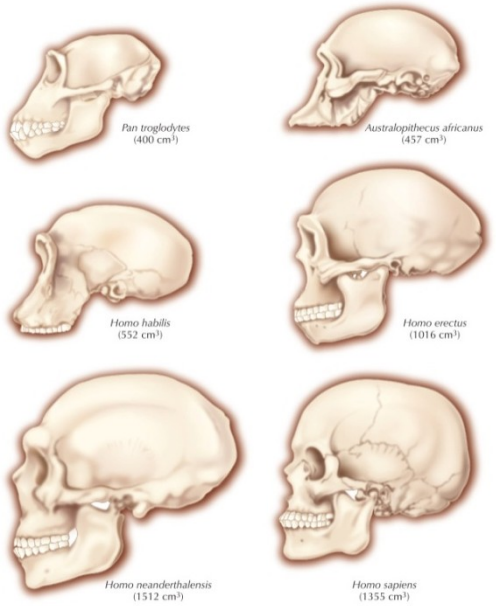
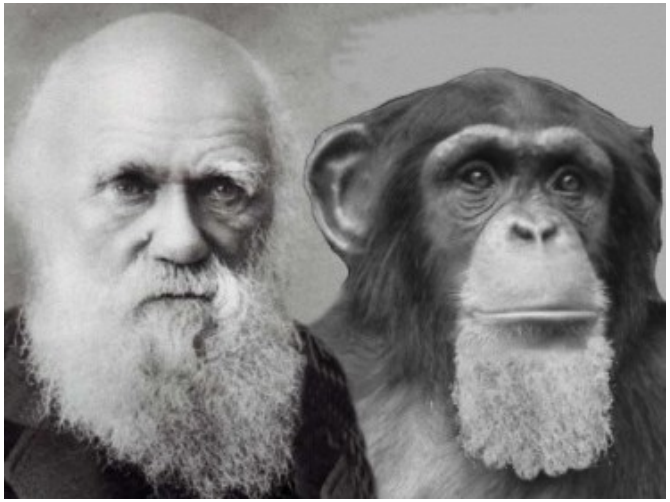
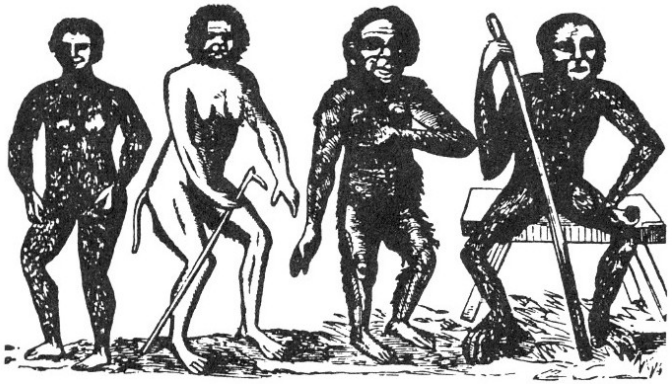
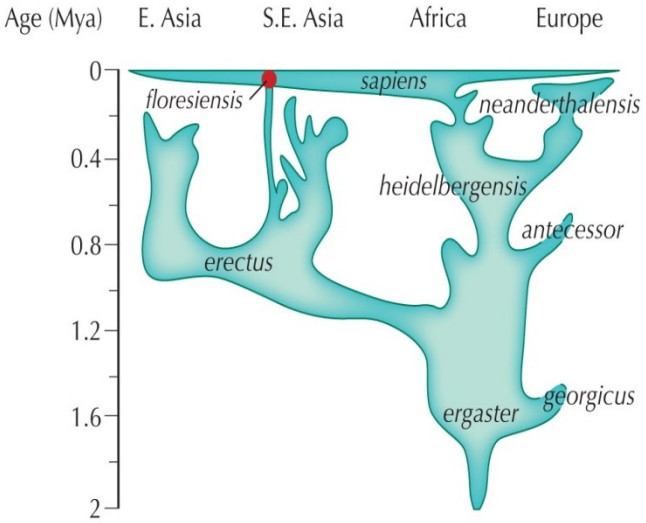
EVOLUCE ČLOVĚKA
KULTURNÍ EVOLUCE

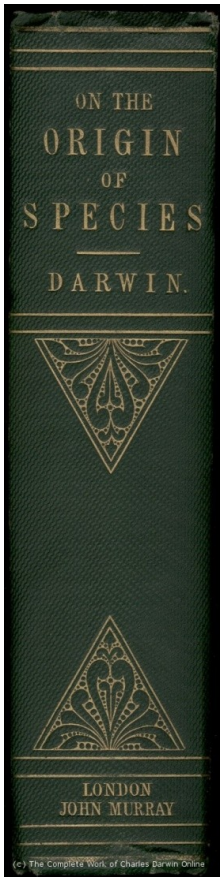


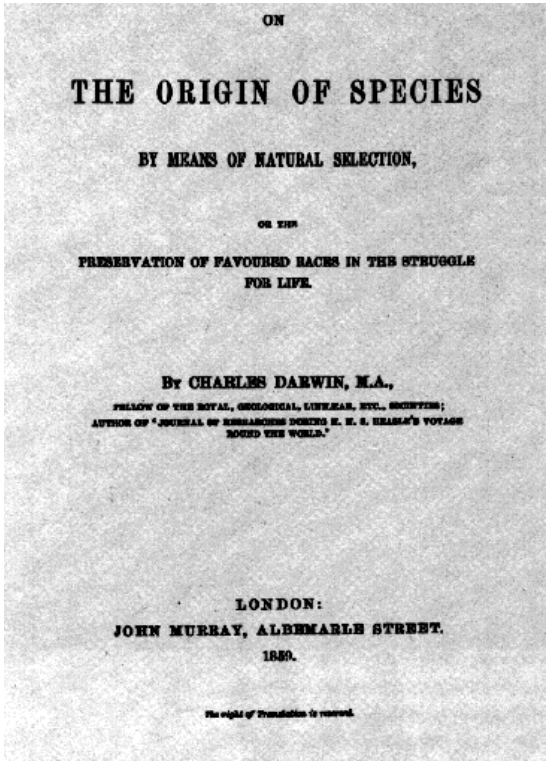






Light will be thrown on the origin of man and his history.




ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

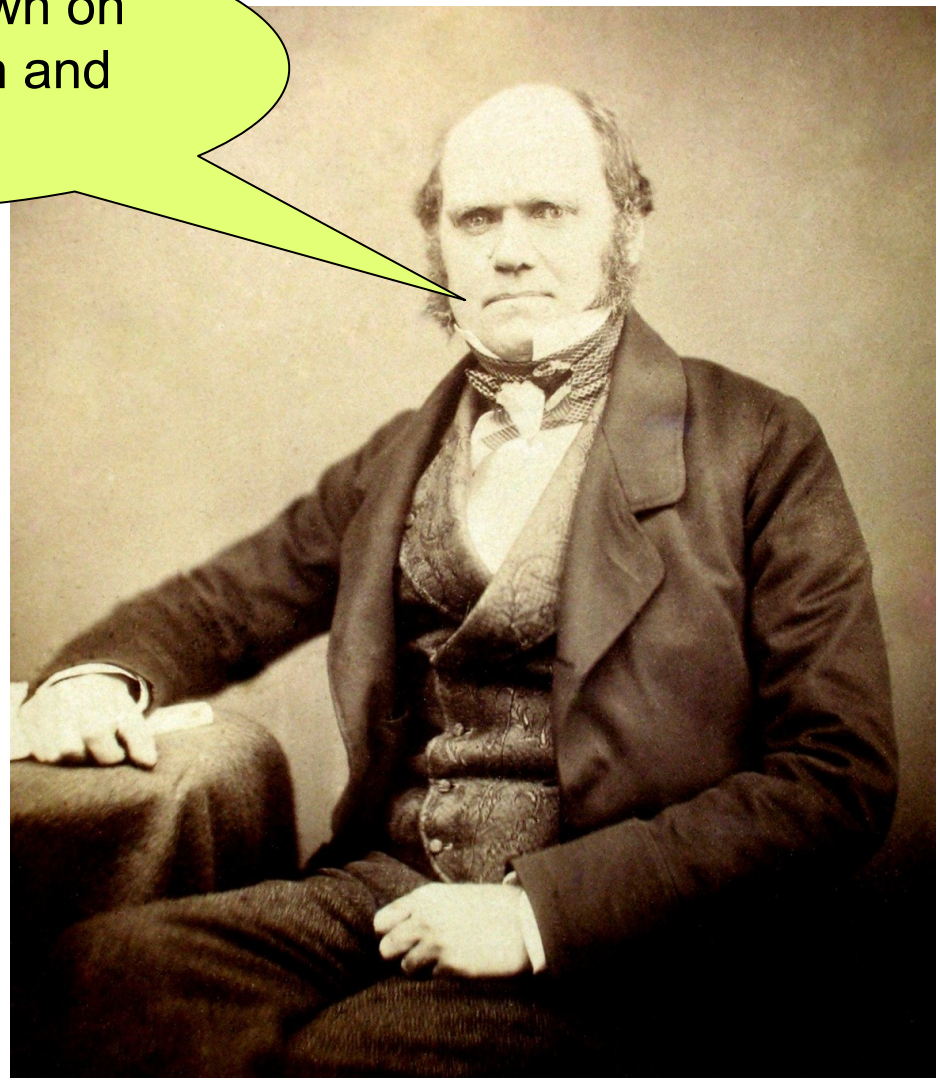
OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNEAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

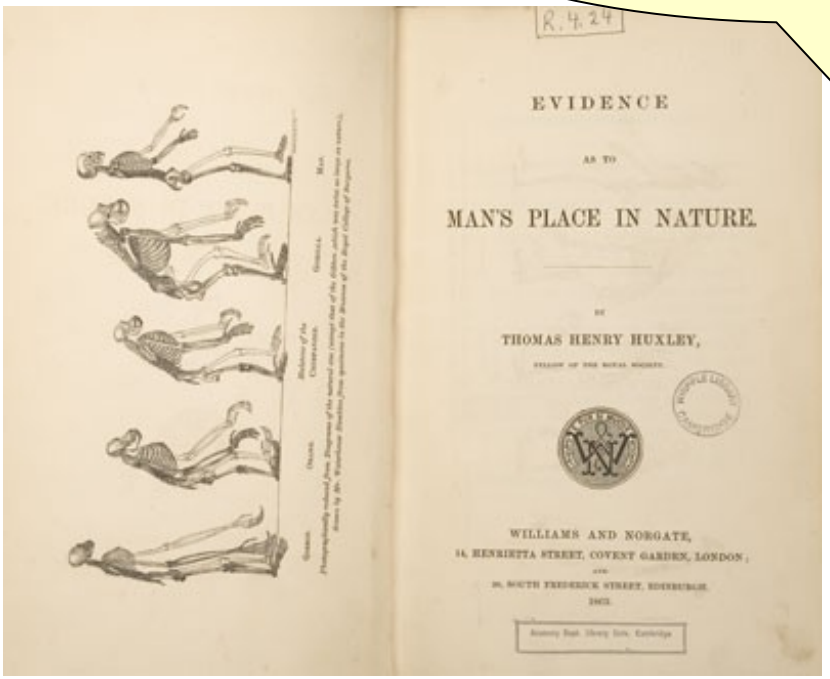
LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

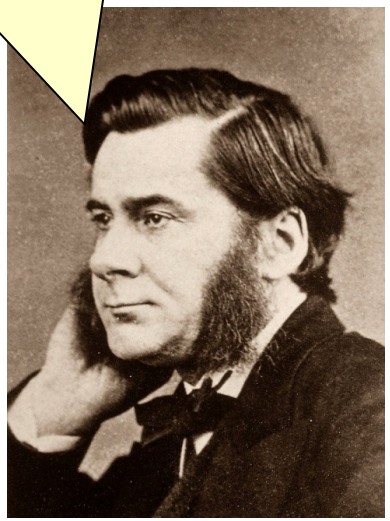


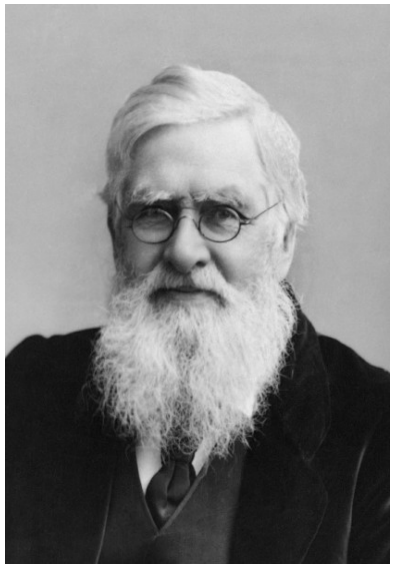
T. H. Huxley (1863):

Evidence as to Man's place in Nature (*Důkazy o místě člověka v přírodě*)

Člověk se ve všech částech svého těla odlišuje od lidoopů méně než lidoopi od nižších primátů.



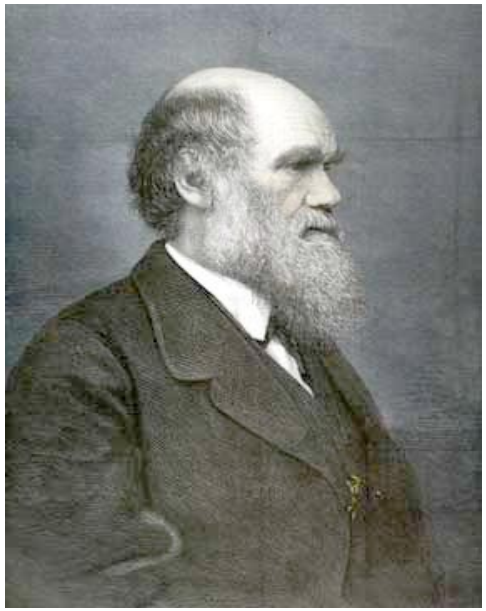


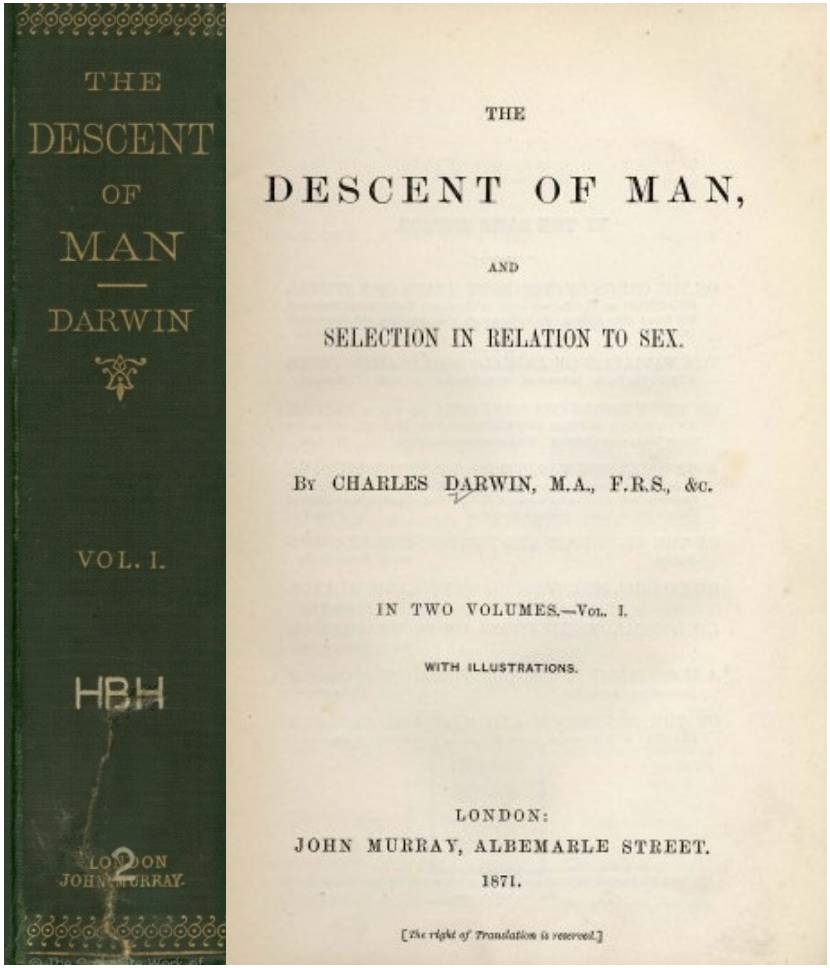


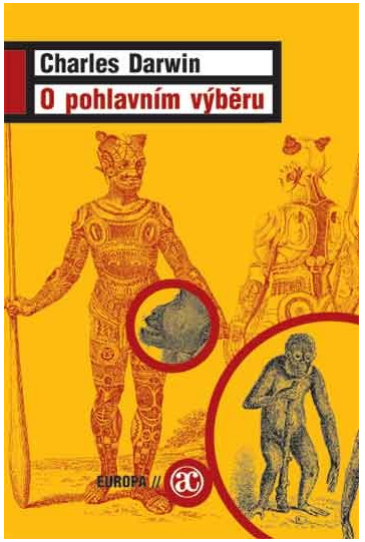
A. R. Wallace (1864):

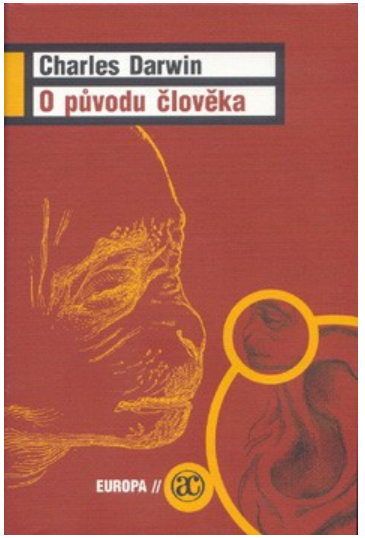
The origin of human races and the antiquity of Man deduced from the theory of ‚Natural Selection' (*Původ lidských ras a starobylost člověka vyvozená z teorie přírodního výběru*)

1871: *The descent of man, and selection in relation to sex* (*Původ člověka a pohlavní výběr*)

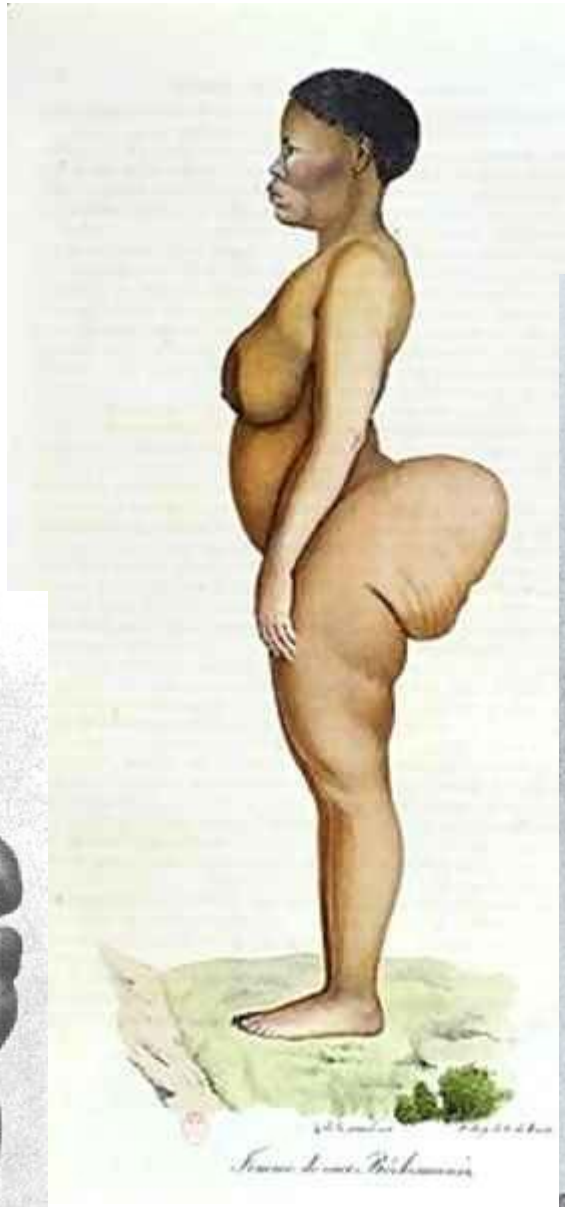


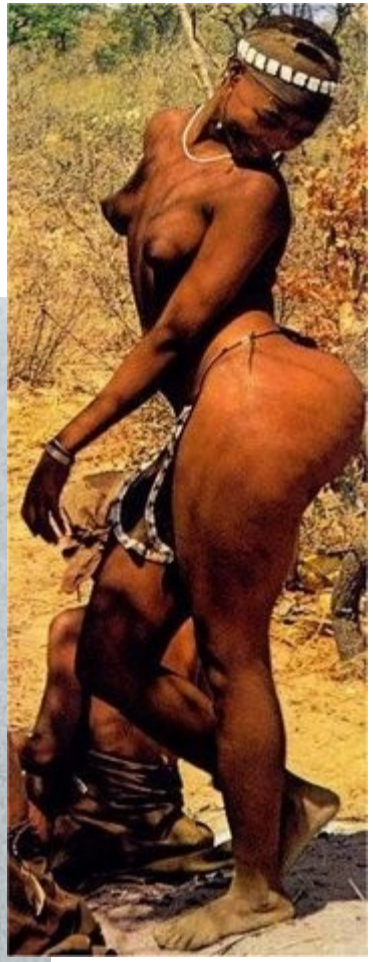




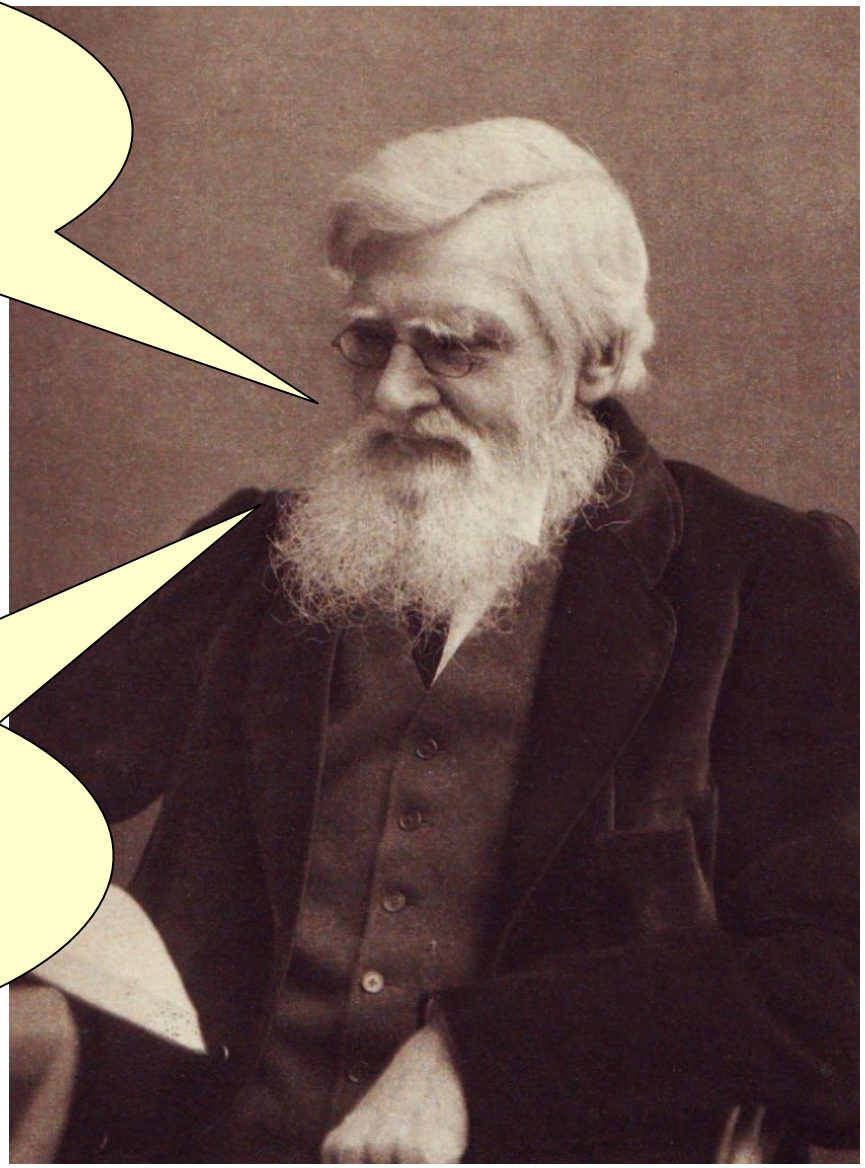


Khoi San

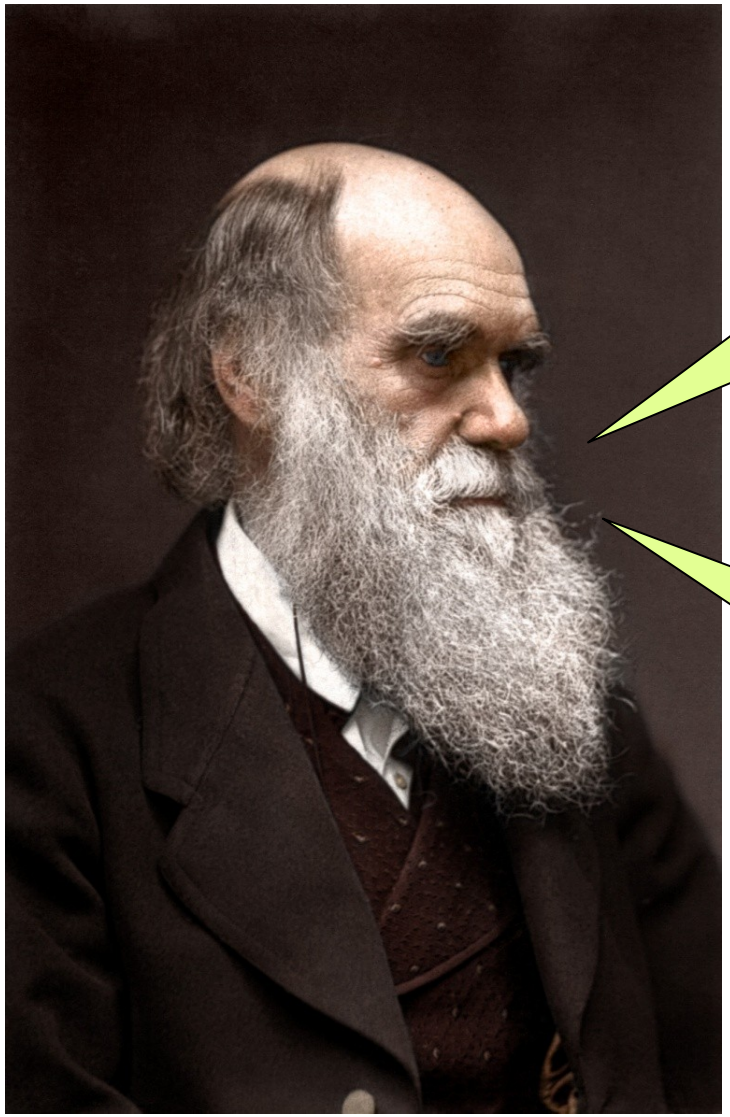




Mezera mezi lidoopy a člověkem je příliš velká, „divoši“ ji ani zdaleka nevyplňují.



