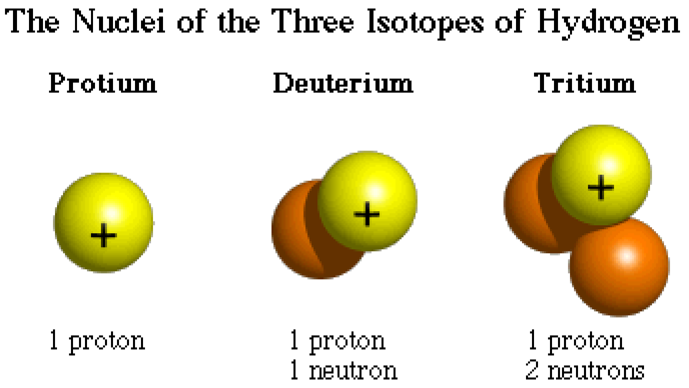
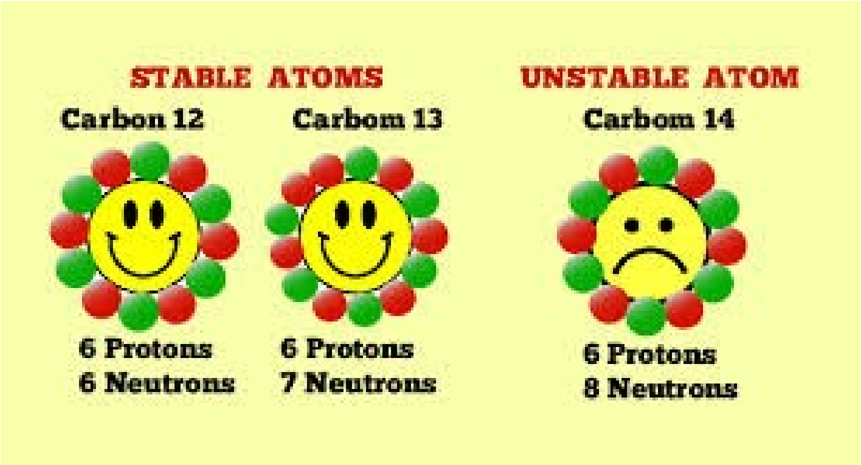
Izotopy

Izotopy v přírodě

nukleonové číslo → 2
protonové číslo → 1

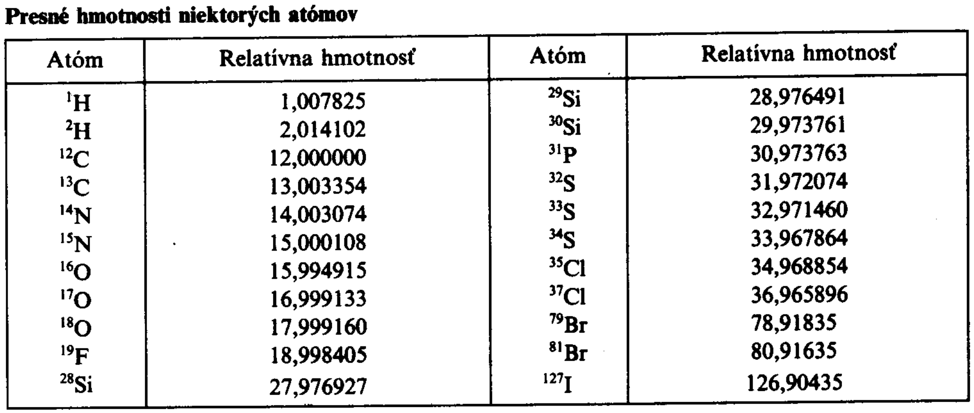
$^{2}_{1}\mathrm{H}$


The Nuclei of the Three Isotopes of Hydrogen



$$\delta^{13}\mathrm{C} = \left[\frac{(^{13}\mathrm{C}/^{12}\mathrm{C})_{\mathrm{Sample}}}{(^{13}\mathrm{C}/^{12}\mathrm{C})_{\mathrm{Standard}}} - 1\right] \times 1000$$

$$\delta^{15}\mathrm{N} = \left[\frac{(^{15}\mathrm{N}/^{14}\mathrm{N})_{\mathrm{Sample}}}{(^{15}\mathrm{N}/^{14}\mathrm{N})_{\mathrm{Standard}}} - 1\right] \times 1000$$


