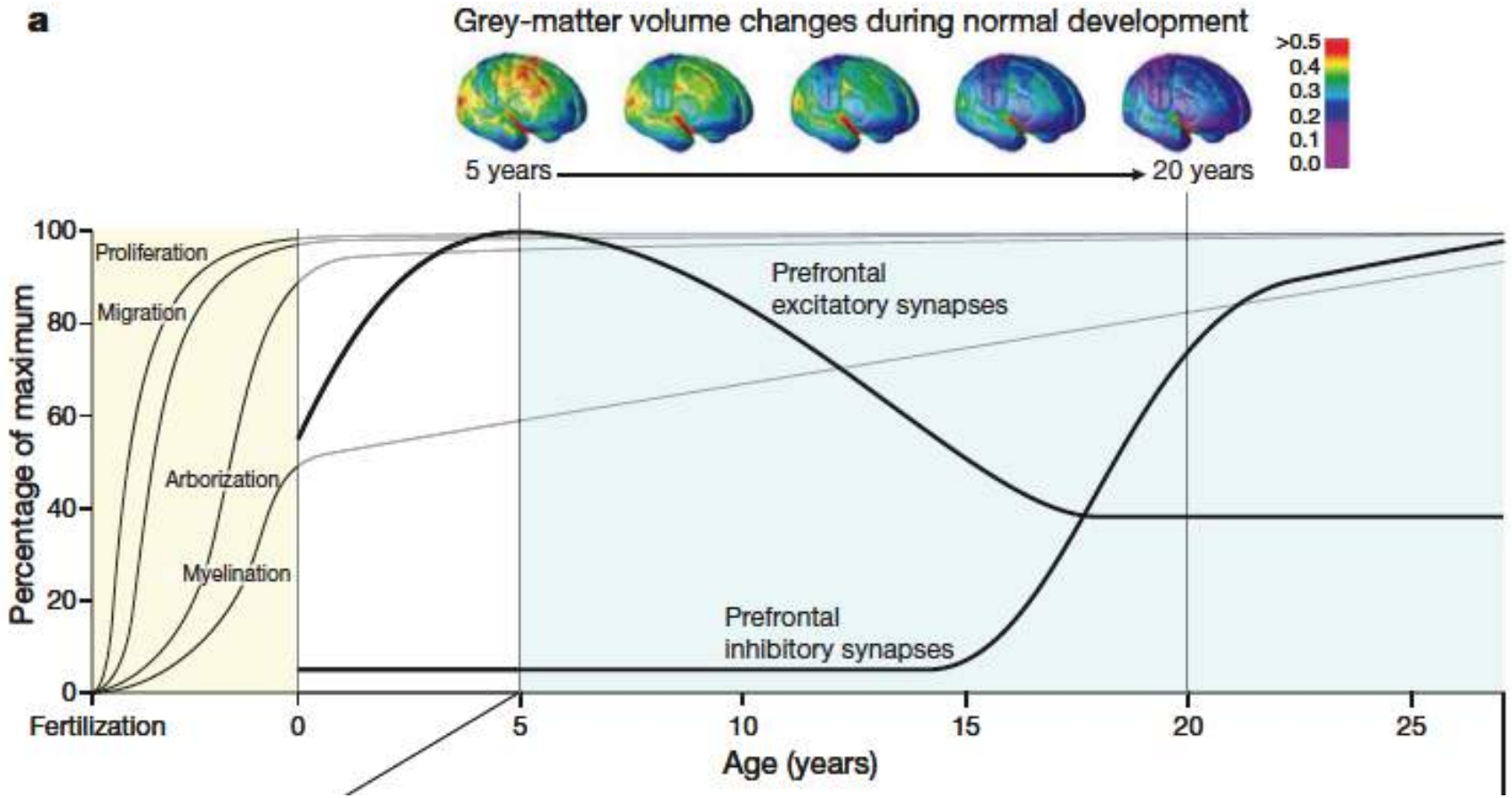






Rethinking schizophrenia

Thomas R. Insel



Vol 437|1 September 2005|doi:10.1038/nature04023

The second inheritance system of chimpanzees and humans

Andrew Whiten[1]

Half a century of dedicated field research has brought us from ignorance of our closest relatives to the discovery that chimpanzee communities resemble human cultures in possessing suites of local traditions that uniquely identify them. The collaborative effort required to establish this picture parallels the one set up to sequence the chimpanzee genome, and has revealed a complex social inheritance system that complements the genetic picture we are now developing.

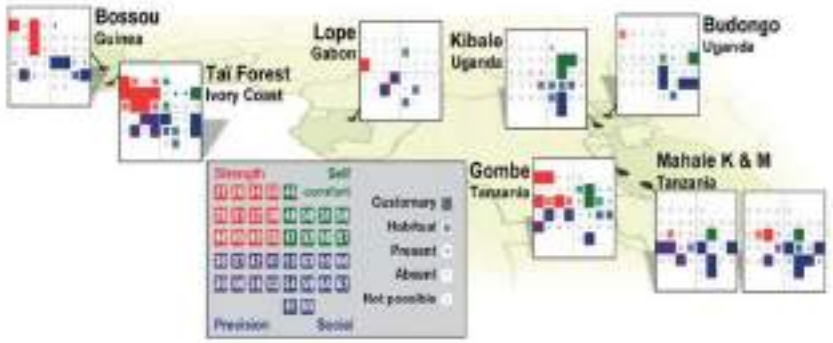


Figure 1 | The cultures of wild chimpanzees. Each chimpanzee community has its own unique array of traditions that together constitute the local 'culture'. 'Customary' acts are those typical in the community, 'habitual' ones are less common but consistent with social transmission, and 'absent' acts are those missing with no apparent straightforward environmental explanation. Traditions are defined as behaviour patterns that are customary or habitual in at least one site but absent elsewhere. Transmission is attributed to social learning on the basis of a complex of circumstantial evidence, ranging from intense observation by juveniles to distributions inconsistent with alternative explanations[13,14,15]. The numbers in cells refer to behaviour patterns in the catalogue of ref. 13, illustrated at http://culture.st-and.ac.uk/chimp.