Selekce nemůže vysvětlit smysl pro humor, důvtip, nadání pro matematiku, filozofii, umění nebo hudbu.



Rozdíl mezi živočichy a člověkem je pouze kvantitativní. Existence morálky, soucitu, smyslu pro krásu u zvířat.

U zvířat existuje chování analogické lásce, laskavosti, náboženství nebo altruismu.

neandertálci: 1829 Engis (Liège), 1848 Gibraltar, 1856 Neandertal

hledání chybějícího článku:

1891 Eugène Dubois: *Pithecanthropus erectus*, Trinil, Jáva

1924 Raymond Dart: *Australopithecus africanus*, Taung, J Afrika

neandertálci: 1829 Engis (Liège), 1848 Gibraltar, 1856 Neandertal

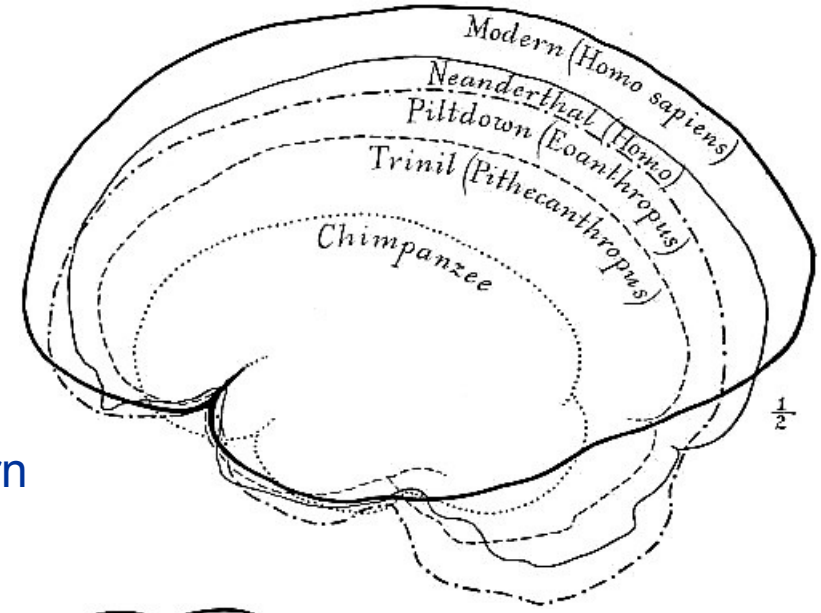
hledání chybějícího článku:

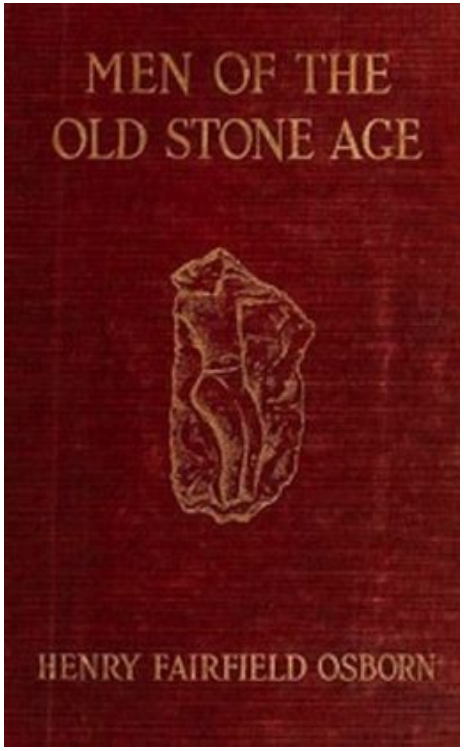
1891 Eugène Dubois: *Pithecanthropus erectus*, Trinil, Jáva

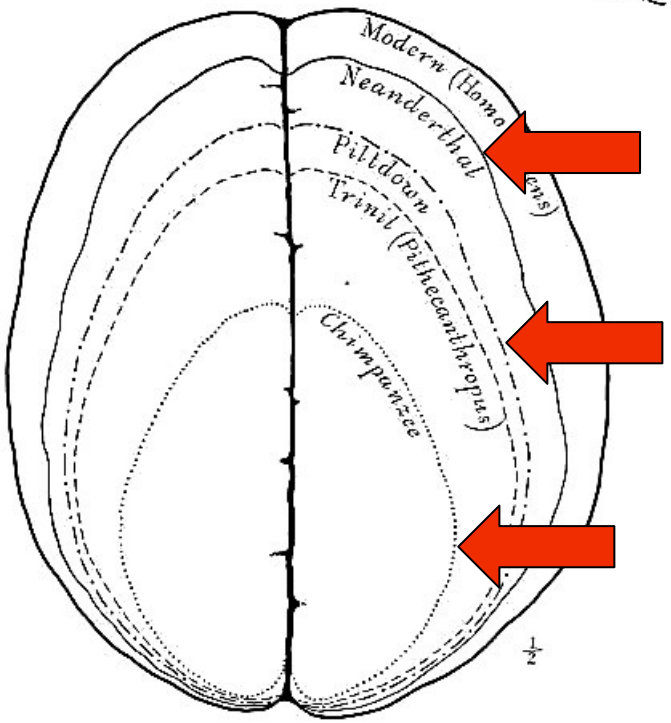
1924 Raymond Dart: *Australopithecus africanus*, Taung, J Afrika

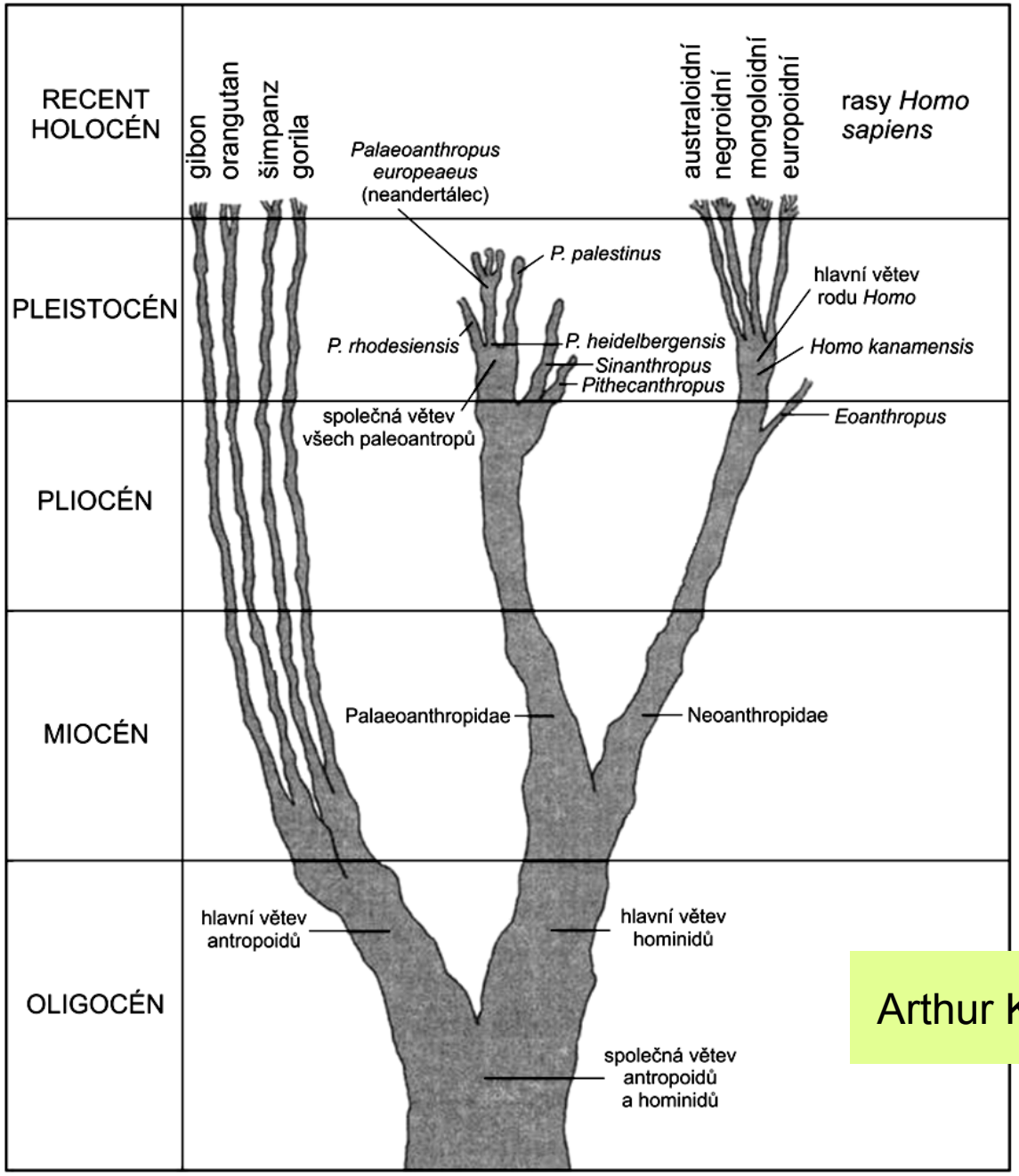
1912: Piltdown – *Eoanthropus dawsoni* („piltdownský člověk“)

Henry Fairfield Osborn

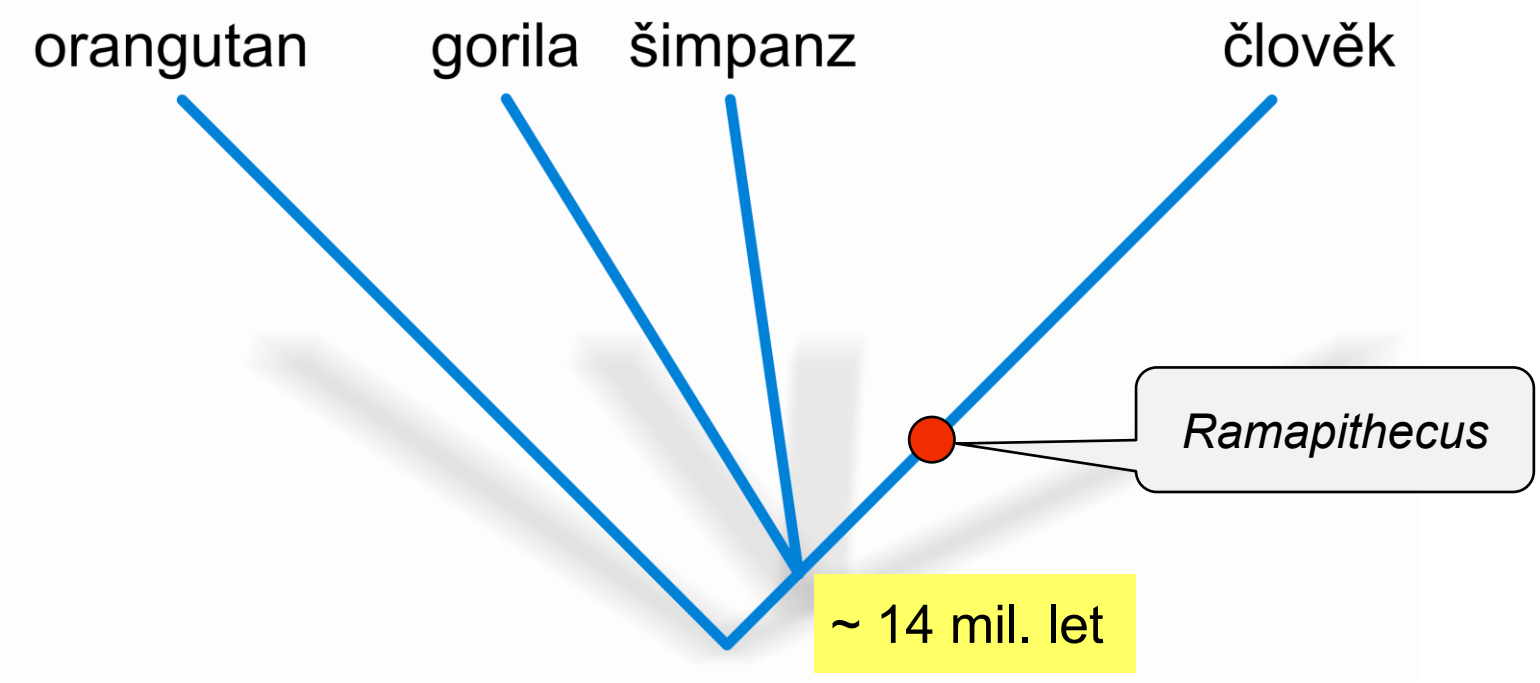


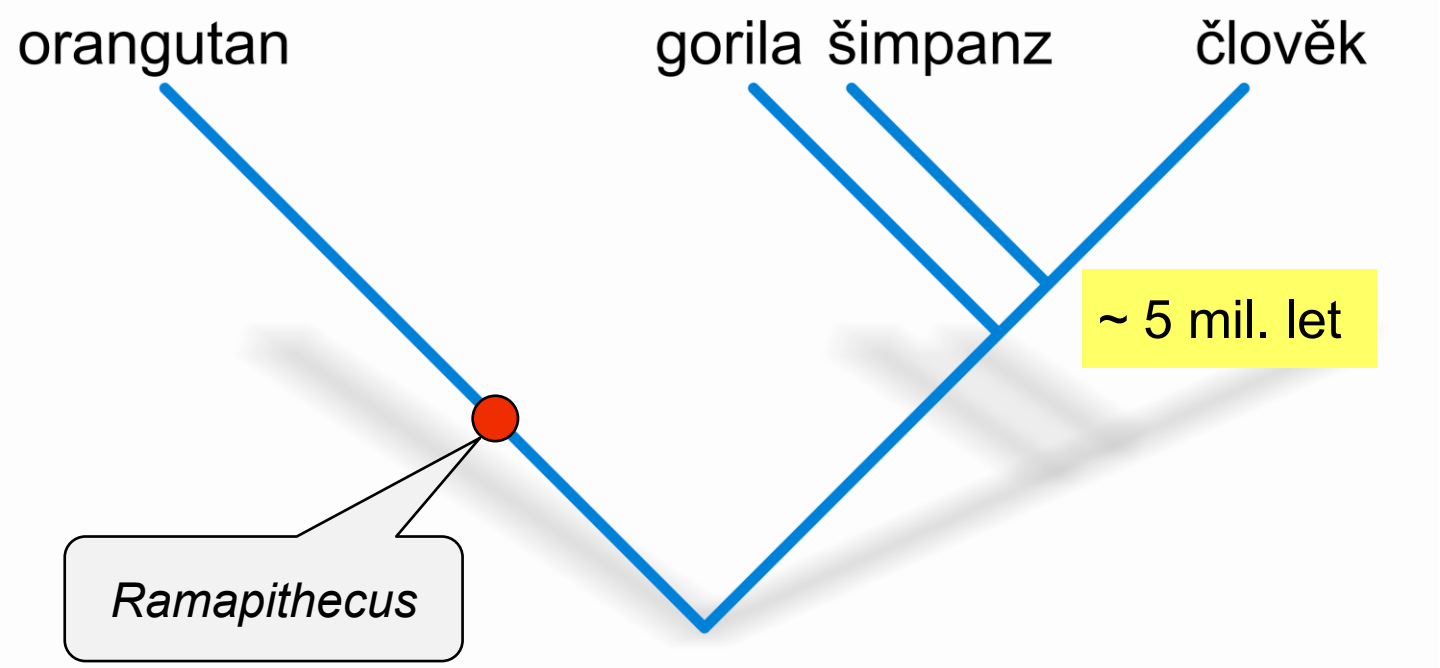






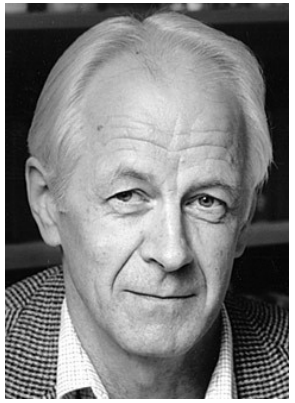
Arthur Keith (1935)

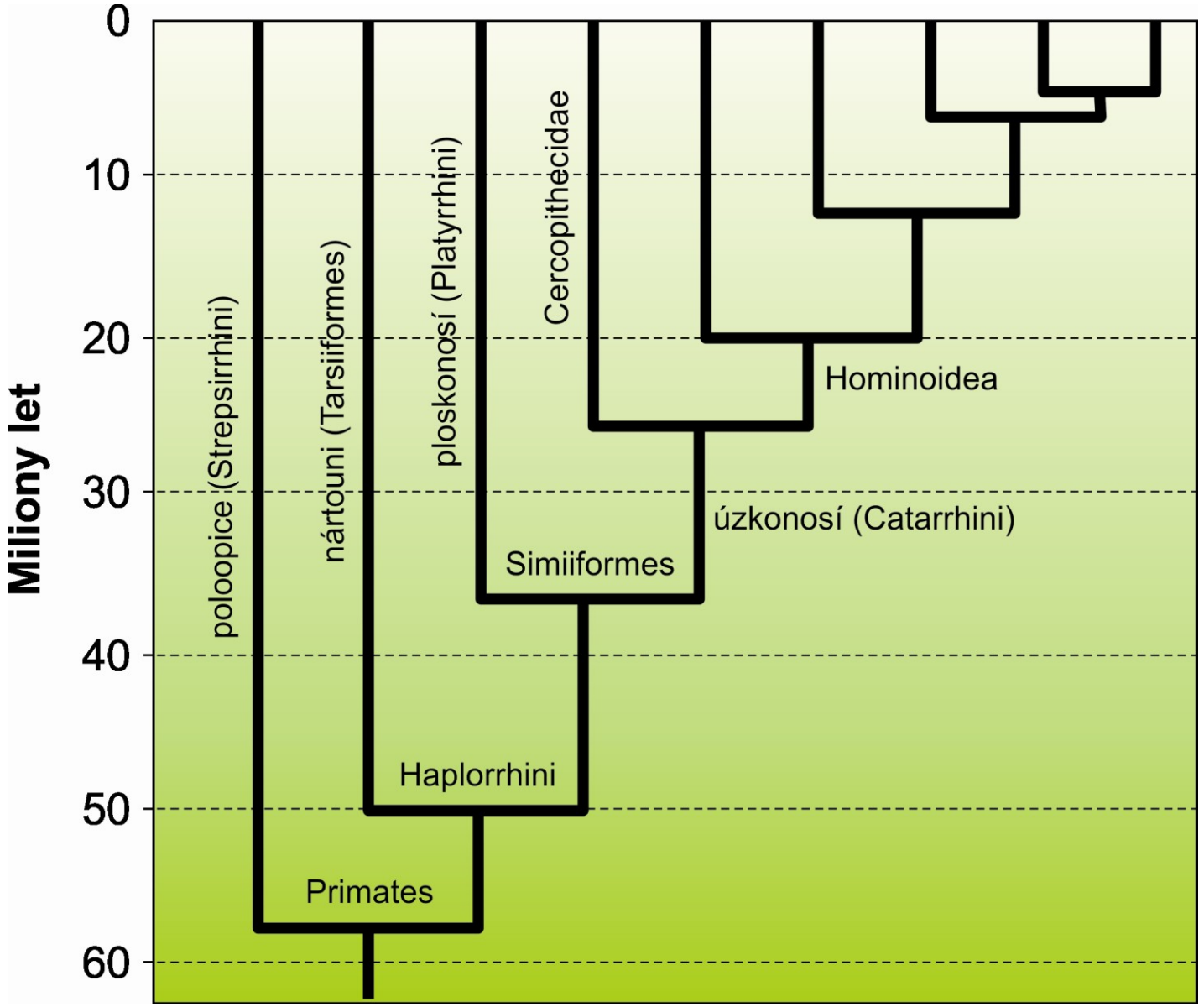

orangutan
gorila
šimpanz
člověk
Ramapithecus
~ 14 mil. let



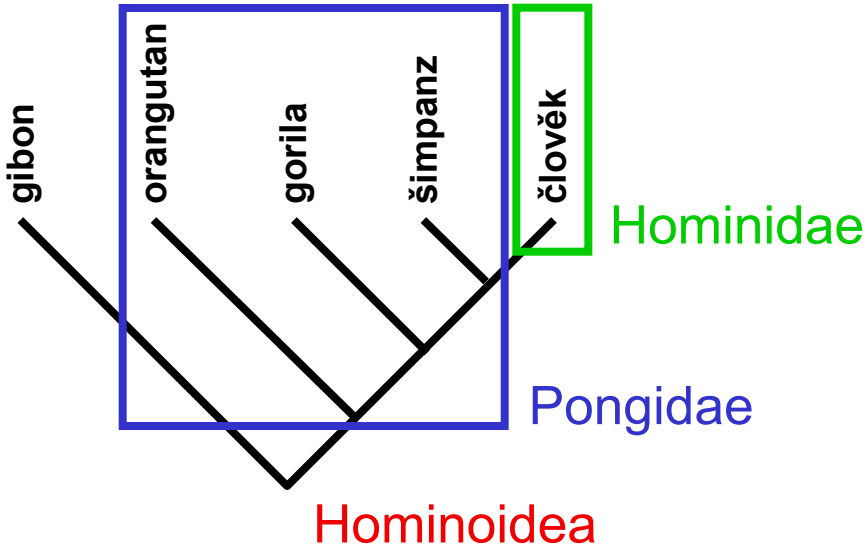
1967: Vincent Sarich, Allan C. Wilson
sérový albumin, imunologické distance
člověk-šimpanz ≈ 4-5 mil.