Presné hmotnosti niektorých atómov

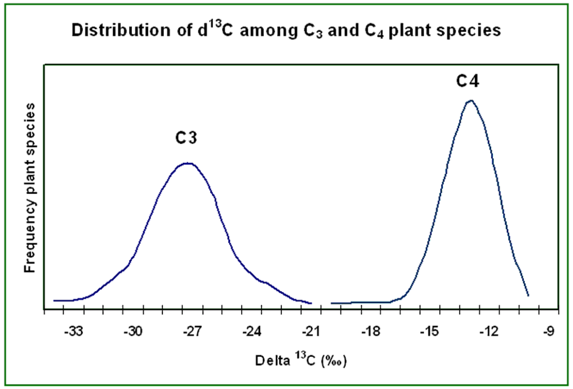
Atóm	Relatívna hmotnosť	Atóm	Relatívna hmotnosť
$^{1}\mathrm{H}$	1,007825	$^{29}\mathrm{Si}$	28,976491
$^{2}\mathrm{H}$	2,014102	$^{30}\mathrm{Si}$	29,973761
$^{12}\mathrm{C}$	12,000000	$^{31}\mathrm{P}$	30,973763
$^{13}\mathrm{C}$	13,003354	$^{32}\mathrm{S}$	31,972074
$^{14}\mathrm{N}$	14,003074	$^{33}\mathrm{S}$	32,971460
$^{15}\mathrm{N}$	15,000108	$^{34}\mathrm{S}$	33,967864
$^{16}\mathrm{O}$	15,994915	$^{35}\mathrm{Cl}$	34,968854
$^{17}\mathrm{O}$	16,999133	$^{37}\mathrm{Cl}$	36,965896
$^{18}\mathrm{O}$	17,999160	$^{79}\mathrm{Br}$	78,91835
$^{19}\mathrm{F}$	18,998405	$^{81}\mathrm{Br}$	80,91635
$^{28}\mathrm{Si}$	27,976927	$^{127}\mathrm{I}$	126,90435

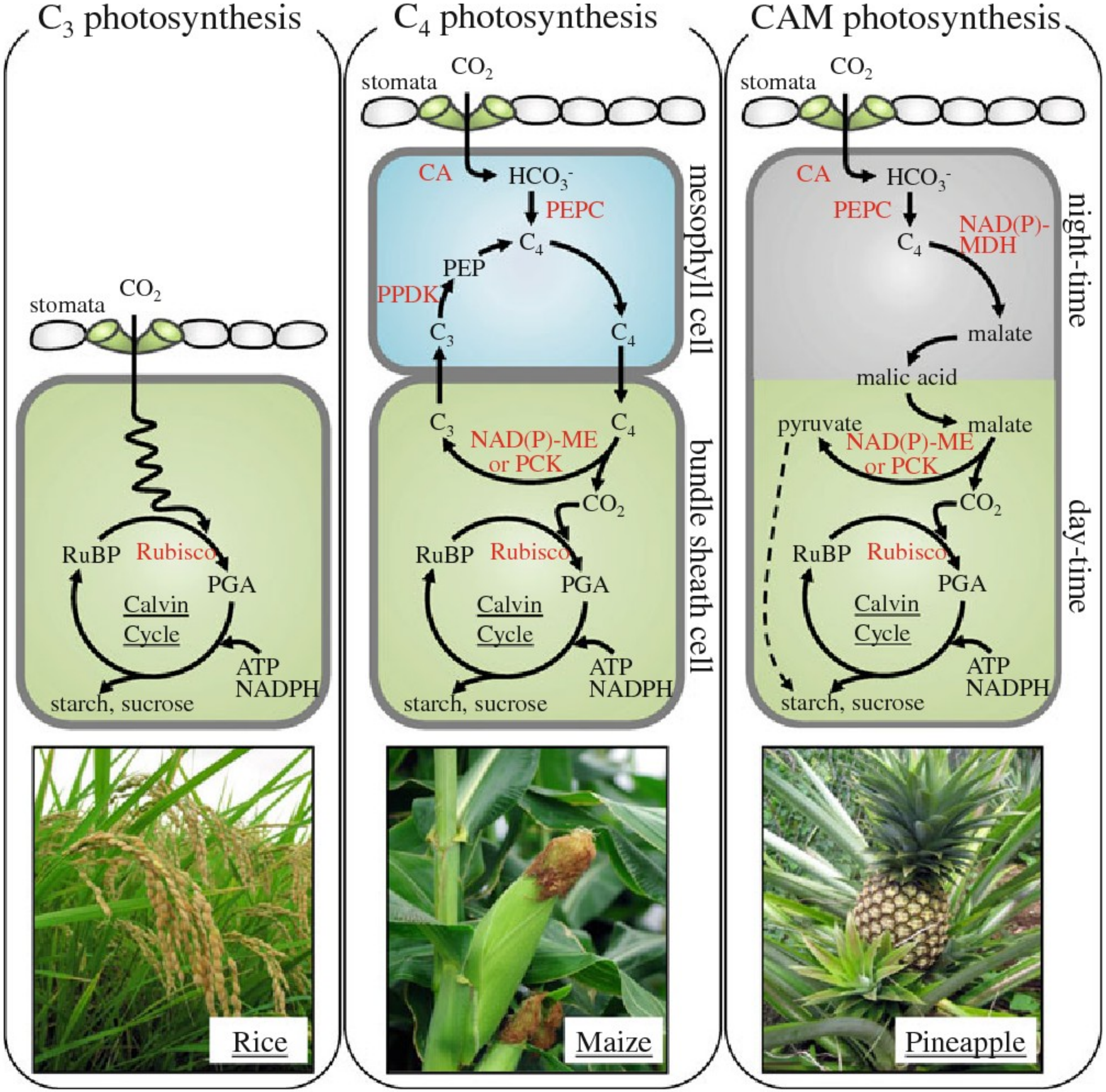
Fotosyntéza

C3 rostliny
ječmen, pšenice, brambory, cukrová řepa,

C4 rostliny
kukuřice, cukrová třtina

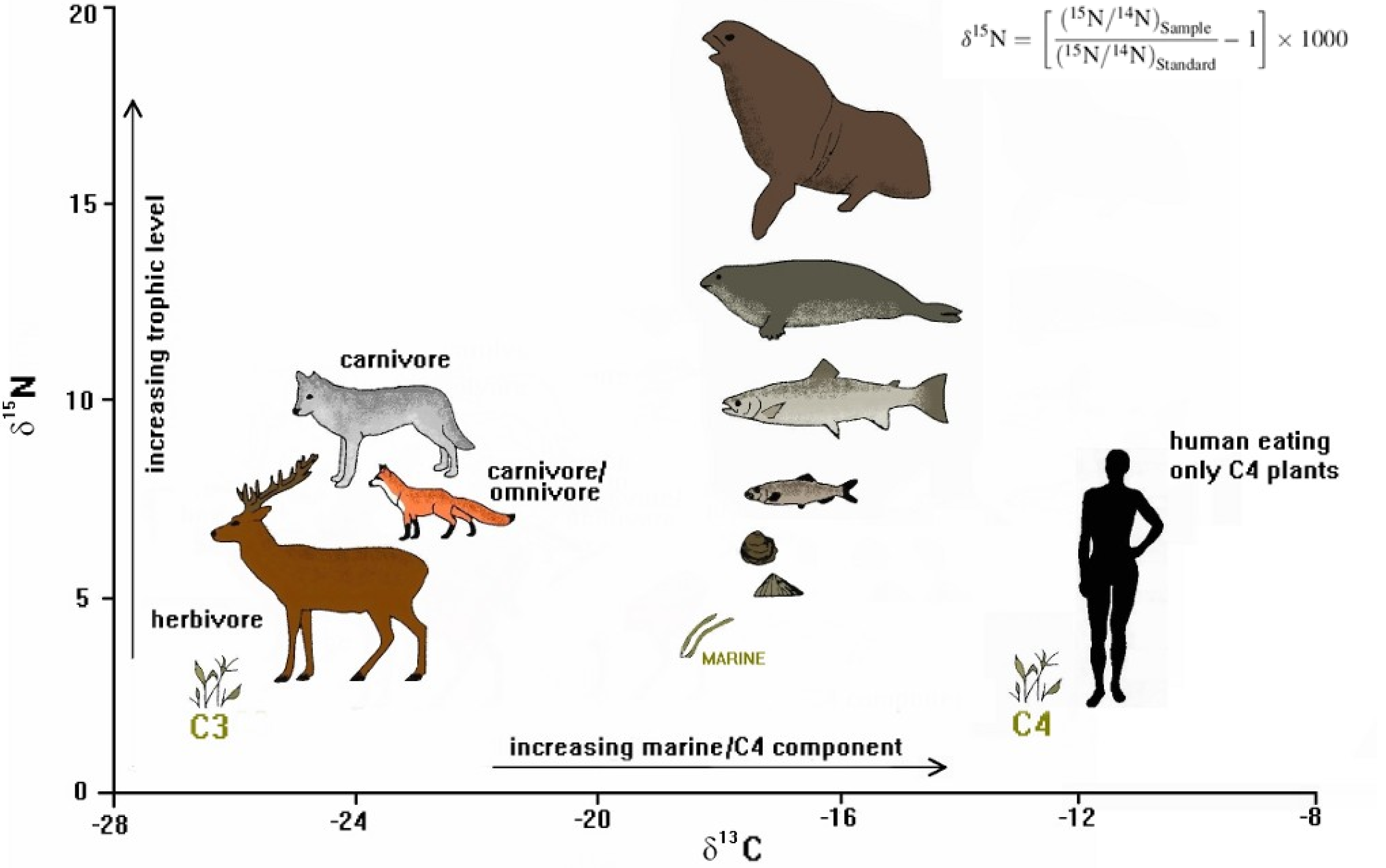
CAM rostliny
ananas, sukulenty