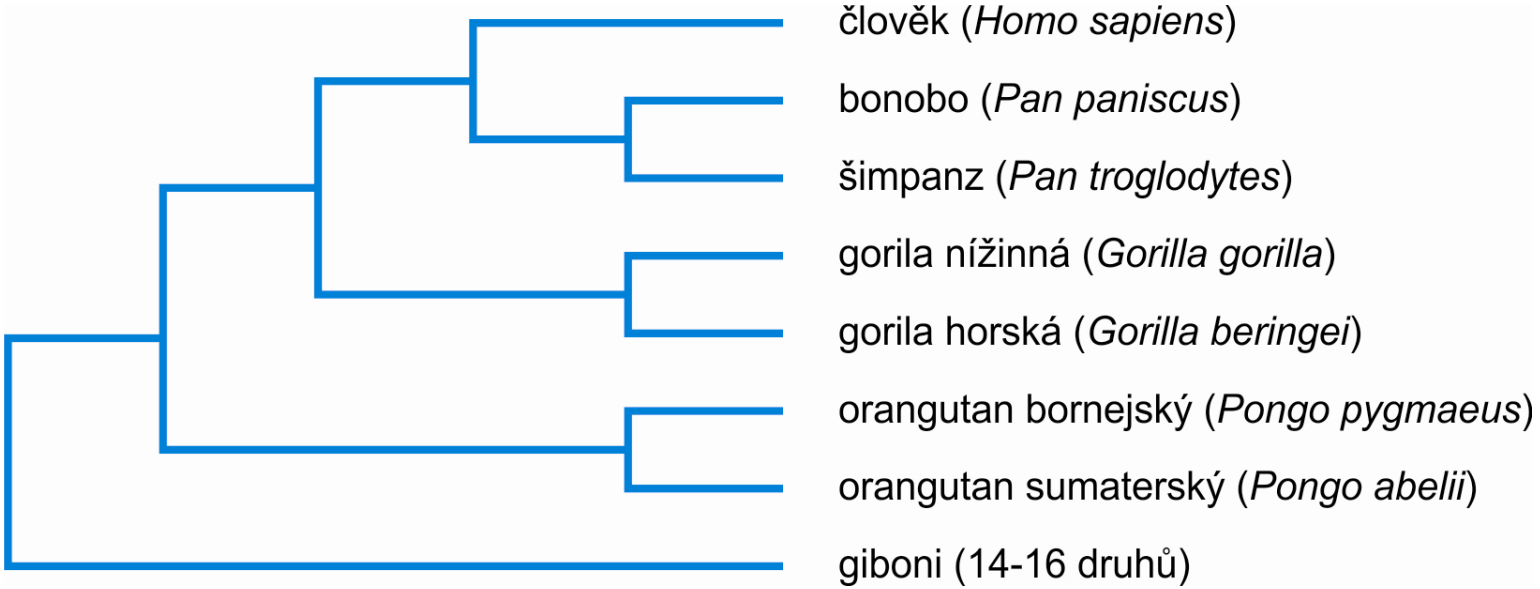
dnes: *Ramapithecus* předkem orangutana
člověk-šimpanz ≈ 7,5 M

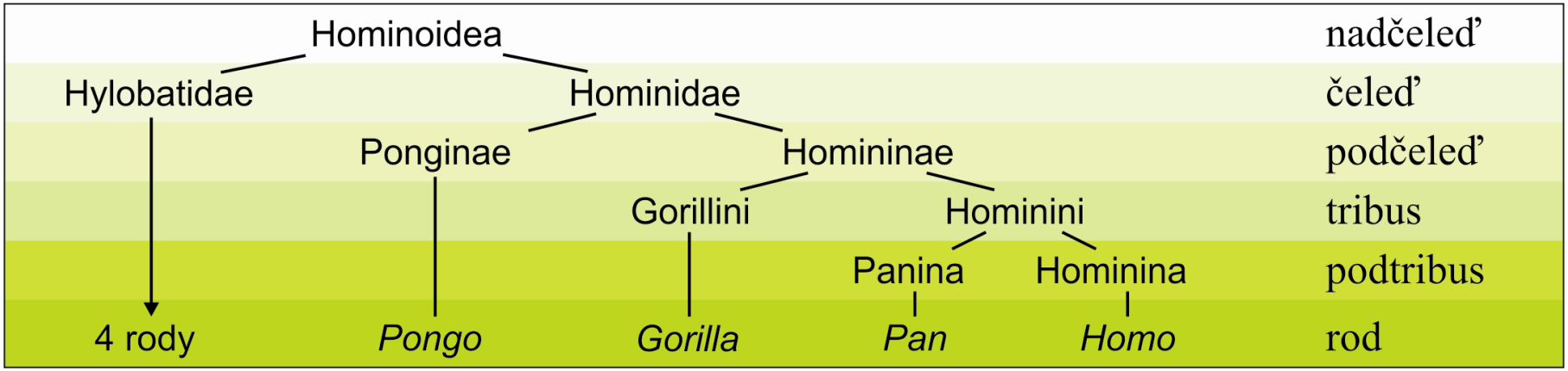



Miliony let
0
10
20
30
40
50
60
poloopice (Strepsirrhini)
nártouni (Tarsiiformes)
ploskonosí (Platyrrhini)
Cercopithecidae
Hominoidea
úzkonosí (Catarrhini)
Simiiformes
Haplorrhini
Primates

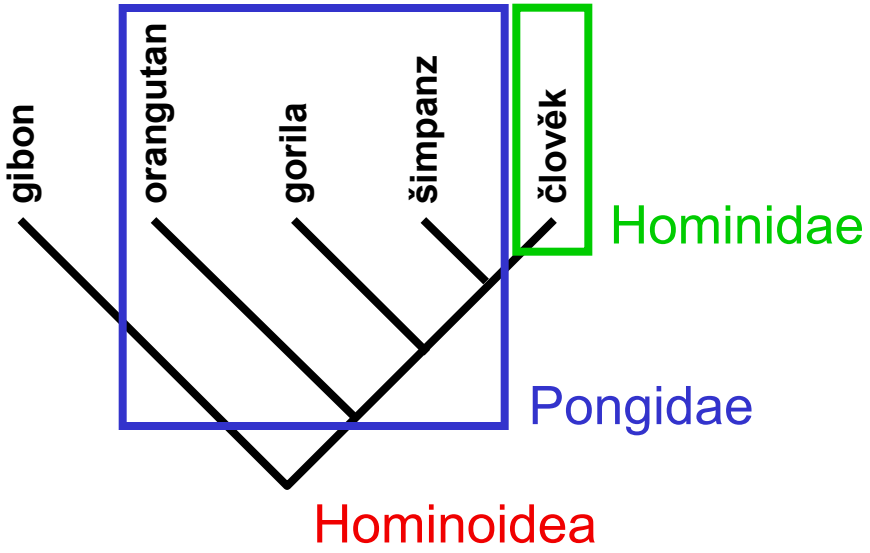
3 pohledy na systém lidoopů a člověka

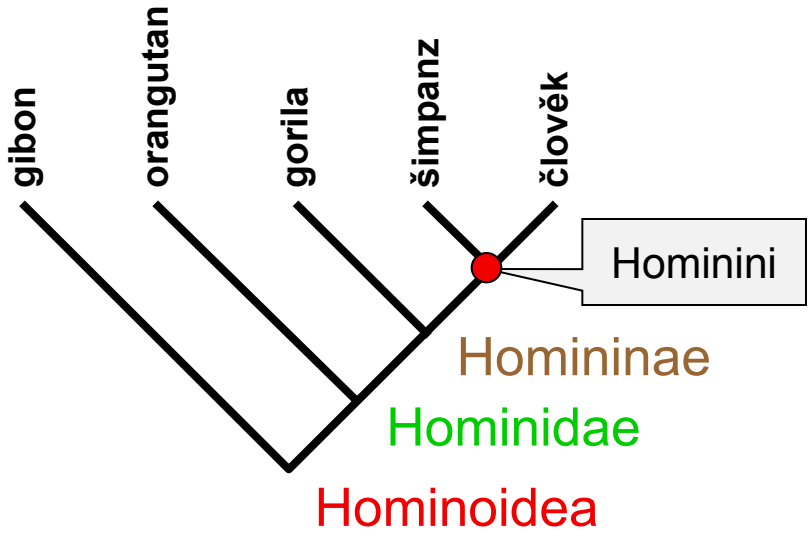


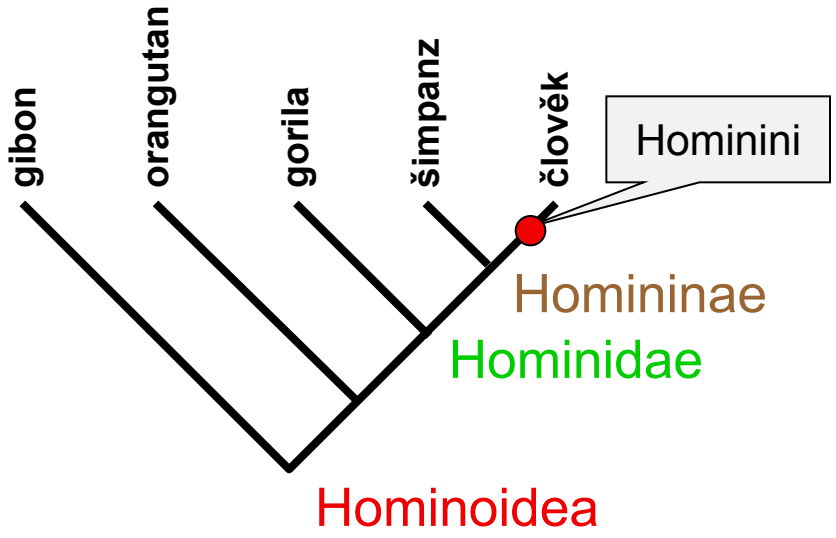

člověk (*Homo sapiens*)
bonobo (*Pan paniscus*)
šimpanz (*Pan troglodytes*)
gorila nížinná (*Gorilla gorilla*)
gorila horská (*Gorilla beringei*)
orangutan bornejský (*Pongo pygmaeus*)
orangutan sumaterský (*Pongo abelii*)
giboni (14-16 druhů)


Hominoidea
nadčeleď
Hylobatidae
Hominidae
čeleď
Ponginae
Homininae
podčeleď
Gorillini
Hominini
tribus
Panina
Hominina
podtribus
4 rody
Pongo
Gorilla
Pan
Homo
rod

3 pohledy na systém lidoopů a člověka







Fosilní nálezy:

1924 Raymond Dart: Taung, J Afrika
A. africanus („dítě z Taungu“)

1959 Louis S.B. Leakey, Mary Leakey:
Olduvai, Tanzanie, V Afrika –
Australopithecus (Paranthropus) boisei

A. africanus

P. boisei

Lucy

1974 Donald Johanson:
Hadar, Awaš, Afarská proláklina, Etiopie
Australopithecus afarensis (Lucy)

hledání nejstaršího předka:

1994: *Ardipithecus ramidus* („Ardi“), Awaš, Etiopie – 4,4 mil. (2004: *Ar. kadabba* – 5,6 mil.)

2001: *Orrorin tugenensis*, Tugen Hills, Keňa – 6 mil.

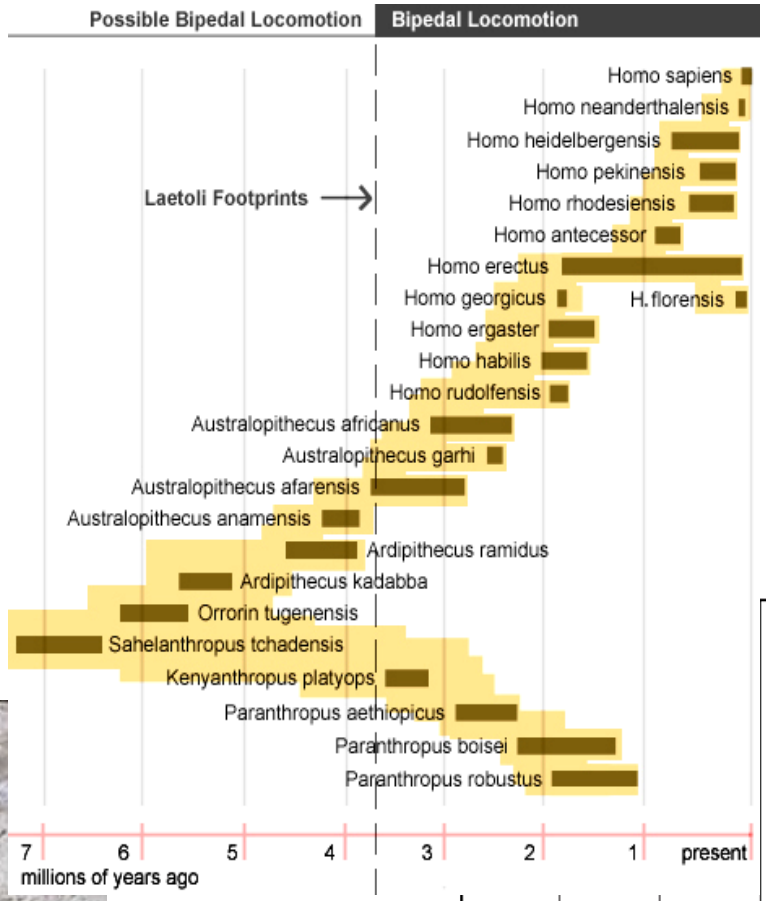
2002: *Sahelanthropus tchadensis* („Toumai“), J Čad – 6-7 mil.

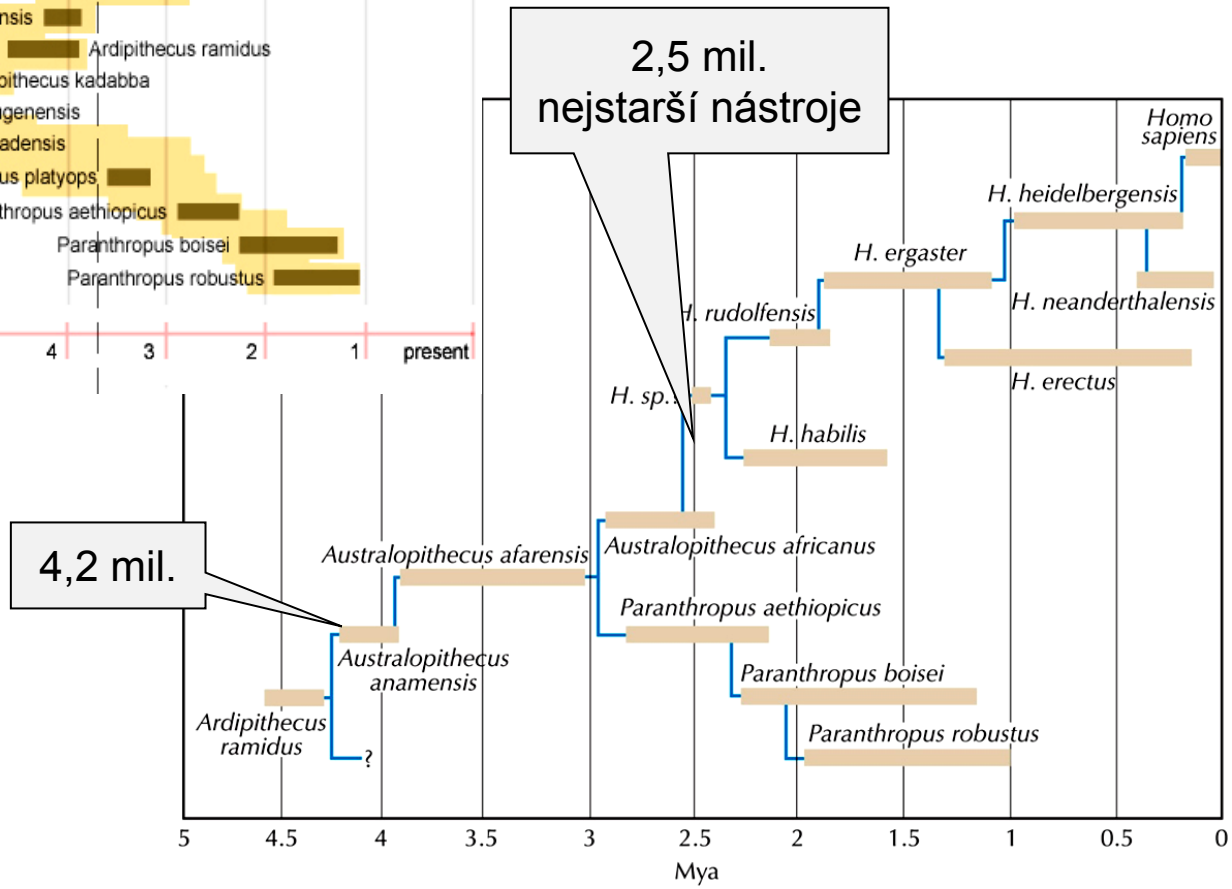
Ar. ramidus

Orrorin tugenensis

Sahelanthropus tchadensis

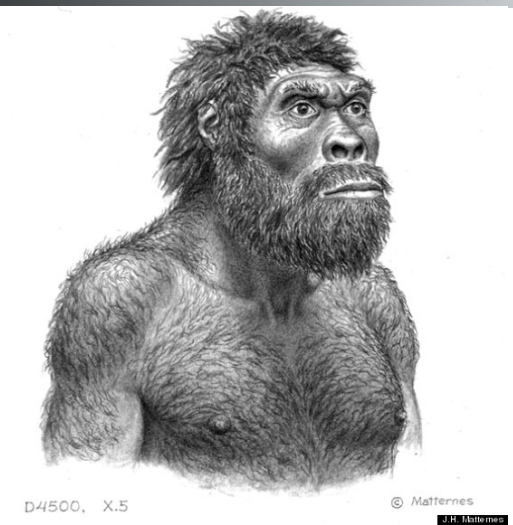
stopy *A. afarensis*
Laetoli, Tanzánie, 3,6 M



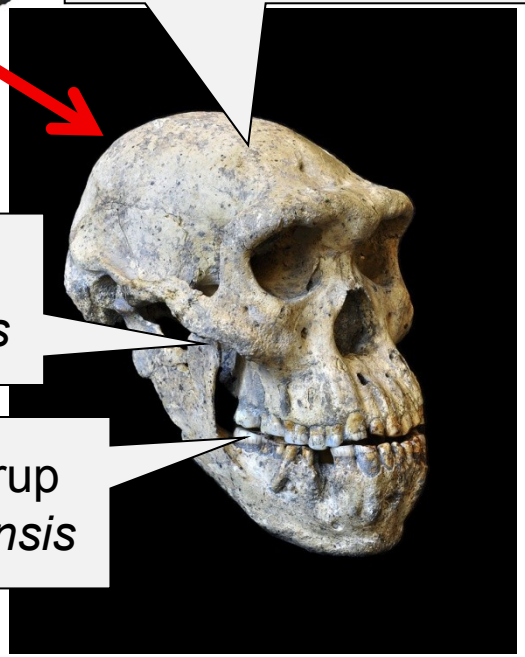


Komplikace: Dmanisi

„*H. georgicus*“
~ 1,8 mil.
~ raný *H. erectus*
velká variabilita
jedinec D4500



mozkovna 546 cm^3
~ *H. habilis*

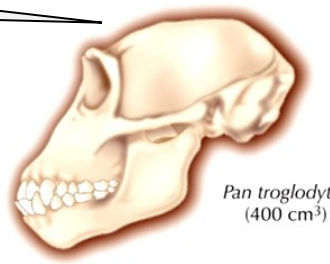


obličej
~ *H. erectus*

masívní chrup
~ *H. rudolfensis*

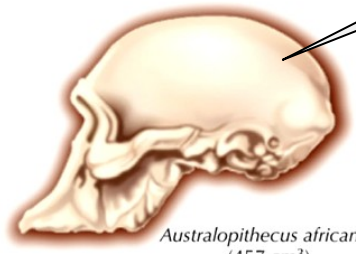
Růst velikosti mozkovny:

400 cm^3



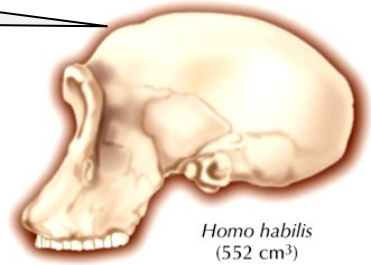
Pan troglodytes
(400 cm^3)

457 cm^3

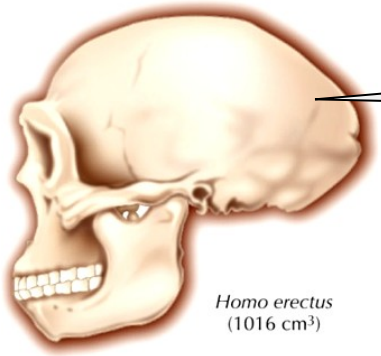


Australopithecus africanus
(457 cm^3)

552 cm^3



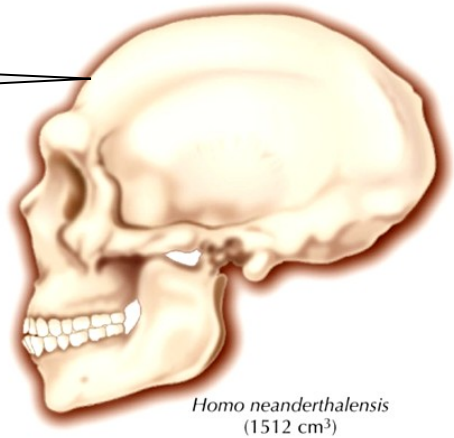
Homo habilis
(552 cm^3)



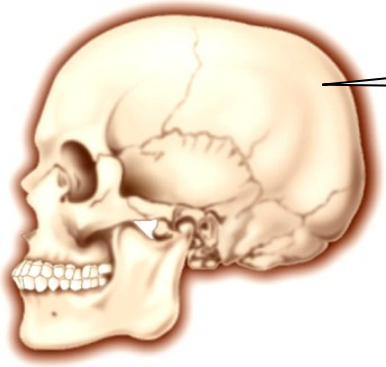
1016 cm^3

Homo erectus
(1016 cm^3)