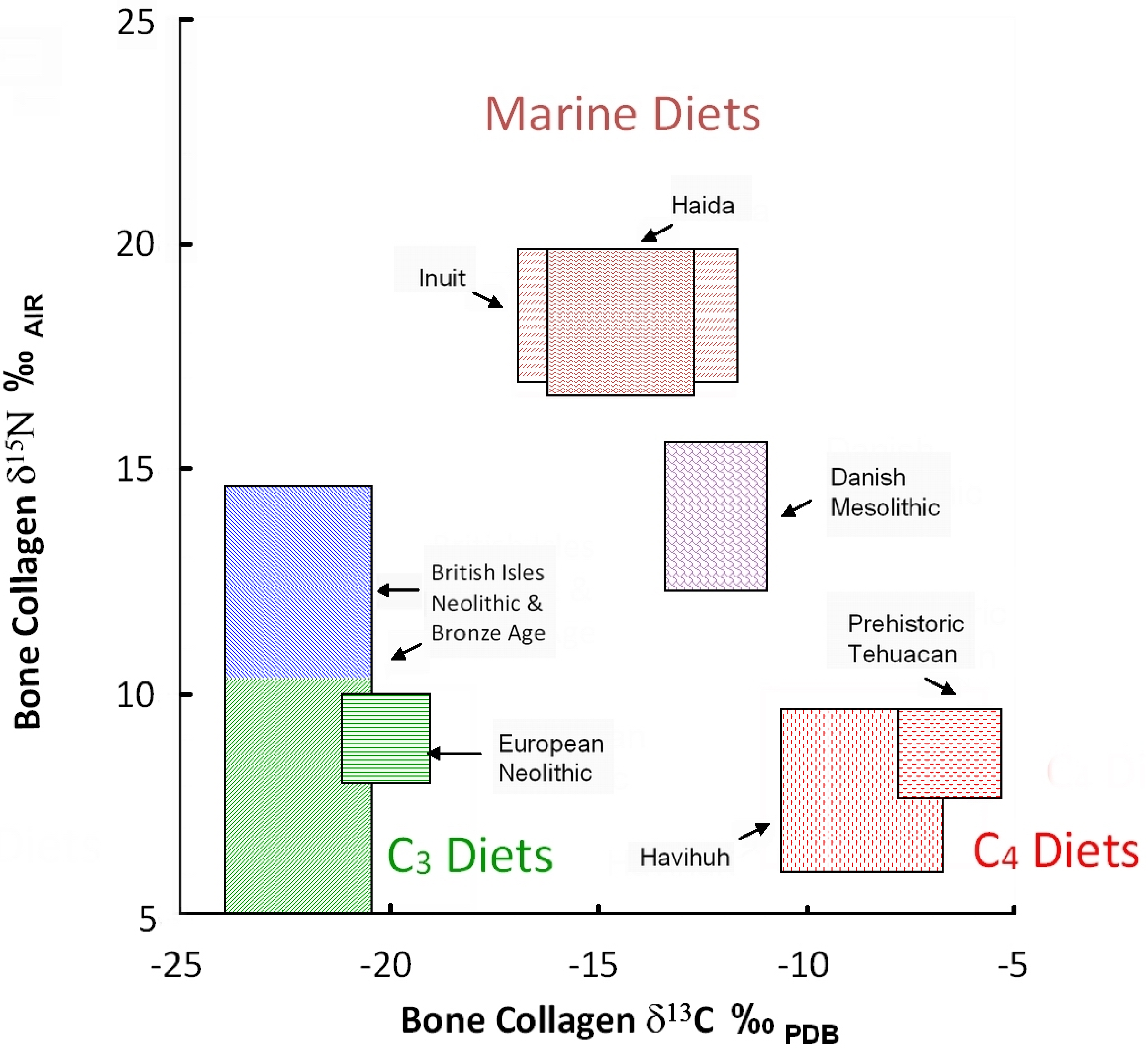




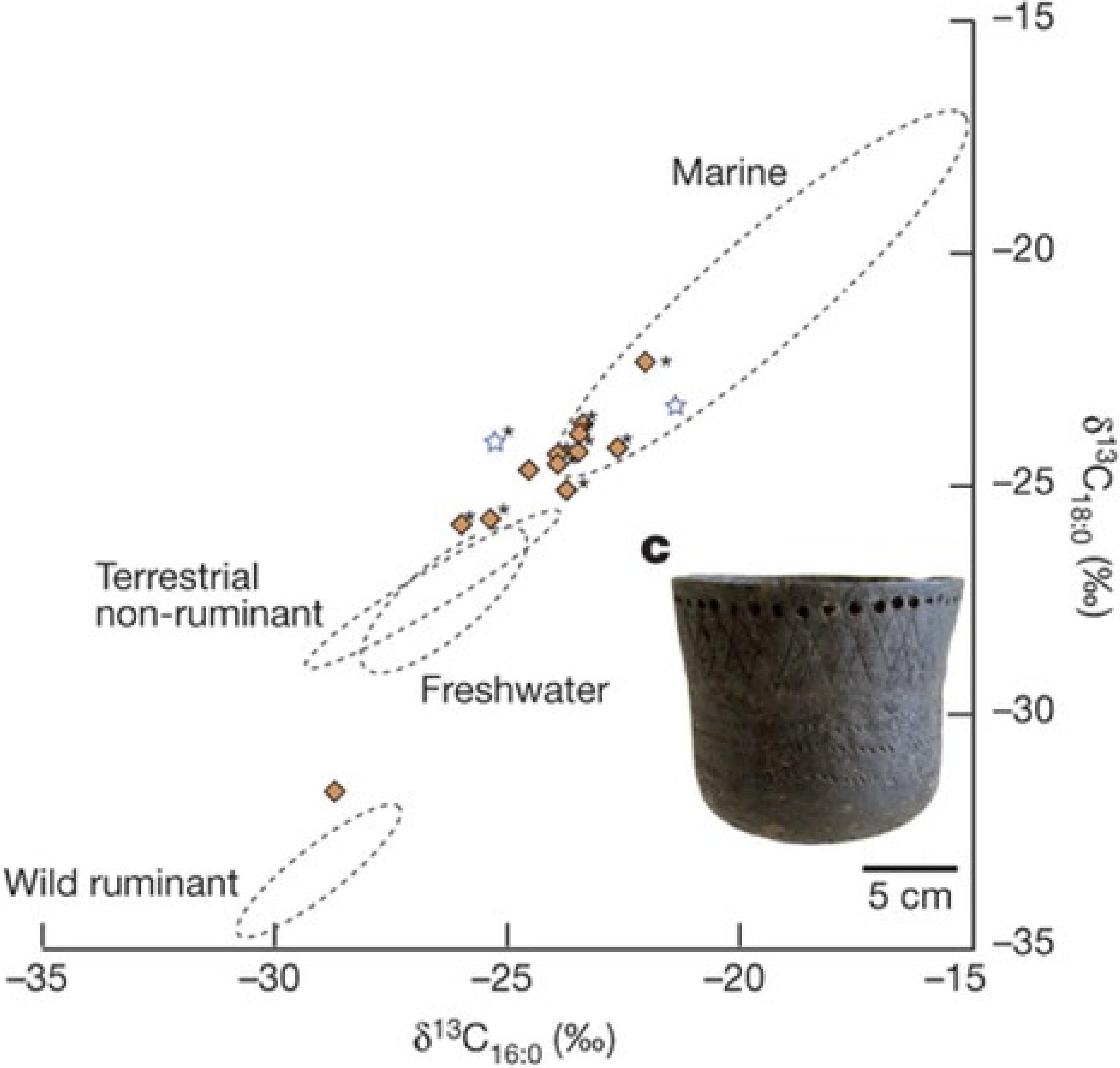
$$\delta^{13}\mathrm{C} = \left[\frac{(^{13}\mathrm{C}/^{12}\mathrm{C})_{\mathrm{Sample}}}{(^{13}\mathrm{C}/^{12}\mathrm{C})_{\mathrm{Standard}}} - 1 \right] \times 1000$$

$$\delta^{15}\mathrm{N} = \left[\frac{(^{15}\mathrm{N}/^{14}\mathrm{N})_{\mathrm{Sample}}}{(^{15}\mathrm{N}/^{14}\mathrm{N})_{\mathrm{Standard}}} - 1 \right] \times 1000$$




Marine Diets
Haida
Inuit
Danish Mesolithic
British Isles Neolithic & Bronze Age
Prehistoric Tehuacan
European Neolithic
C3 Diets
Havihuh
C4 Diets
25
20
15
10
5
-25
-20
-15
-10
-5
Bone Collagen δ15N ‰ AIR
Bone Collagen δ13C ‰ PDB