1512 cm^3



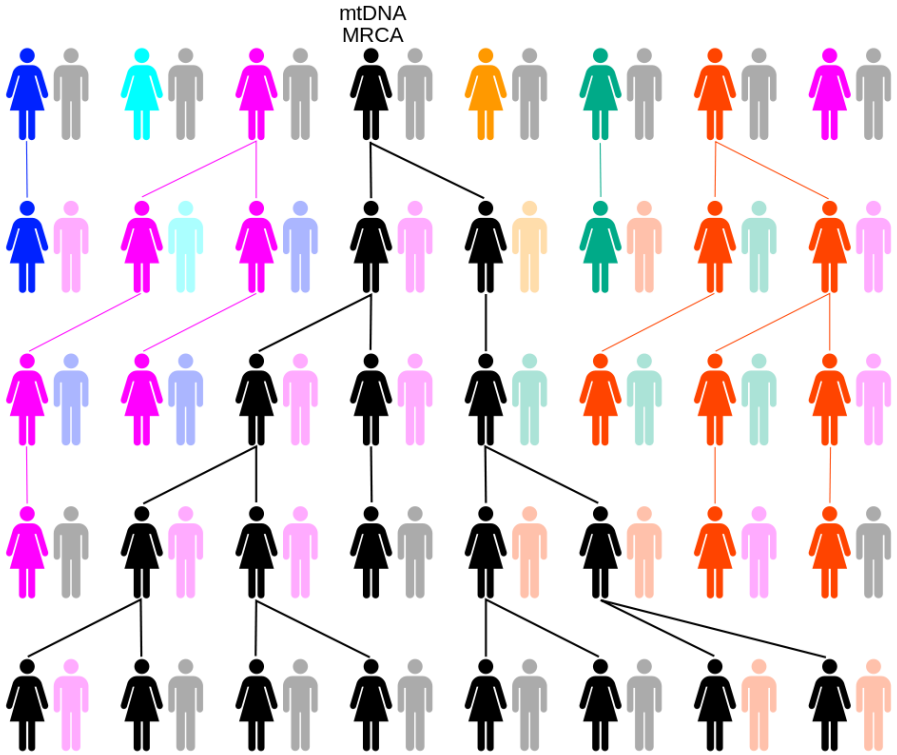
Homo neanderthalensis
(1512 cm^3)



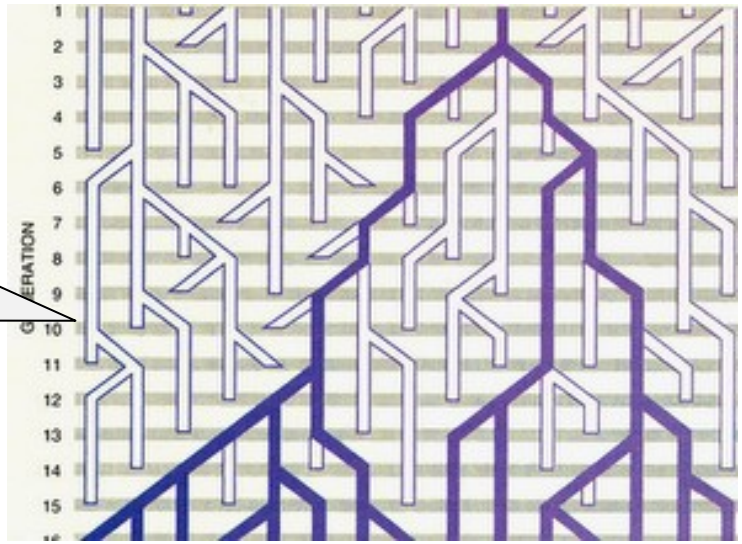
1355 cm^3

Homo sapiens
(1355 cm^3)

1987: Rebecca Cann, Mark Stoneking, A. C. Wilson

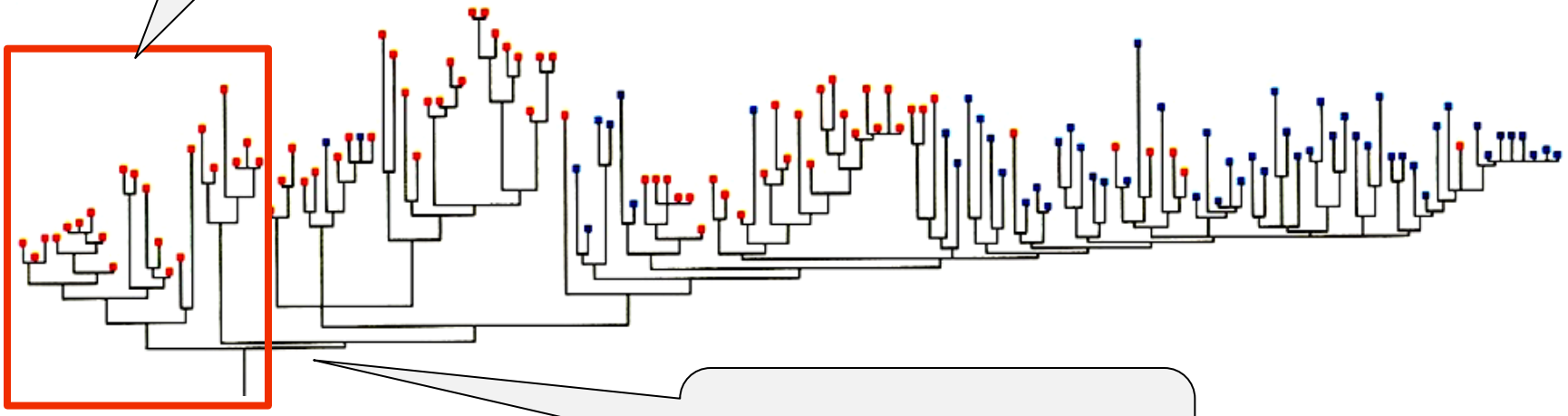


náhodné třídění mitochondriálních linií

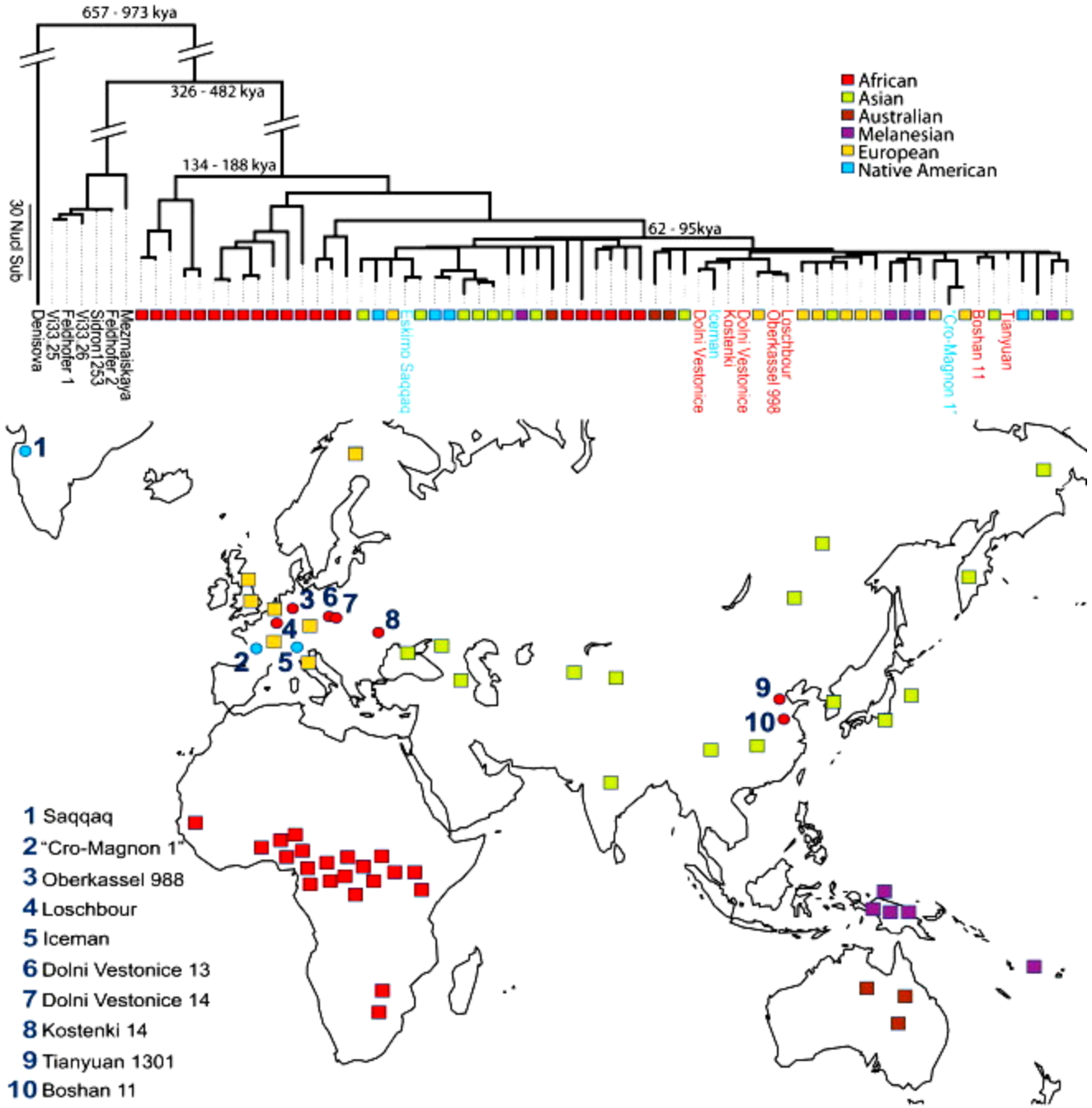


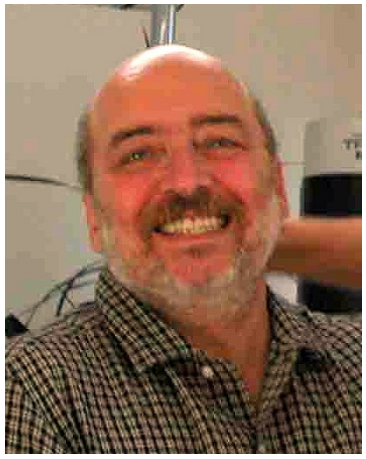
1987: Rebecca Cann, Mark Stoneking, A. C. Wilson

nejstarší linie mají africký původ



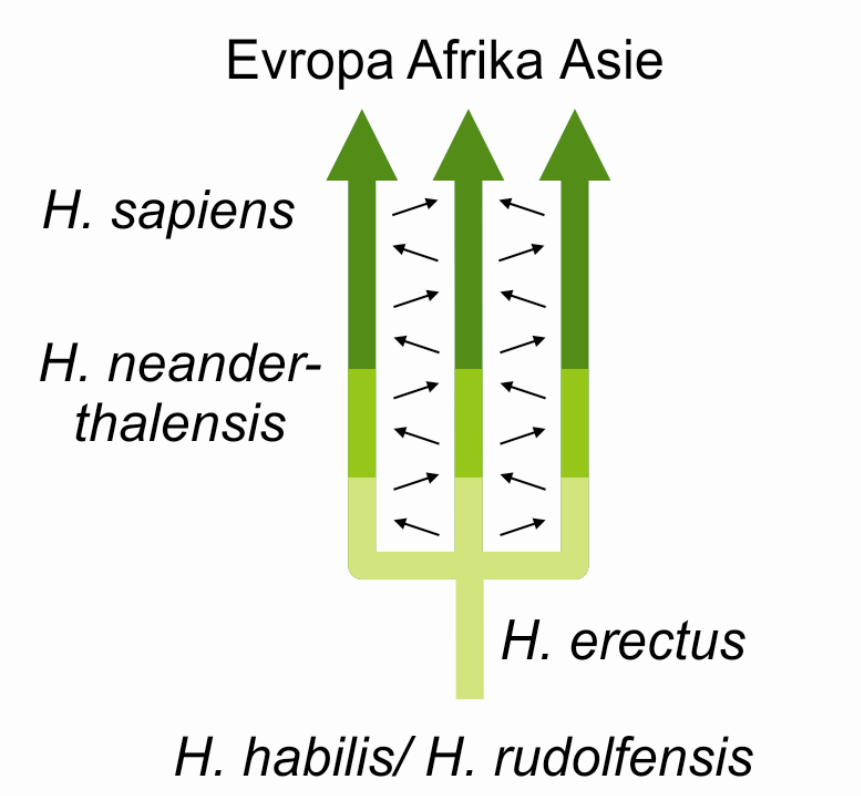
„Mitochondriální Eva“: ~ 200 000 let


657 - 973 kya
326 - 482 kya
134 - 188 kya
62 - 95kya
30 Nucl Sub
African
Asian
Australian
Melanesian
European
Native American
Denisova
Vi33.25
Feldhofer 1
Vi33.26
Sidron1253
Feldhofer 2
Mezmaiskaya
Eskimo Saqqaq
Dolni Vestonice
Iceman
Kostenki
Dolni Vestonice
Oberkassel 998
Loschbour
Cro-Magnon 1*
Boshan 11
Tianyuan
1 Saqqaq
2 "Cro-Magnon 1"
3 Oberkassel 988
4 Loschbour
5 Iceman
6 Dolni Vestonice 13
7 Dolni Vestonice 14
8 Kostenki 14
9 Tianyuan 1301
10 Boshan 11

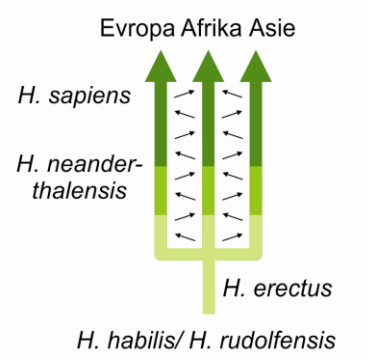


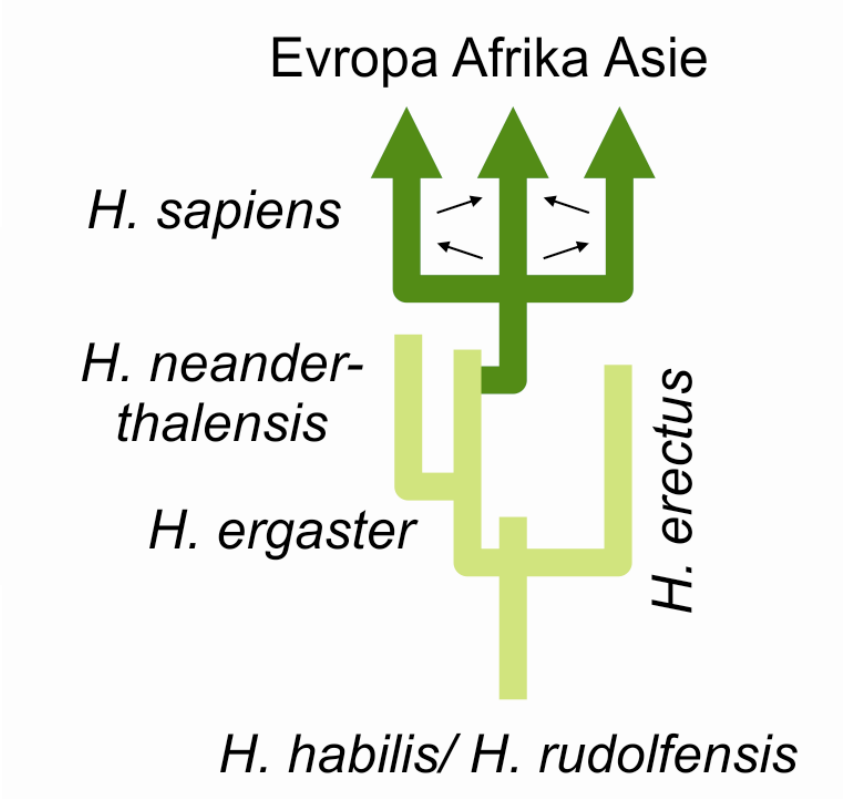
Milford H. Wolpoff

multiregionální model

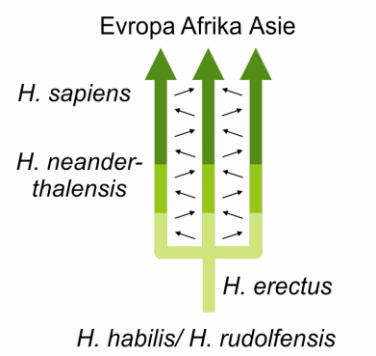


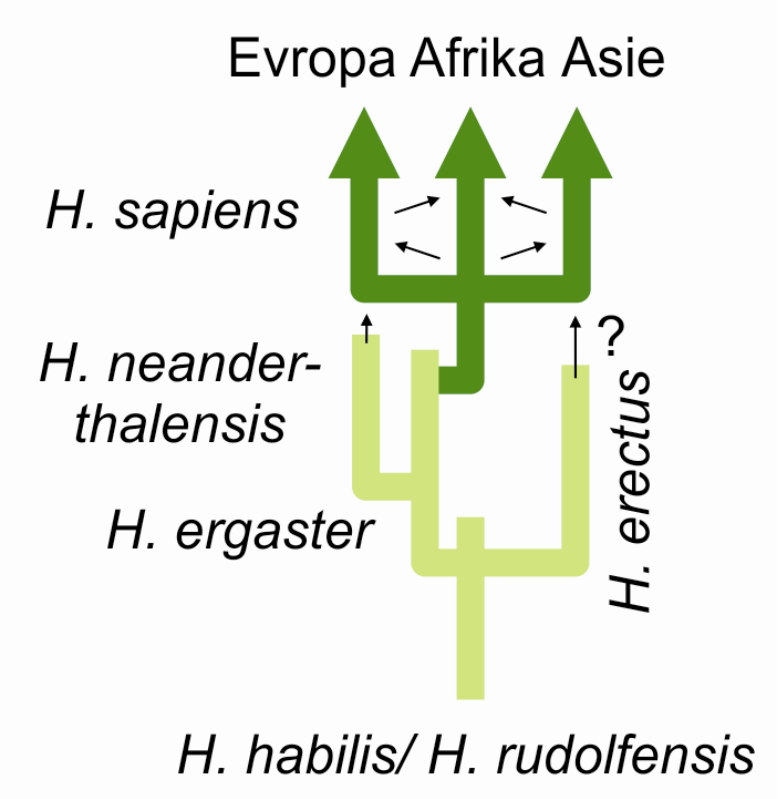
„out-of-Africa“

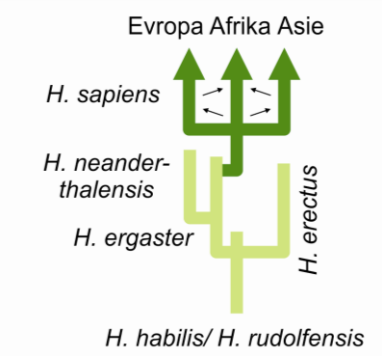




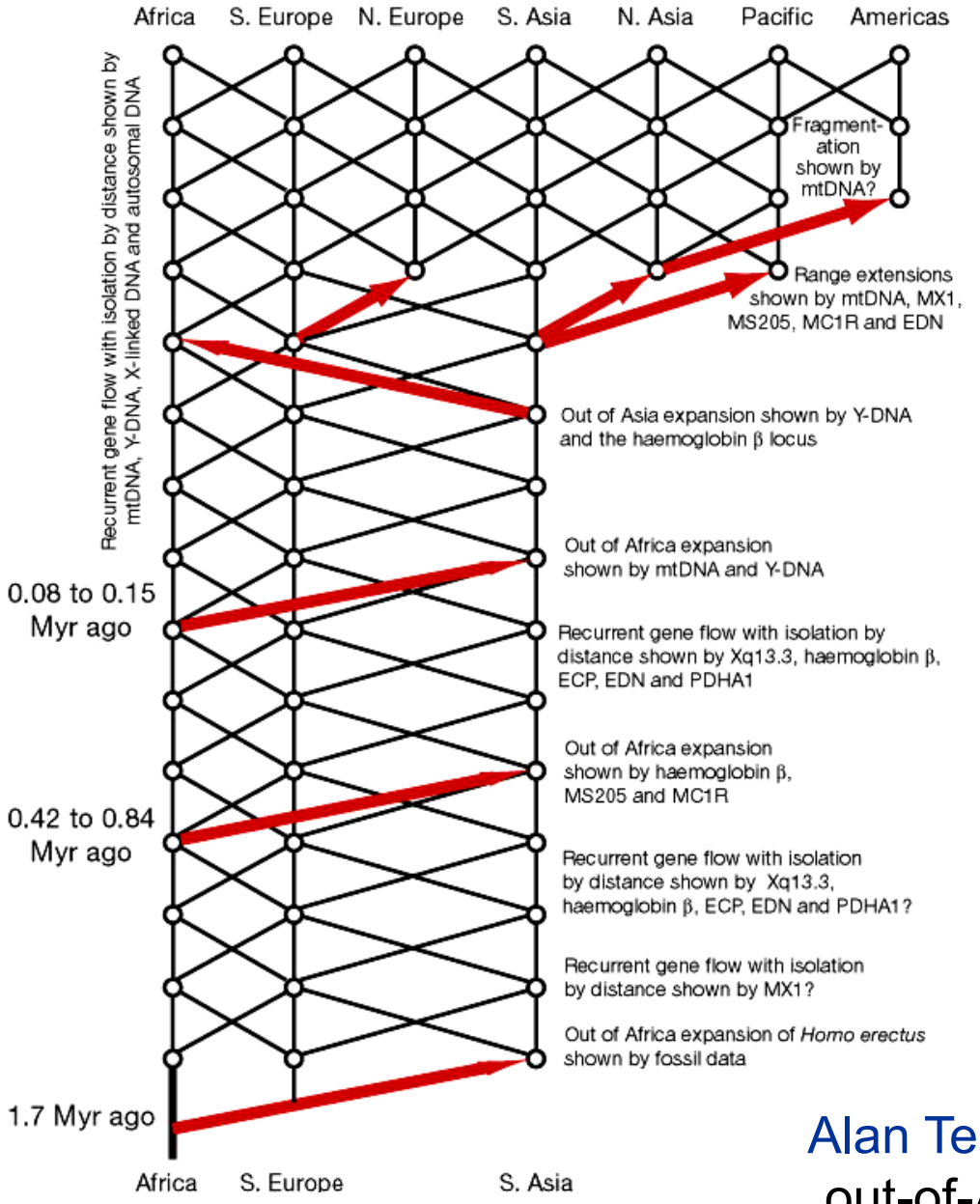
„out-of-Africa“ s křížením





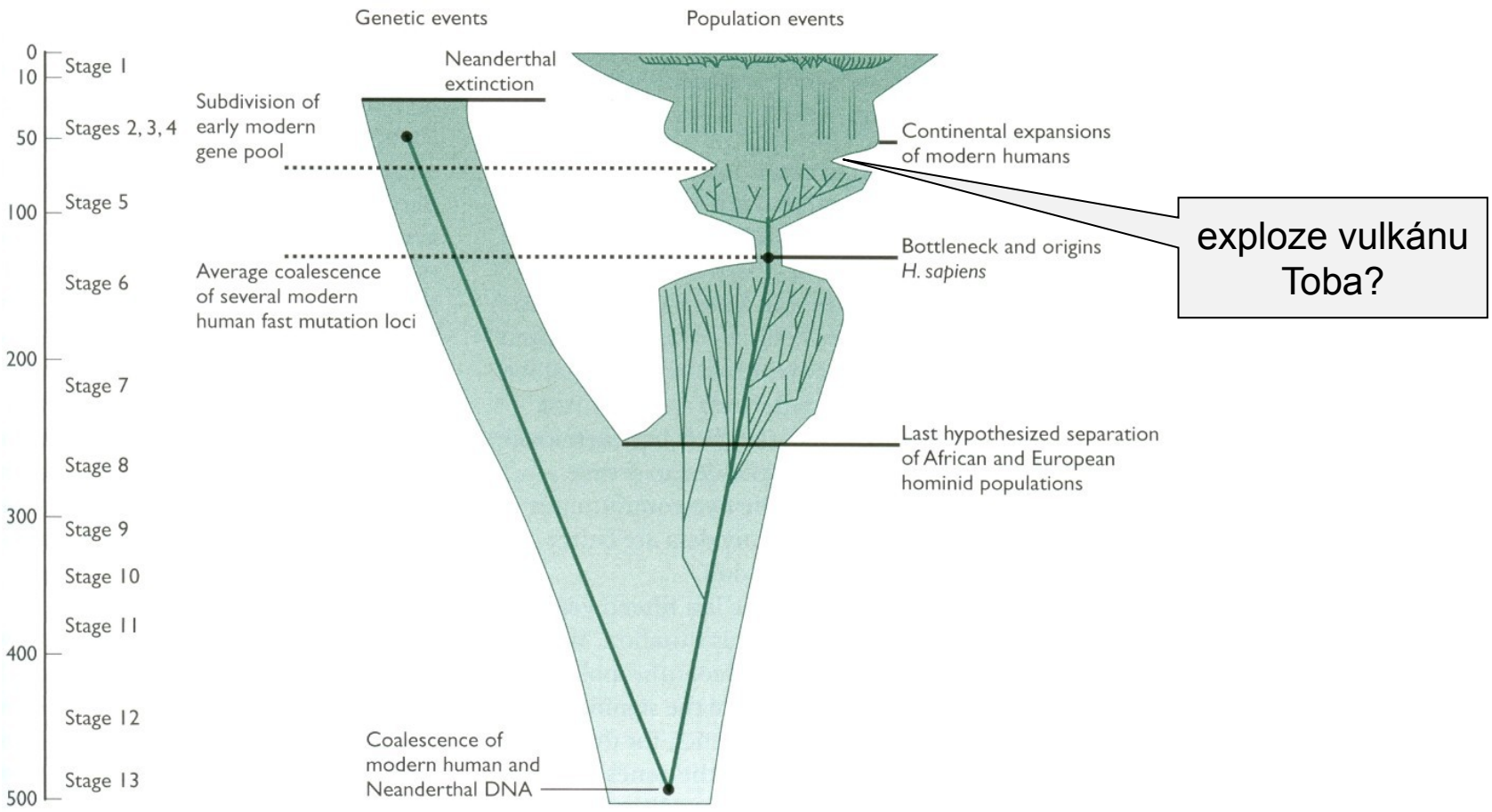


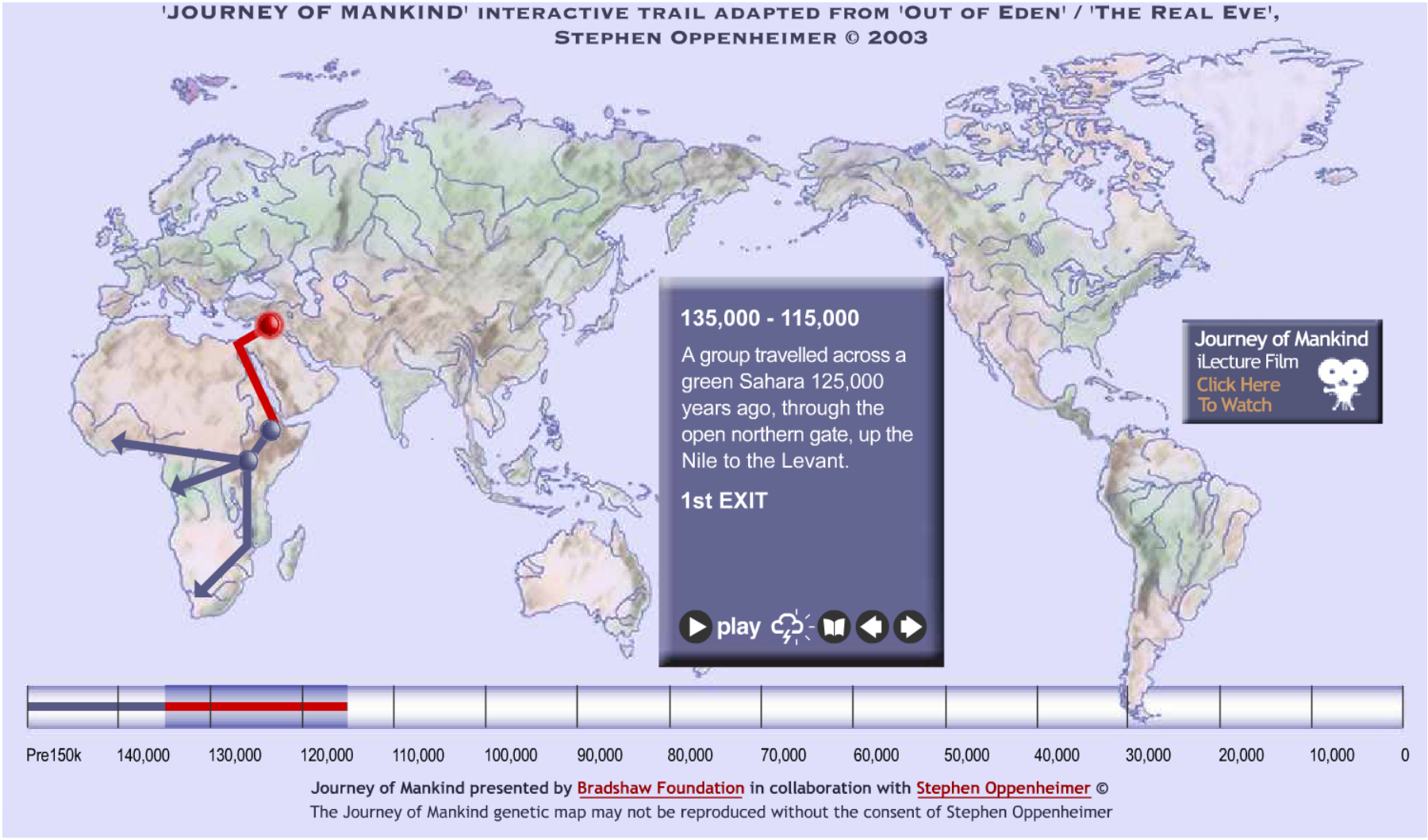
Problém: i multiregionální hyp. předpokládá africký původ



Alan Templeton (2002):
„out-of-Africa again and again“

Expanze a bottlenecky:





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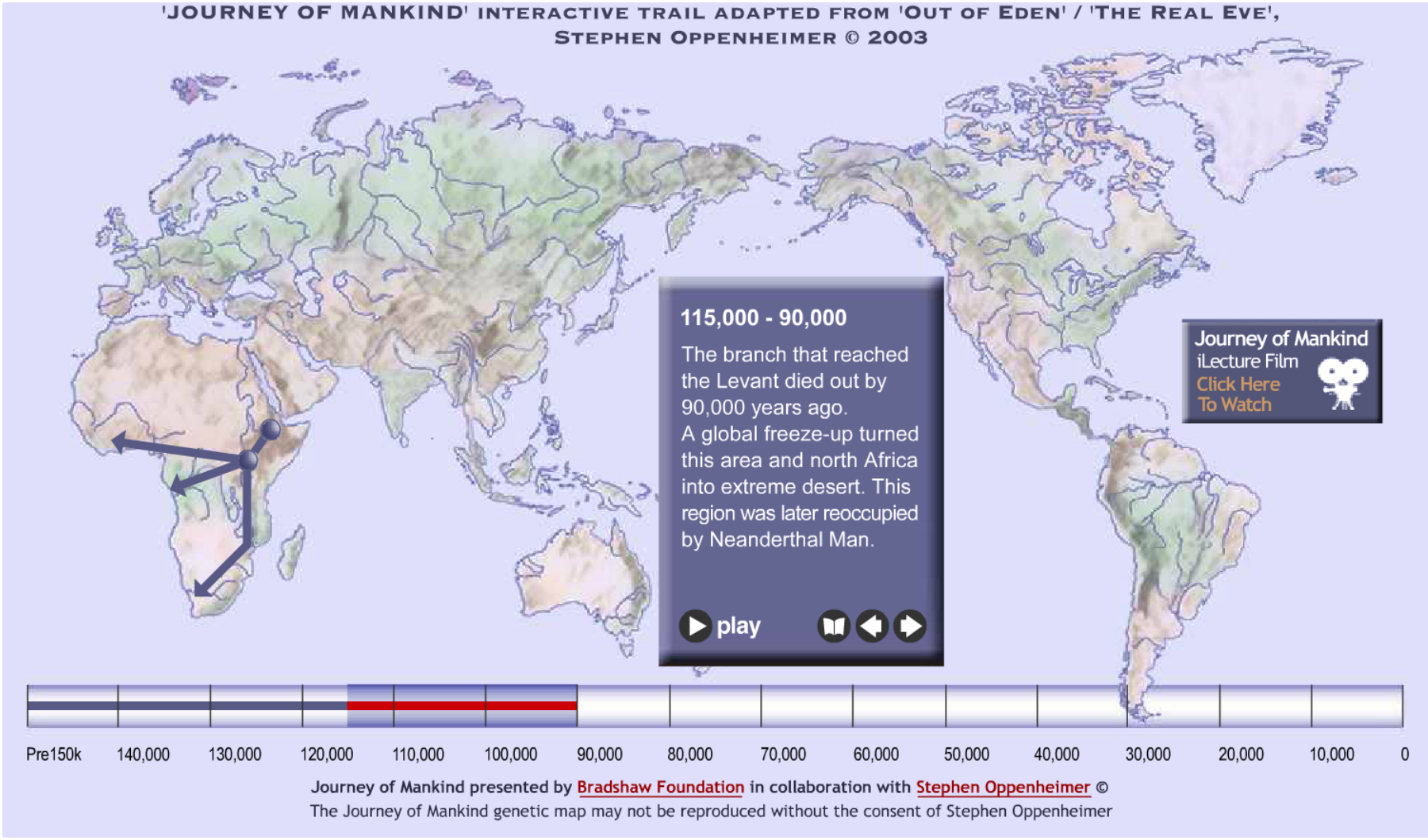

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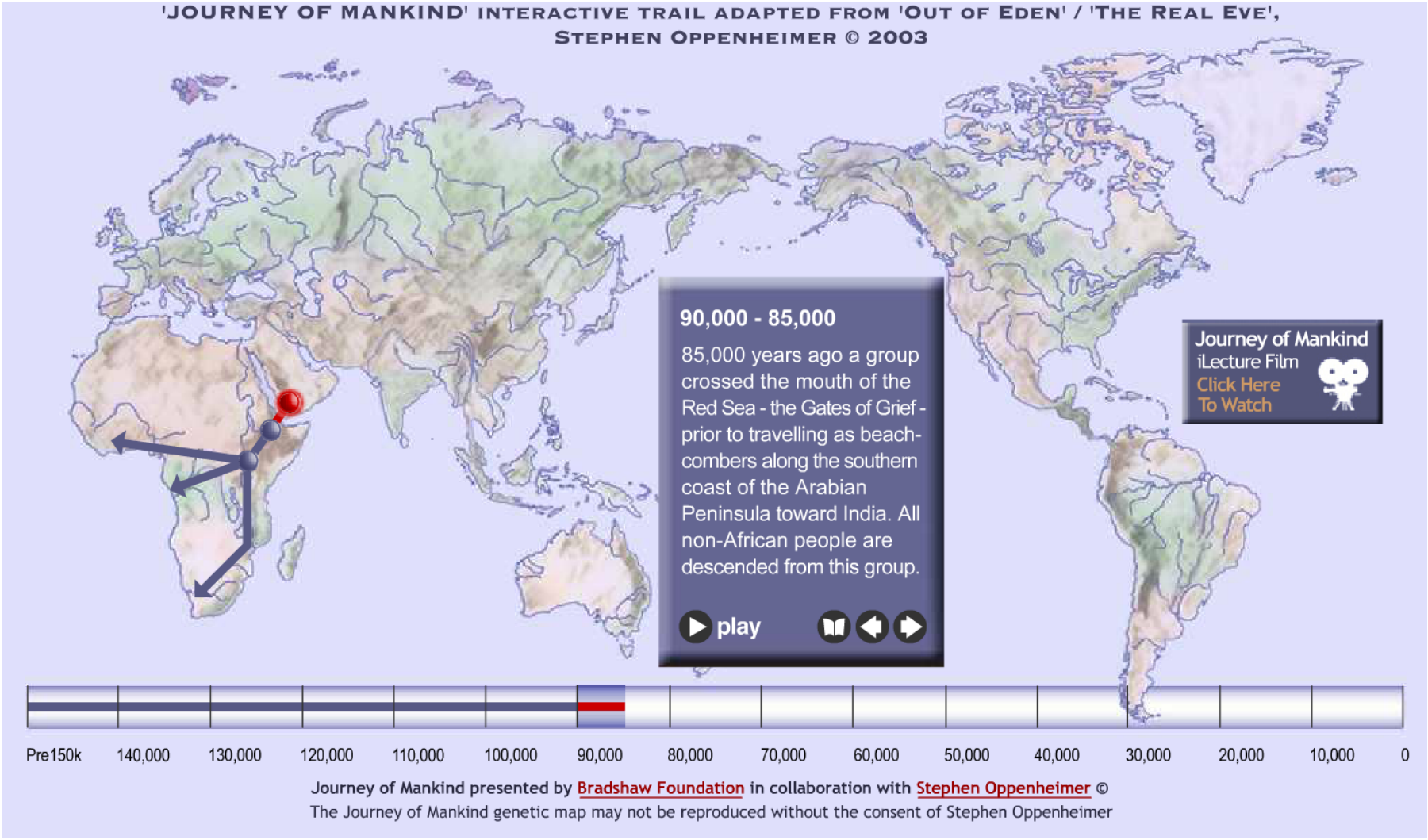
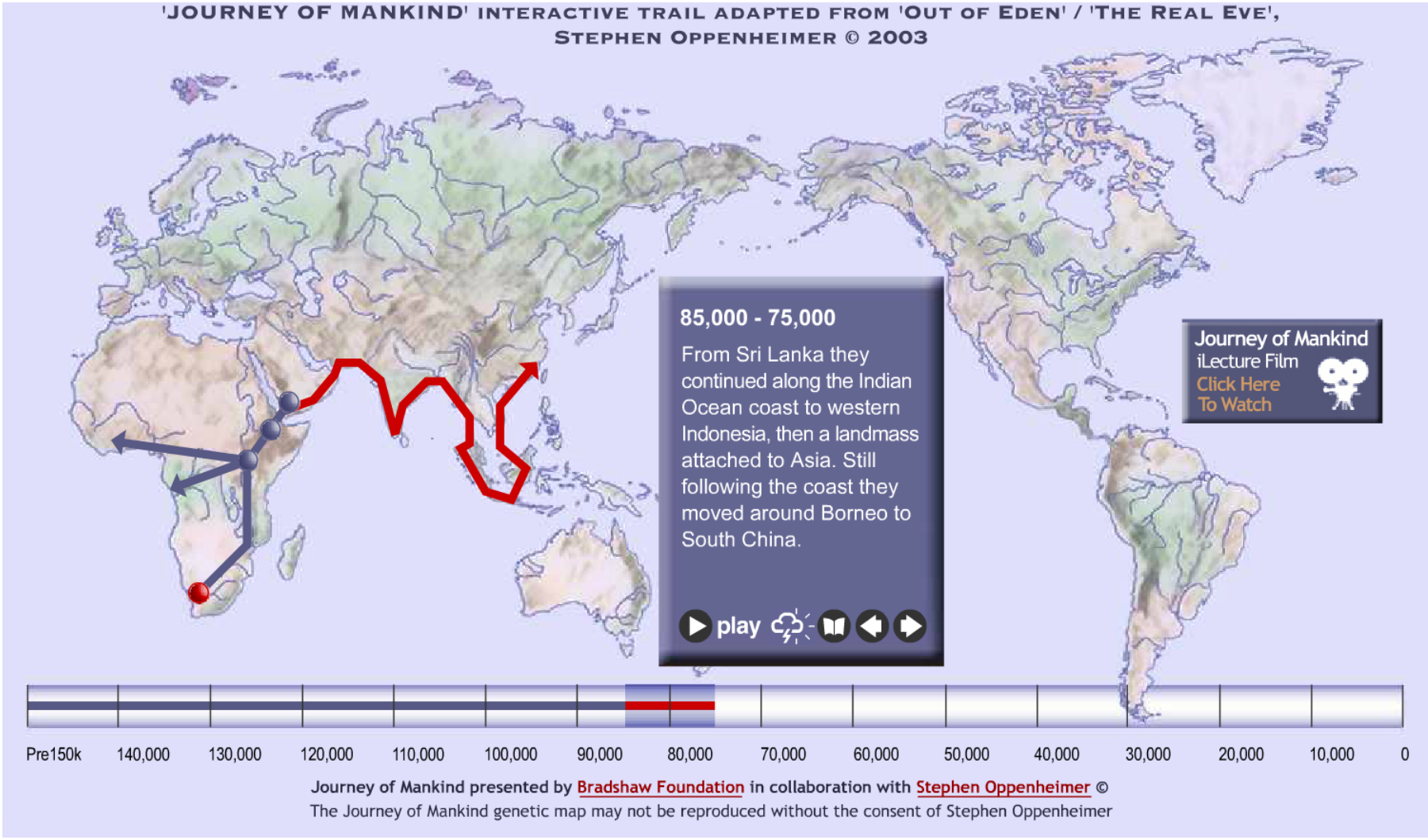

'JOURNEY OF MANKIND' INTERACTIVE TRAIL ADAPTED FROM 'OUT OF EDEN' / 'THE REAL EVE',
STEPHEN OPPENHEIMER © 2003
90,000 - 85,000
85,000 years ago a group crossed the mouth of the Red Sea - the Gates of Grief - prior to travelling as beach-combers along the southern coast of the Arabian Peninsula toward India. All non-African people are descended from this group.
play
Journey of Mankind
iLecture Film
Click Here
To Watch
Pre150k
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Journey of Mankind presented by Bradshaw Foundation in collaboration with Stephen Oppenheimer ©
The Journey of Mankind genetic map may not be reproduced without the consent of Stephen Oppenheimer


'JOURNEY OF MANKIND' INTERACTIVE TRAIL ADAPTED FROM 'OUT OF EDEN' / 'THE REAL EVE',
STEPHEN OPPENHEIMER © 2003
85,000 - 75,000
From Sri Lanka they continued along the Indian Ocean coast to western Indonesia, then a landmass attached to Asia. Still following the coast they moved around Borneo to South China.
play
Journey of Mankind
iLecture Film
Click Here
To Watch
Pre150k
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Journey of Mankind presented by Bradshaw Foundation in collaboration with Stephen Oppenheimer ©
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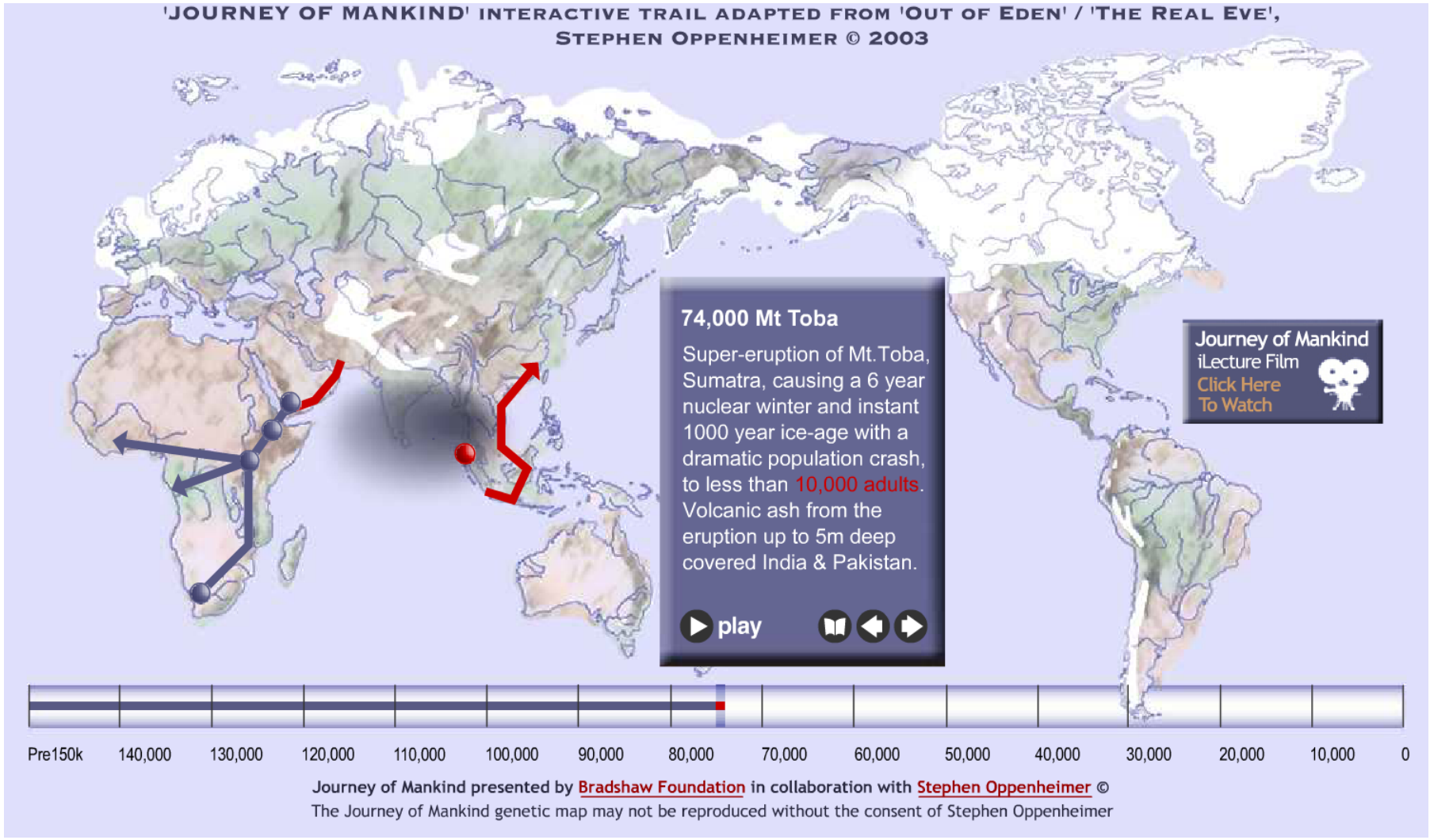
'JOURNEY OF MANKIND' INTERACTIVE TRAIL ADAPTED FROM 'OUT OF EDEN' / 'THE REAL EVE',
STEPHEN OPPENHEIMER © 2003
74,000 Mt Toba
Super-eruption of Mt.Toba, Sumatra, causing a 6 year nuclear winter and instant 1000 year ice-age with a dramatic population crash, to less than 10,000 adults. Volcanic ash from the eruption up to 5m deep covered India & Pakistan.
play
Journey of Mankind
iLecture Film
Click Here
To Watch
Pre150k
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Journey of Mankind presented by Bradshaw Foundation in collaboration with Stephen Oppenheimer ©
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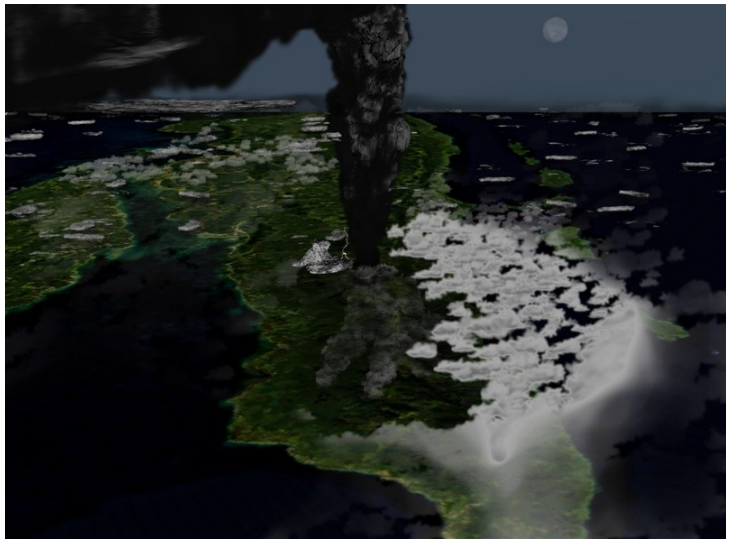
Expanze a bottlenecky:



Toba:

sever Sumatry

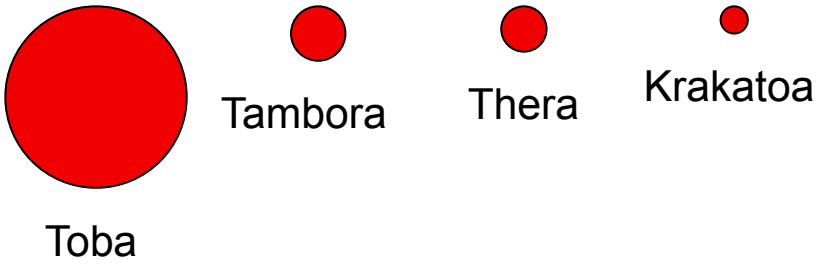
73 000 let

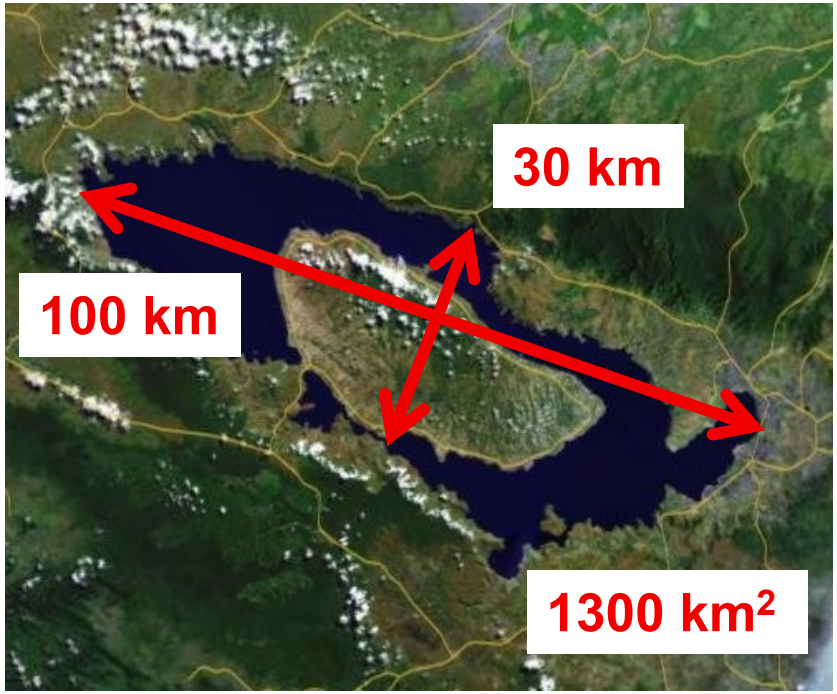
75% živých jedinců

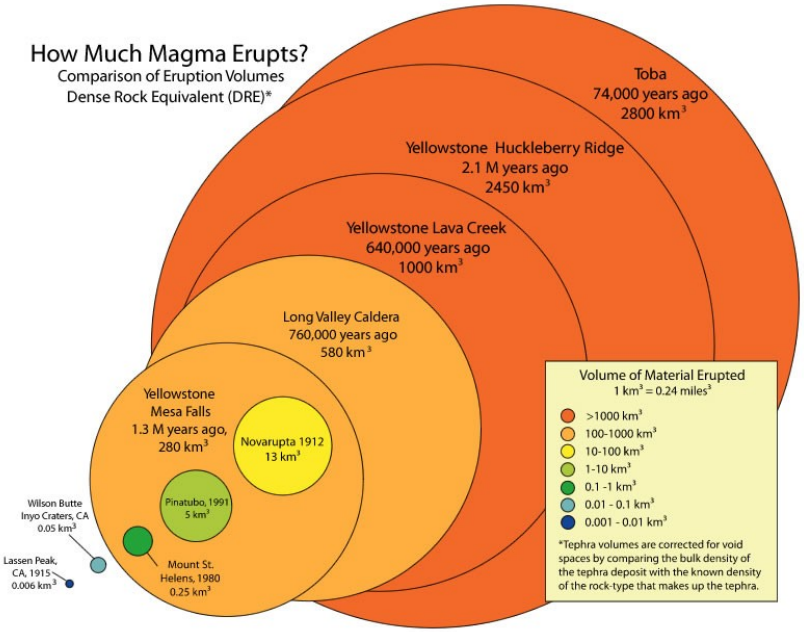
2800 km^3 horniny

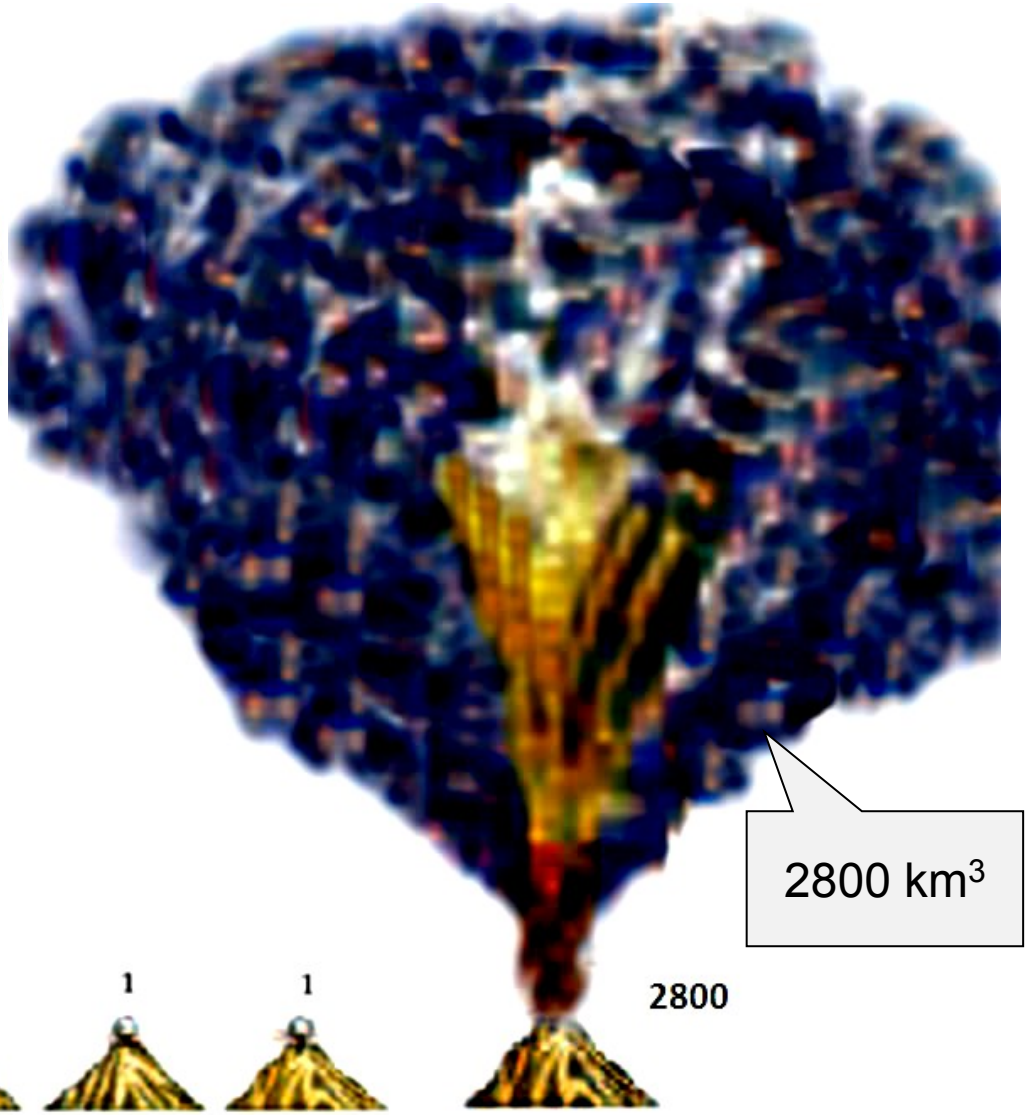
pokles teploty o 16°C

ztráta variability



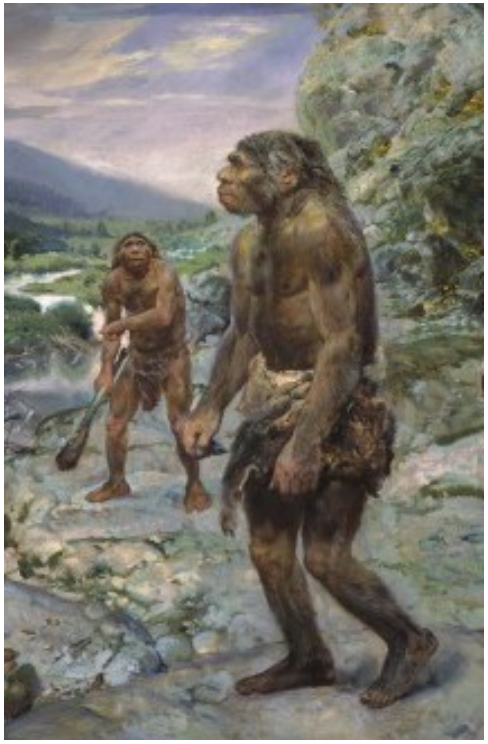


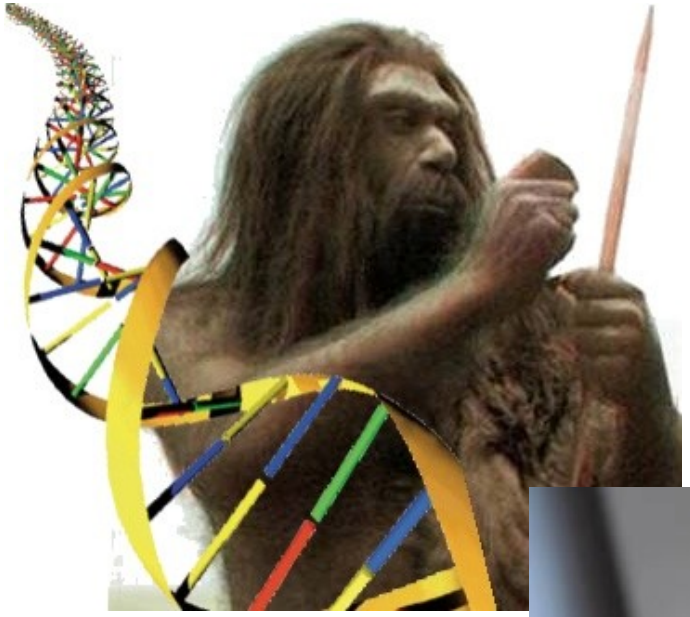

How Much Magma Erupts?
Comparison of Eruption Volumes
Dense Rock Equivalent (DRE)*
Toba
74,000 years ago
2800 km³
Yellowstone Huckleberry Ridge
2.1 M years ago
2450 km³
Yellowstone Lava Creek
640,000 years ago
1000 km³
Long Valley Caldera
760,000 years ago
580 km³
Yellowstone
Mesa Falls
1.3 M years ago,
280 km³
Novarupta 1912
13 km³
Pinatubo, 1991
5 km³
Wilson Butte
Inyo Craters, CA
0.05 km³
Lassen Peak,
CA, 1915
0.006 km³
Mount St.
Helens, 1980
0.25 km³
Volume of Material Erupted
1 km³ = 0.24 miles³
>1000 km³
100-1000 km³
10-100 km³
1-10 km³
0.1 -1 km³
0.01 - 0.1 km³
0.001 - 0.01 km³
*Tephra volumes are corrected for void spaces by comparing the bulk density of the tephra deposit with the known density of the rock-type that makes up the tephra.


2800 km³


3
80
18
12
1
1
2800
Vesuvius
Italy
79 CE
Tambora
Indonesia
1815
Krakatau
Indonesia
1883
Katmai
Alaska
1912
Mt. St. Helens
Washington
1980
El Chichón
Mexico
1982
Toba Supervolcano
Indonesia
75.000 tahun yang lalu

D-094





sekvence neandertálské mtDNA:

mimo variabilitu současných lidí

není bližší současným než archaickým lidem

Svante Pääbo

~1-4 % neandertálských sekvencí v genomu člověka

Evropa, Asie (asi o 20 % víc)

ne subsaharská Afrika

⊕

neandertálský keratin (adaptace na chladné podnebí?)

interleukin 18 (cytokiny)

gen *MC1R*: El Sidrón, Španělsko (43 tis.), Monti Lessini, Itálie (50 tis.)
→ „keltský typ“ min. u 1 % (u člověka 1-2 %)

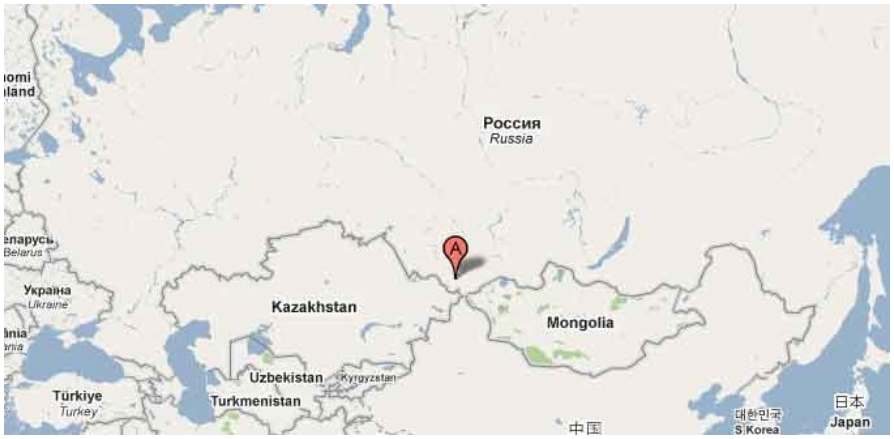
⊗

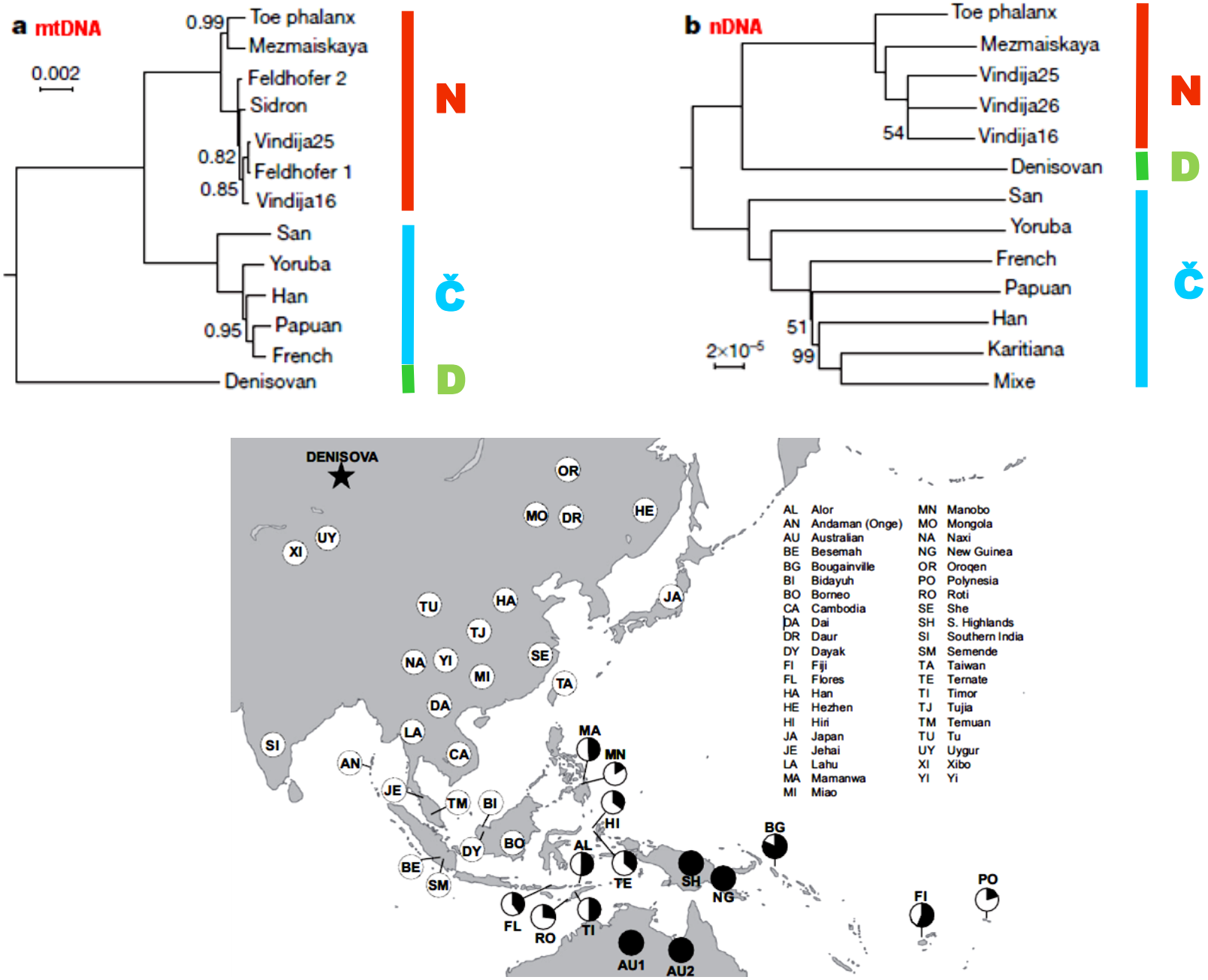
systémový lupus erythematodes, primární biliární cirhóza,
Crohnova nemoc, cukrovka II. typu

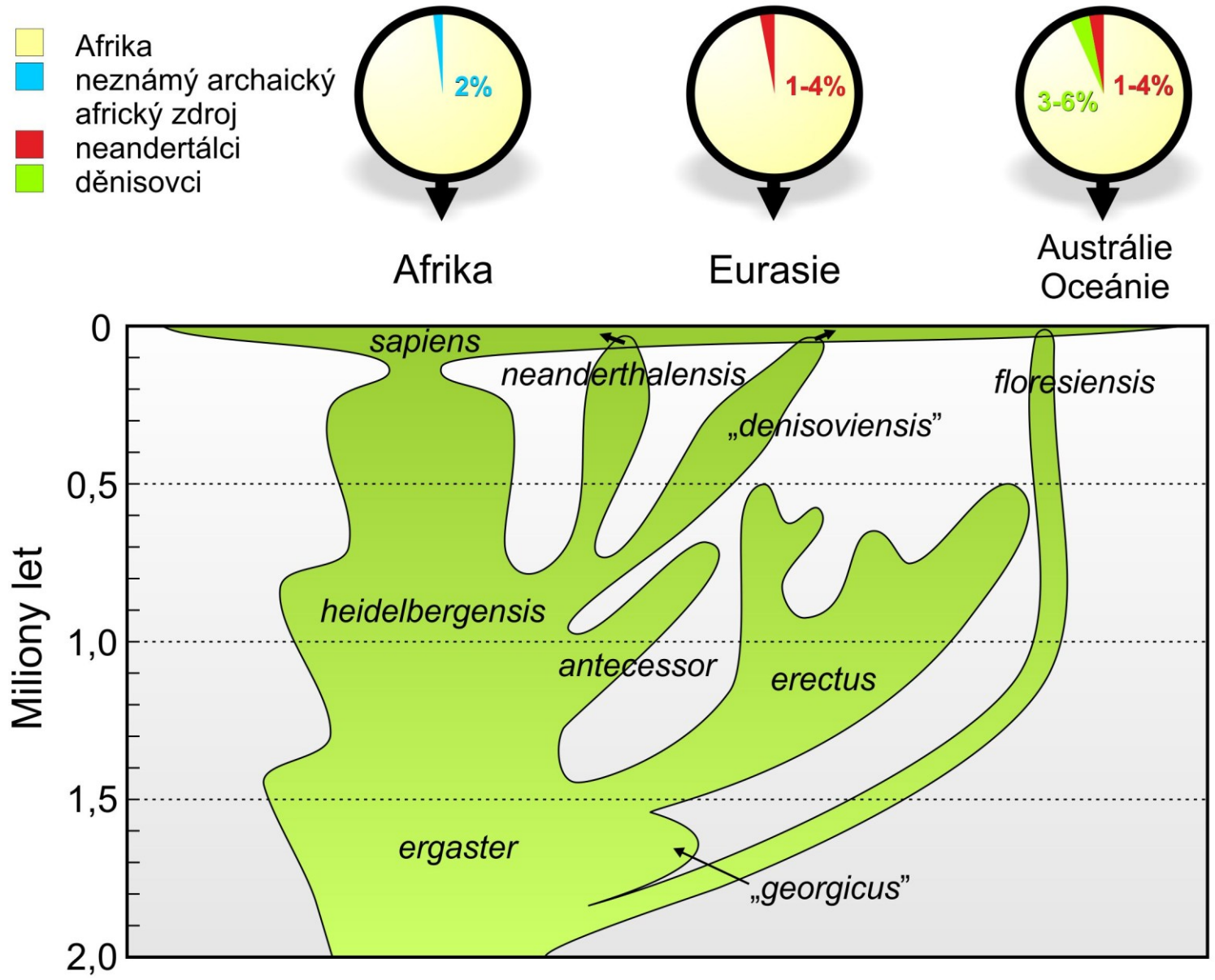
závislost na nikotinu

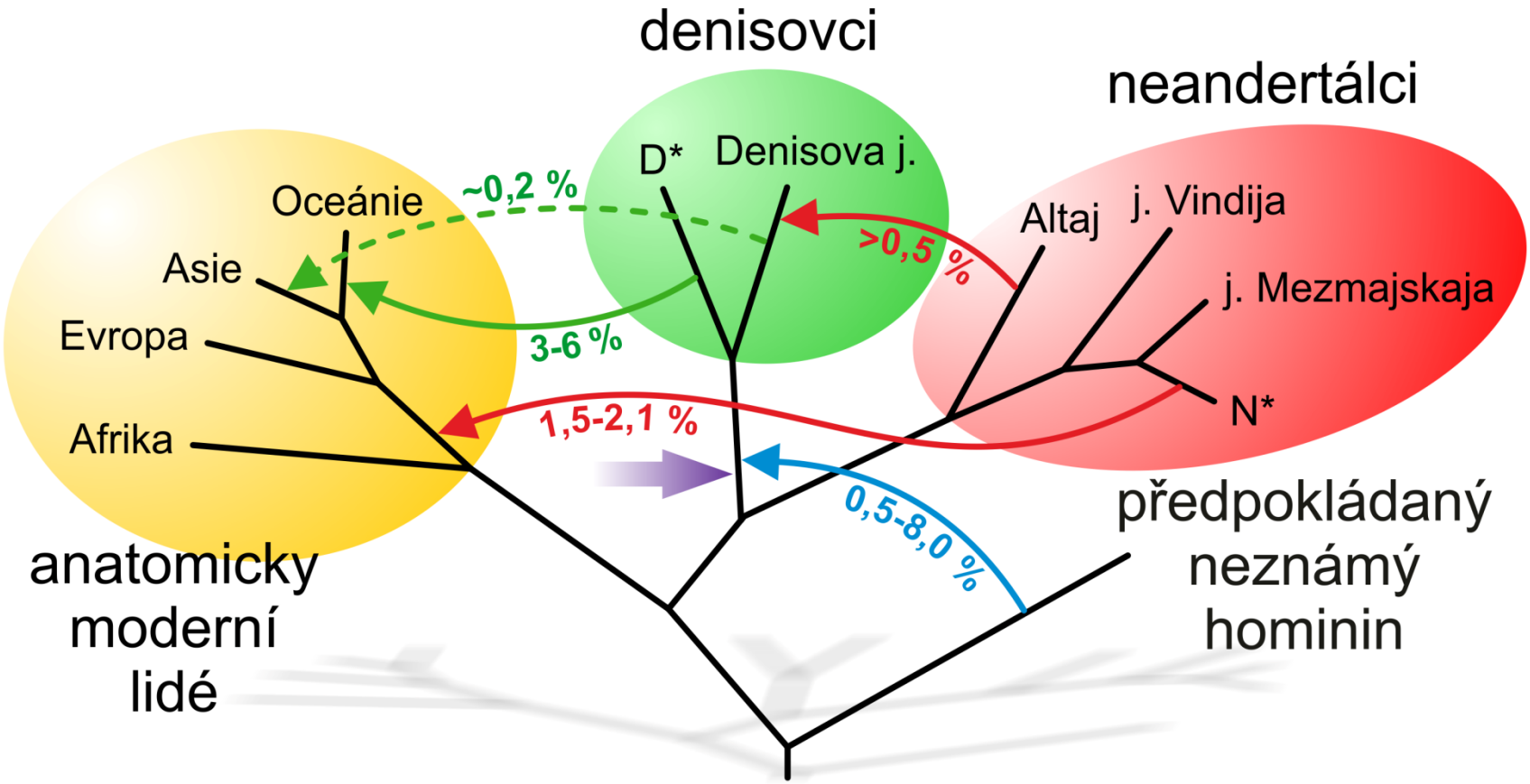
absence genů na chromozomu X → Haldaneovo pravidlo

Denisova jeskyně




a mtDNA
0.002
0.99
Toe phalanx
Mezmaiskaya
Feldhofer 2
Sidron
0.82
Vindija25
Feldhofer 1
0.85
Vindija16
San
Yoruba
Han
0.95
Papuan
French
Denisovan
N
Č
D
b nDNA
Toe phalanx
Mezmaiskaya
Vindija25
Vindija26
54
Vindija16
Denisovan
San
Yoruba
French
Papuan
51
Han
2×10⁻⁵
99
Karitiana
Mixe
N
D
Č
DENISOVA
OR
MO
DR
HE
UY
XI
TU
HA
JA
TJ
NA
YI
SE
MI
TA
DA
LA
SI
CA
AN
MA
MN
JE
TM
BI
HI
DY
BO
AL
BG
BE
TE
SH
NG
SM
FL
RO
TI
AU1
AU2
FI
PO
AL Alor
AN Andaman (Onge)
AU Australian
BE Besemah
BG Bougainville
BI Bidayuh
BO Borneo
CA Cambodia
DA Dai
DR Daur
DY Dayak
FI Fiji
FL Flores
HA Han
HE Hezhen
HI Hiri
JA Japan
JE Jehai
LA Lahu
MA Mamanwa
MI Miao
MN Manobo
MO Mongola
NA Naxi
NG New Guinea
OR Oroqen
PO Polynesia
RO Roti
SE She
SH S. Highlands
SI Southern India
SM Semende
TA Taiwan
TE Ternate
TI Timor
TJ Tujia
TM Temuan
TU Tu
UY Uygur
XI Xibo
YI Yi

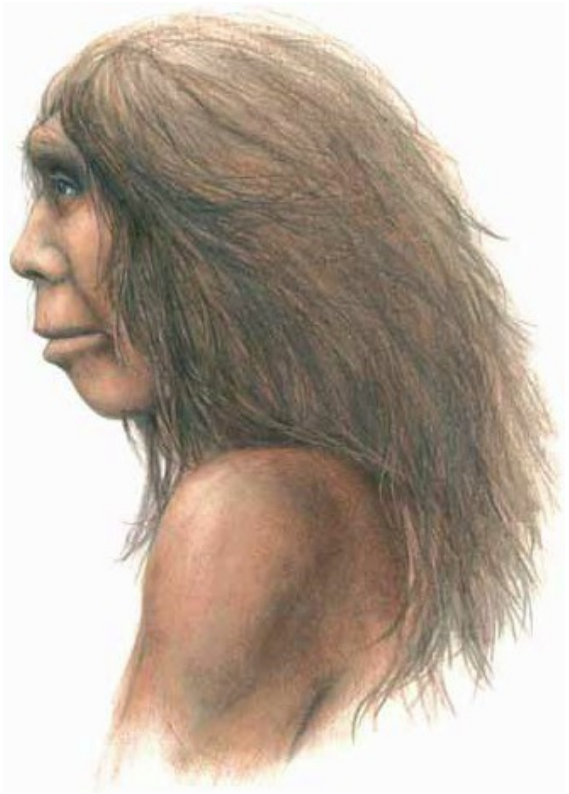

Afrika
neznámý archaický africký zdroj
neandertálci
děnisovci
2%
1-4%
3-6%
1-4%
Afrika
Eurasie
Austrálie Oceánie
Miliony let
0
0,5
1,0
1,5
2,0
sapiens
neanderthalensis
floresiensis
„denisoviensis"
heidelbergensis
antecessor
erectus
ergaster
„georgicus"


denisovci
neandertálci
D*
Denisova j.
Oceánie
~0,2 %
Asie
Evropa
Afrika
3-6 %
>0,5 %
Altaj
j. Vindija
j. Mezmajskaja
N*
1,5-2,1 %
0,5-8,0 %
anatomicky moderní lidé
předpokládaný neznámý hominin

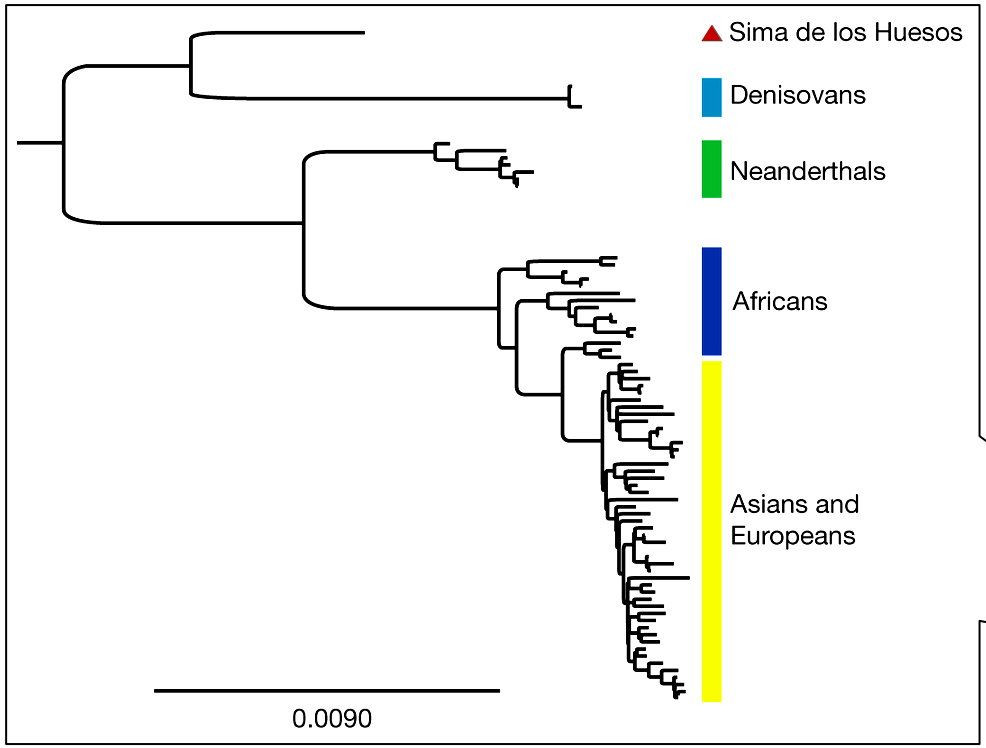
Sima de los Huesos, Cueva Mayor (Atapuerca, S Španělsko)

„Miguelón“

Homo heidelbergensis



300 – 530 tis.



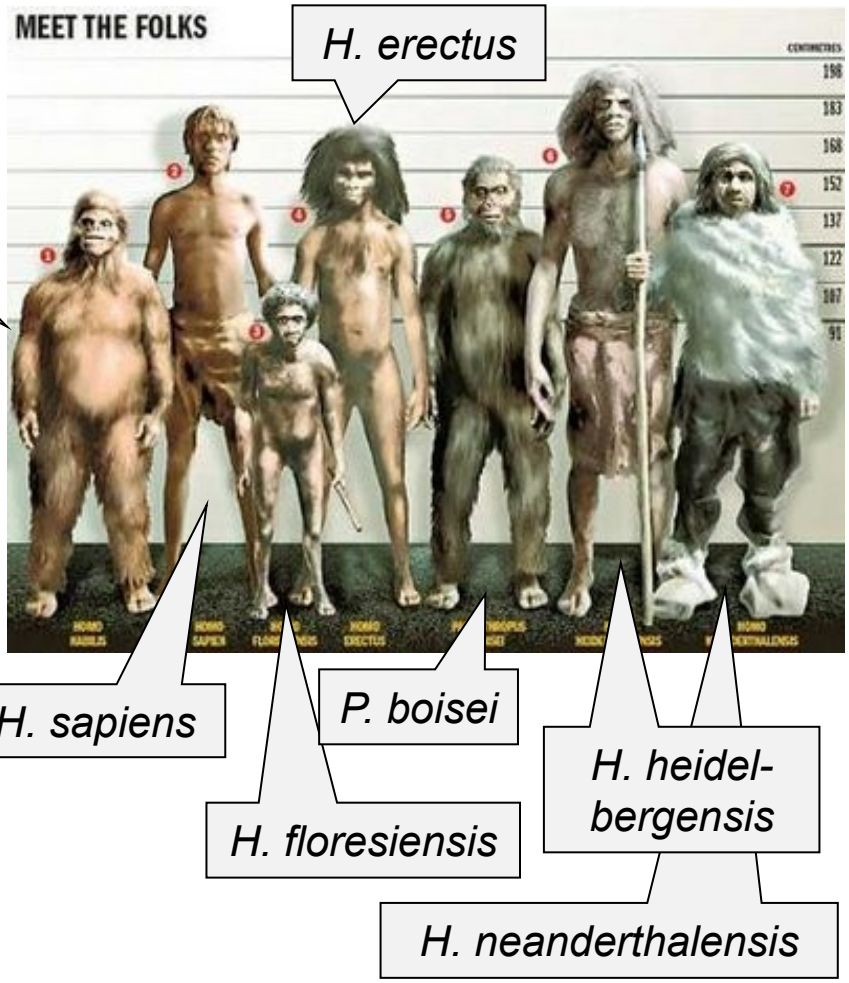
~ 400 000 let

oddělení cca. 800 tis.

„Hobit“ z ostrova Flores

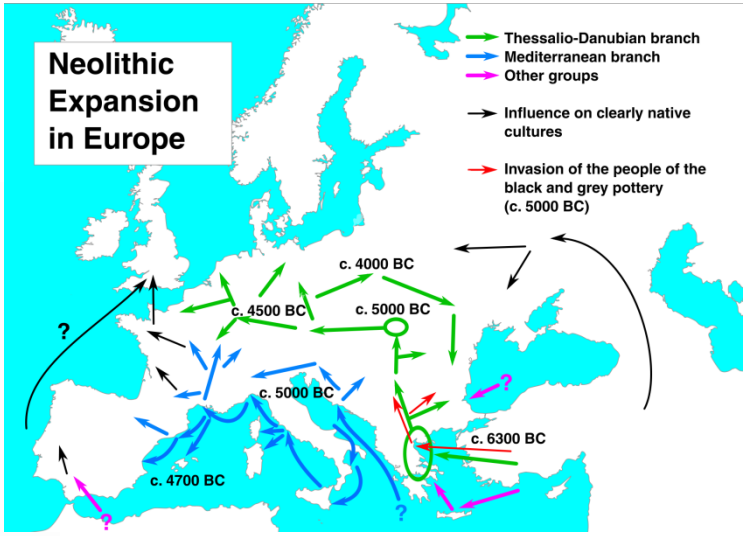
= Ebu Gogo („pramáti, která všechno sní“)?

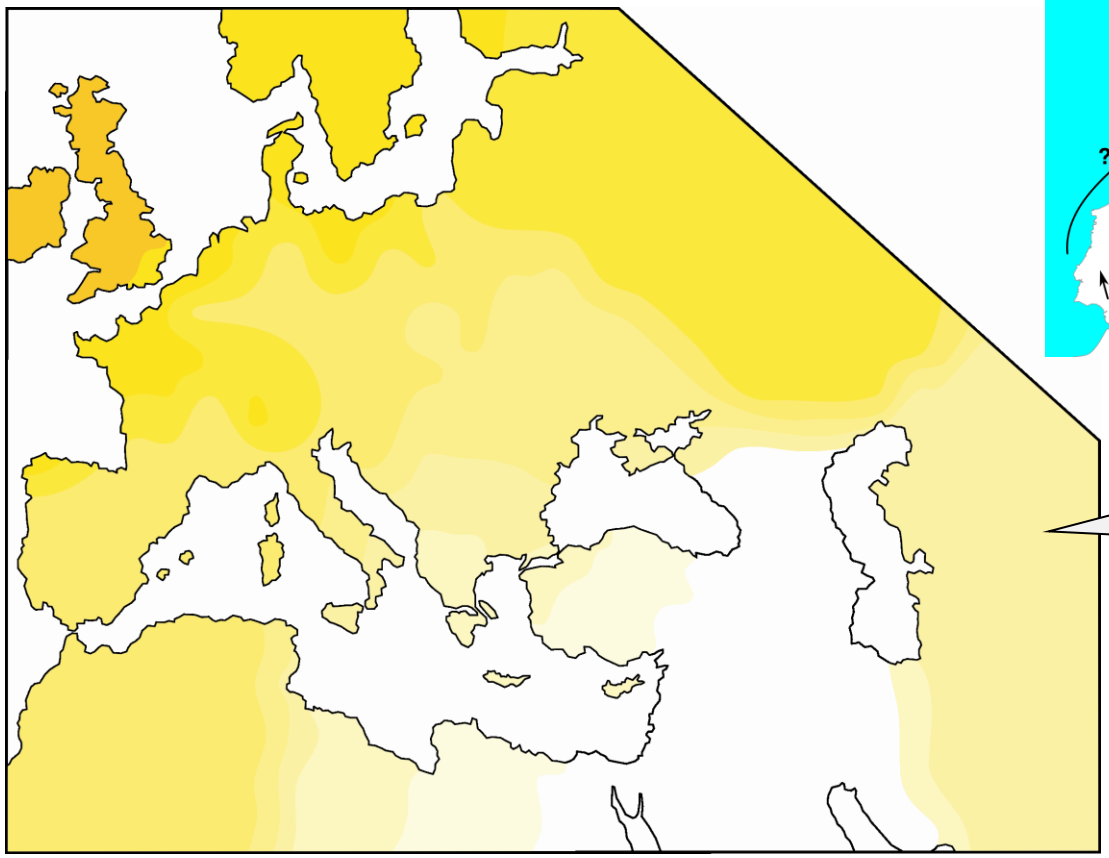
Sumatra: Orang Pendek („malý člověk“)



Příchod neolitiků do Evropy – akulturace vs. démická difuze

Minimálně 8 center:
Úrodný půlměsíc, S a J Čína, Sahel, Papua-Nová Guinea, střední Mexiko, peruánské Andy a V Severní Ameriky



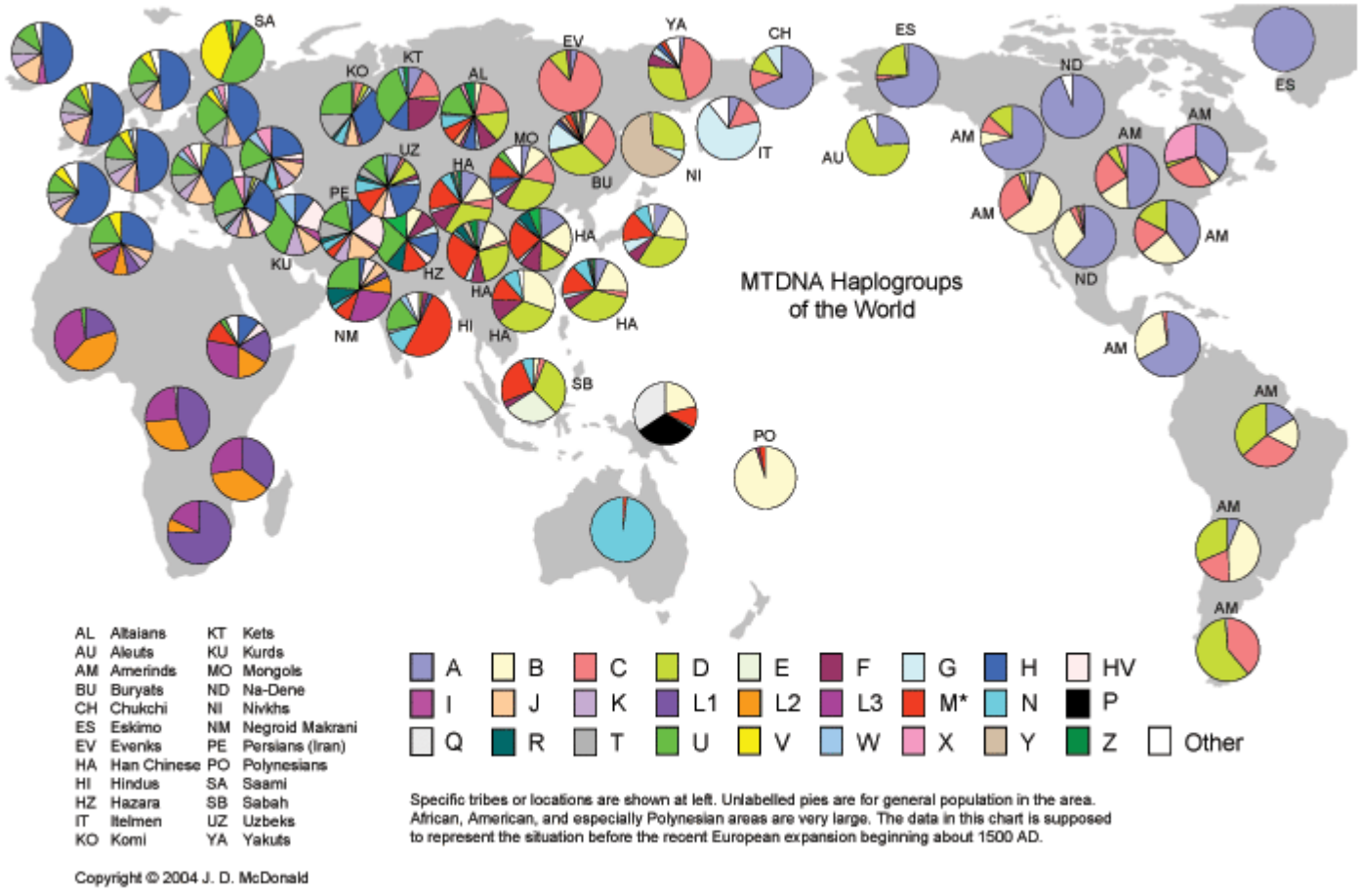


L.-L. Cavalli-Sforza: démická difuze

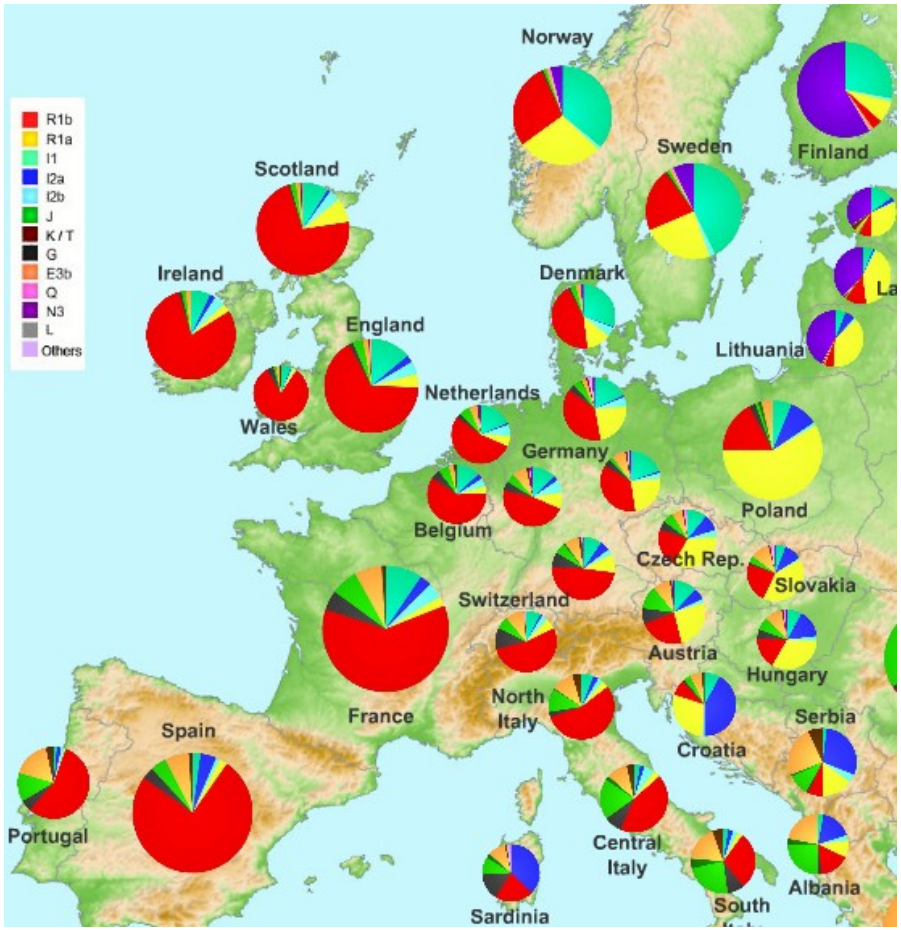
mtDNA

Haplogroup	Possible time of origin	Possible place of origin
N	75,000 ago	India or South Asia
R	70,000 ago	India or South Asia
U	60,000 ago	North-East Africa or South-West Asia
pre-JT	55,000 ago	Middle East
JT	50,000 ago	Middle East
U5	50,000 ago	Western Asia
U6	50,000 ago	North Africa
U8	50,000 ago	Western Asia
pre-HV	50,000 ago	Near East
J	45,000 ago	Near East or Caucasus
HV	40,000 ago	Near East
H	> 35,000 ago	Western Asia
X	> 30,000 ago	north-east Europe
U5a1	30,000 ago	Europe
I	30,000 ago	Caucasus or north-east Europe
J1a	27,000 ago	Near East
W	25,000 ago	north-east Europe or north-west Asia
U4	25,000 ago	Central Asia
J1b	23,000 ago	Near East
T	17,000 ago	Mesopotamia
K	16,000 ago	Near East
V	15,000 ago	Iberia and moved to Scandinavia
H1b	13,000 ago	Europe
K1	12,000 ago	Near East
H3	10,000 ago	Western Europe (Spain)

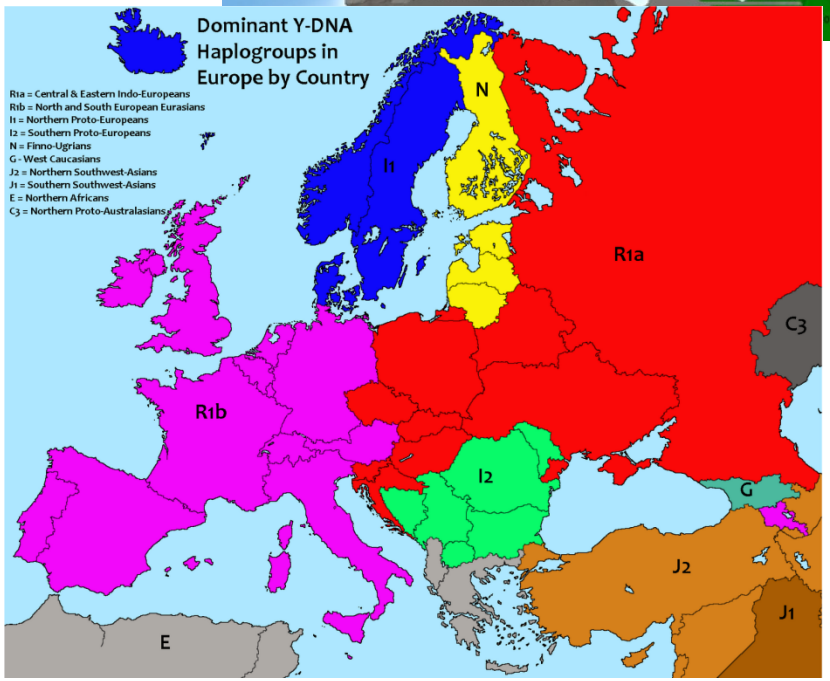
mtDNA


MTDNA Haplogroups
of the World
SA
KO
KT
AL
EV
YA
CH
ES
ND
ES
UZ
MO
HA
BU
NI
IT
AU
AM
AM
AM
PE
HA
HA
KU
HZ
HA
HA
HA
NM
HI
HA
ND
AM
AM
SB
PO
AM
AM
AM
AL Altaians
AU Aleuts
AM Amerinds
BU Buryats
CH Chukchi
ES Eskimo
EV Evenks
HA Han Chinese
HI Hindus
HZ Hazara
IT Itelmen
KO Komi
KT Kets
KU Kurds
MO Mongols
ND Na-Dene
NI Nivkhs
NM Negroid Makrani
PE Persians (Iran)
PO Polynesians
SA Saami
SB Sabah
UZ Uzbeks
YA Yakuts
A B C D E F G H HV
I J K L1 L2 L3 M* N P
Q R T U V W X Y Z Other
Specific tribes or locations are shown at left. Unlabelled pies are for general population in the area. African, American, and especially Polynesian areas are very large. The data in this chart is supposed to represent the situation before the recent European expansion beginning about 1500 AD.
Copyright © 2004 J. D. McDonald

chr. Y


R1b
R1a
I1
I2a
I2b
J
K / T
G
E3b
Q
N3
L
Others
Norway
Sweden
Finland
Scotland
Ireland
Denmark
England
Lithuania
Netherlands
Wales
Germany
Poland
Belgium
Czech Rep.
Slovakia
Switzerland
Austria
Hungary
France
North Italy
Serbia
Croatia
Spain
Portugal
Central Italy
Albania
Sardinia
South


Y-DNA HAPLOGROUPS
map with predominant haplogroups
public domain
made for wikipedia by
robert gabel 12/2011
R1a-Z284
(Northern
Indo-Europeans)
N
(Finno-Ugrians)
I1
(Northern
Proto-Europeans)
R1b-U106
(Northern
West-Europeans)
R1a-M458
(Eastern
Indo-Europeans)
R1a-Z280
(Central Indo-Europeans)
R1b-S116
(Southern
West-Europeans)
I2 (Southern
Proto-Europeans)
G
(West
Caucasians)
J2
(Northern
Southwest-Asians)
E-V257
(Western North-East-Africans)


Dominant Y-DNA
Haplogroups in
Europe by Country
R1a = Central & Eastern Indo-Europeans
R1b = North and South European Eurasians
I1 = Northern Proto-Europeans
I2 = Southern Proto-Europeans
N = Finno-Ugrians
G - West Caucasians
J2 = Northern Southwest-Asians
J1 = Southern Southwest-Asians
E = Northern Africans
C3 = Northern Proto-Australasians
N
I1
R1a
C3
R1b
I2
G
J2
J1
E

mtDNA: ~ 20 % paleolitického původu → spíše akulturace?

kraniometrie, jaderné geny (*NR4*): démická difuze

→ odpovídá modelu samčí migrace

Problém: odhady minulých dějů mohou být velmi variabilní – pouze jediná realizace evolučního procesu

Co definuje člověka?

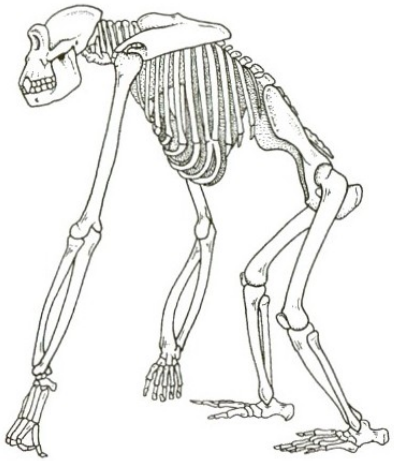
vzpřímená chůze?

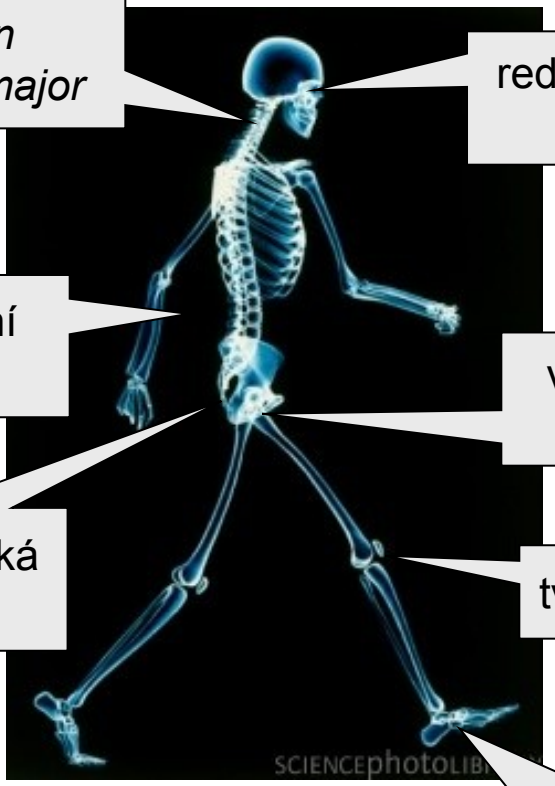
nástroje?

mozek?

řeč?

Typické znaky na kostře:





foramen occipitale major

redukce obličeje a zubů

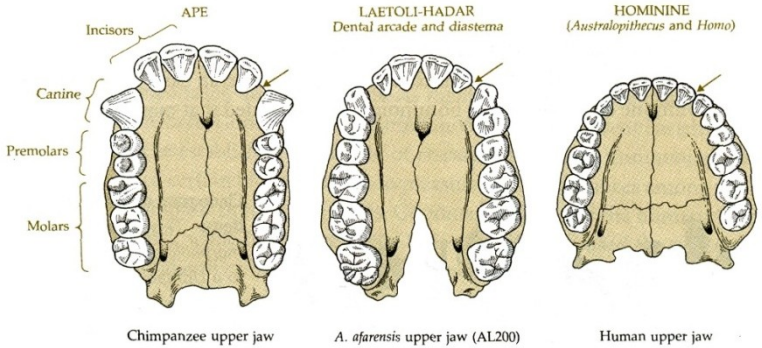
zakřivení páteře

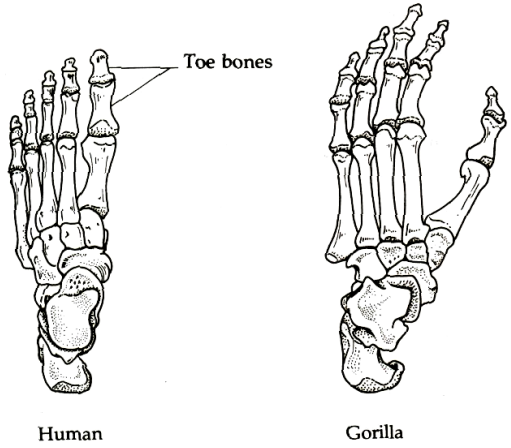
velká hlavice femuru

krátká a široká pánev

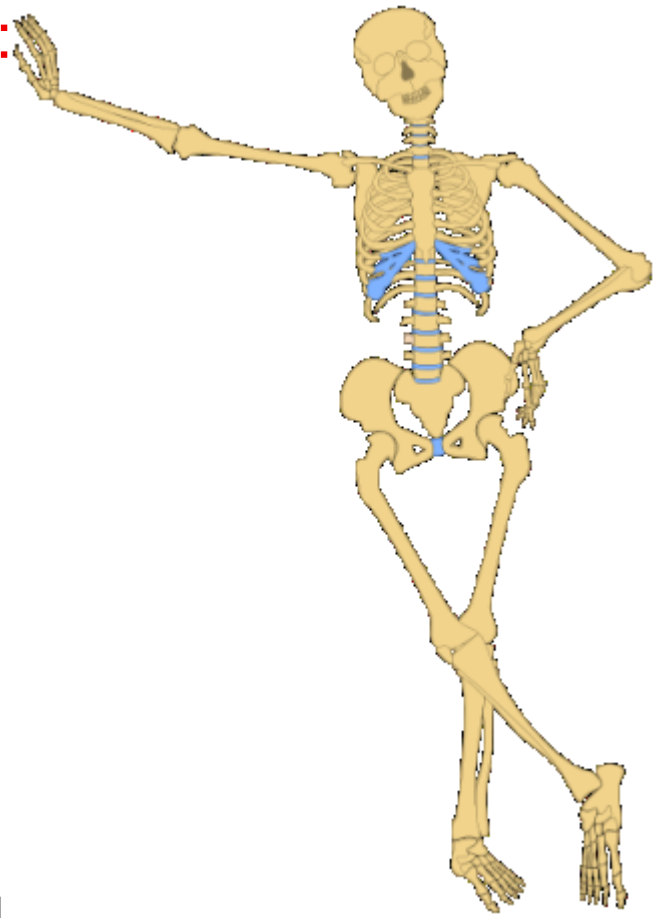
tvar kolen

krátké prsty, zakřivení chodidla





Nevýhody vzpřímené postavy:



zuby moudrosti

bolestivý porod

bolesti páteře

kýla

křečové žíly, oběhové problémy

hemoroidy

nadýmání během těhotenství

ploché nohy, kuří oka, bolesti nohou

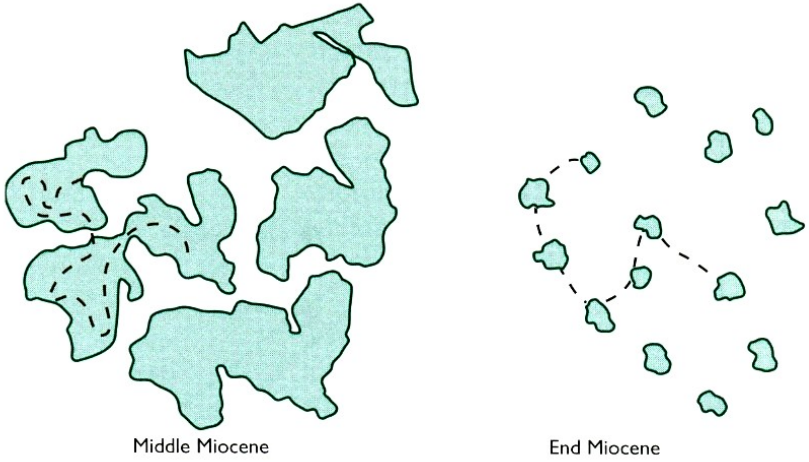
nutnost učit se chodit

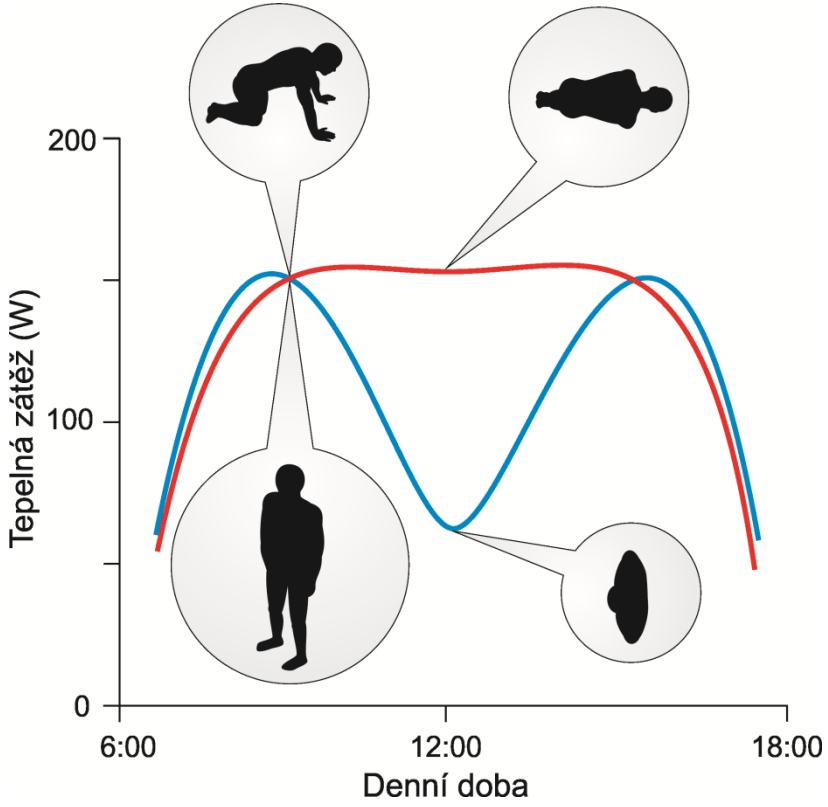
konec miocénu: klimatické změny

les → savana

vzpřímení:

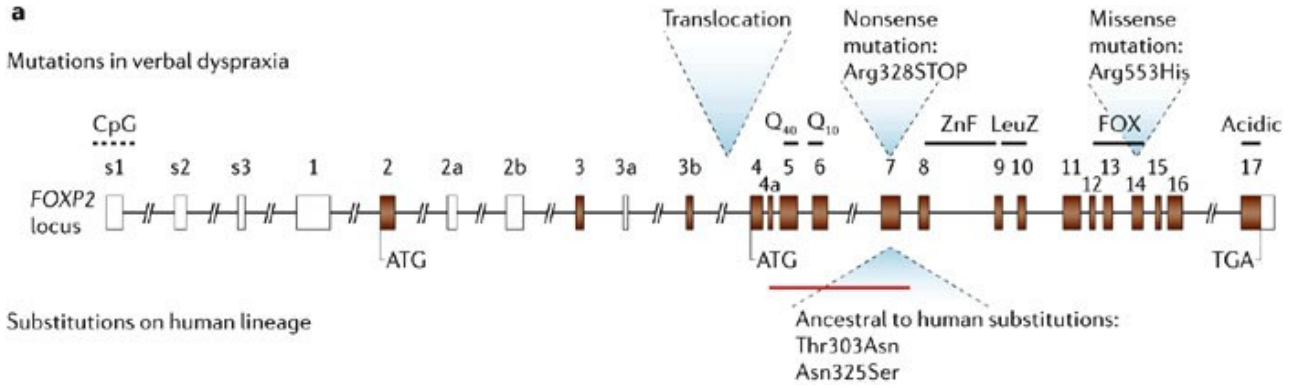
rozhled?, sběr potravy?, nástroje?, přehled o kořisti a predátorech?, termoregulace?, migrace za potravou?





Co definuje člověka?

vzpřímená chůze?
nástroje?
mozek?
řeč?

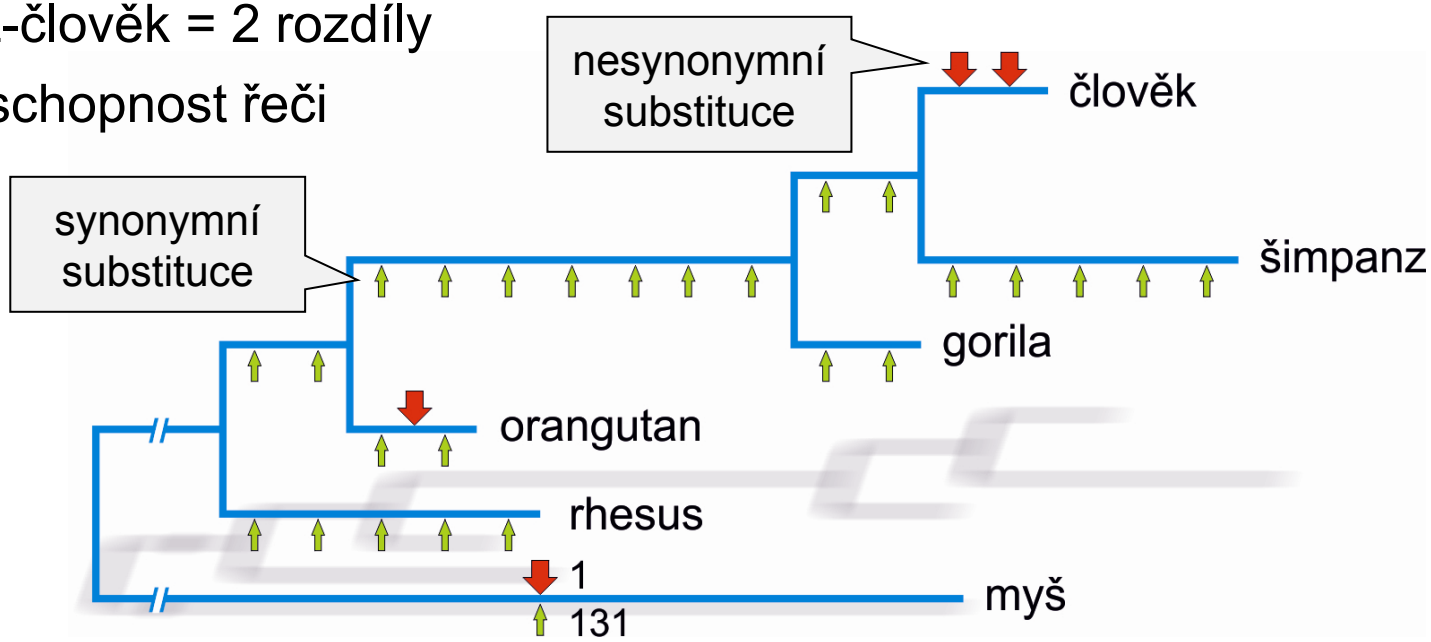


gen *FOXP2* (Forkhead box 2):

velmi konzervativní

člověk-myš = 3 AA rozdíly; orangutan-myš = 2; orangutan-člověk = 3;
šimpanz-člověk = 2 rozdíly

u člověka schopnost řeči



Unikátnost evoluce člověka

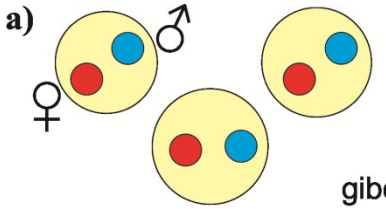
sociální systém: život ve skupině,
monogamie se sklonem k polygamii

paradox: rychlá evoluce, ale pouze
jeden druh

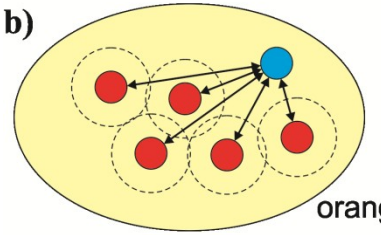
typické 2 procesy:

ekologická dominance: vnější prostředí
→ lidská společnost (člověk sám sobě
„nepřátelskou silou přírody“)

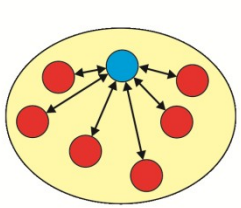
kooperativní kompetice: kooperace
kvůli kompetici (*runaway social
selection*)



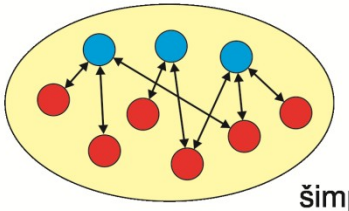
gibon



orangutan



gorila



šimpanz

Rasové a etnické skupiny:

3-60 ras

genetická variabilita se nekryje s morfologickou

genetická variabilita uvnitř „ras“ vyšší než mezi nimi (80 % vs. 8 %)

např. i při vymření všech lidí kromě kmene Kikujů ve V Africe by se zachovalo ~ 80 % variability

Menopauza:

skupinová selekce – nerodit defektní děti a nezhoršovat kvalitu genofondu

zvyšování věku, menopauza jako projev senescence

dnes: pomoc dřívějším potomkům

Skrytá ovulace:

vytěžování komodit („prostituce“)

zasetí pochybností a prevence infanticidy

stálá sexualita, otcovská péče

Bezsrstost:

pohlavní výběr

obrana proti parazitaci

šaty, oheň a přístřeší (zbytečnost srsti)

druhová identifikace

neotenie

akvatický život předků (Alistair Hardy, Elaine Morganová)

termoregulace

KULTURNÍ EVOLUCE

šimpanzi, koňadra, potkan, makak červenolící (*Macaca fuscata*)

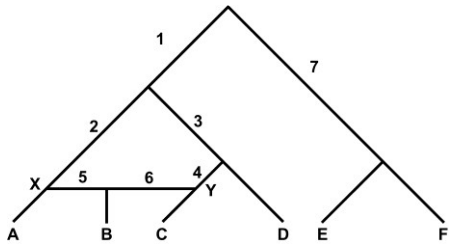
Vlastnosti kulturní evoluce:

vertikální i horizontální

lamarckovská

rychlá

retikulátní



selekce kulturních znaků (memy)

skupinová selekce

nejen kulturní přenos, ale i růst populace (demová difúze)

ovlivnění genetických faktorů kulturou

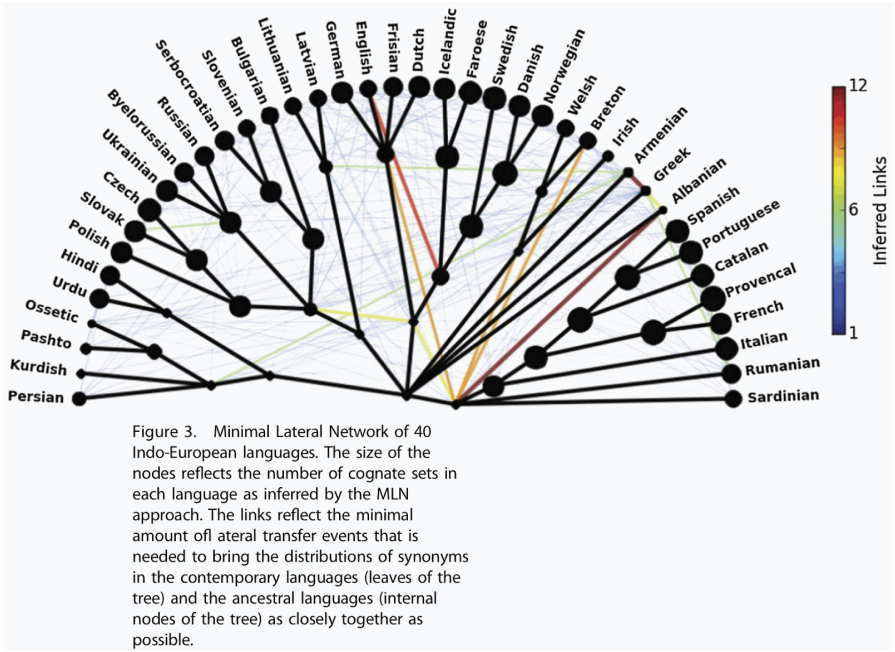


Figure 3. Minimal Lateral Network of 40 Indo-European languages. The size of the nodes reflects the number of cognate sets in each language as inferred by the MLN approach. The links reflect the minimal amount ofl ateral transfer events that is needed to bring the distributions of synonyms in the contemporary languages (leaves of the tree) and the ancestral languages (internal nodes of the tree) as closely together as possible.