Izotopy v lipidech



Mléko and mléčné produkty

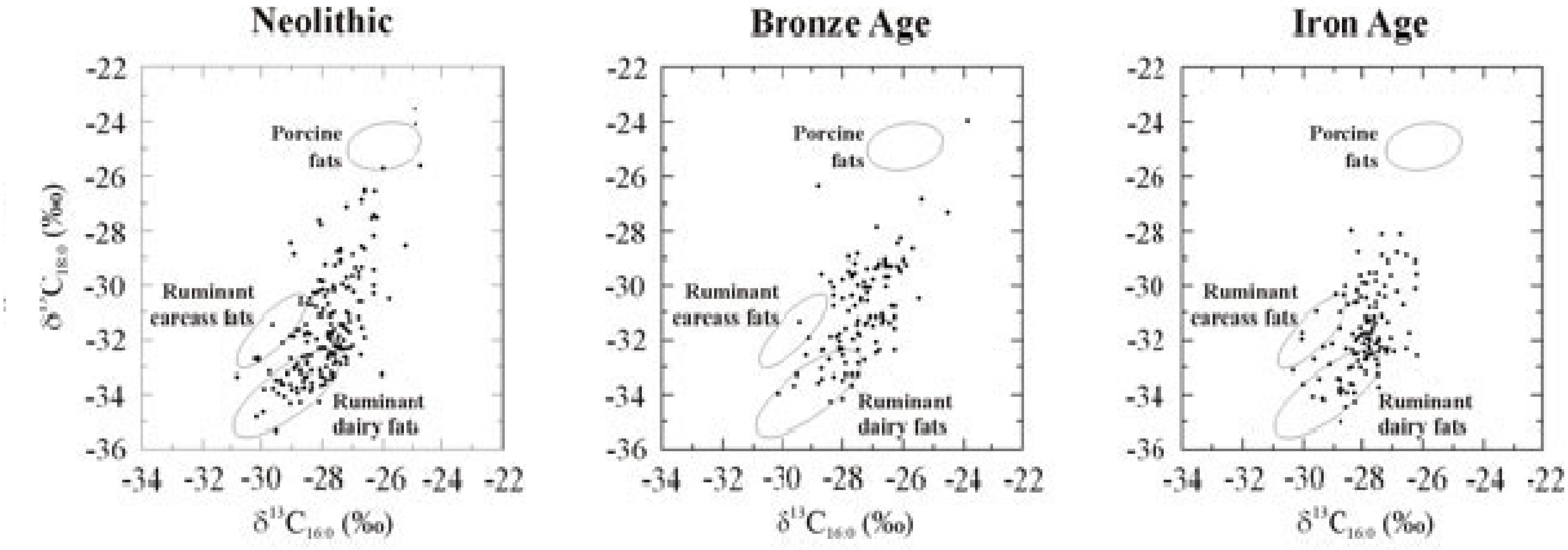
Lipidy

trans-mastné kyseliny (vyšší obsah v extrahovaném tuku)

Proteiny

kasein (termicky degradovaný) – druhově specifický

Keramika

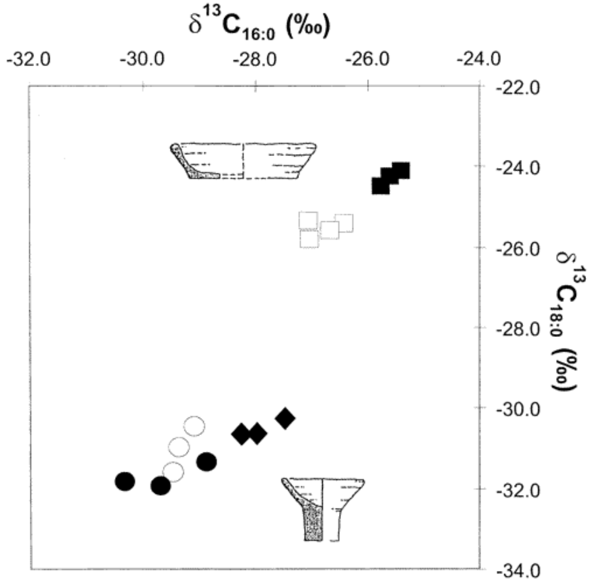


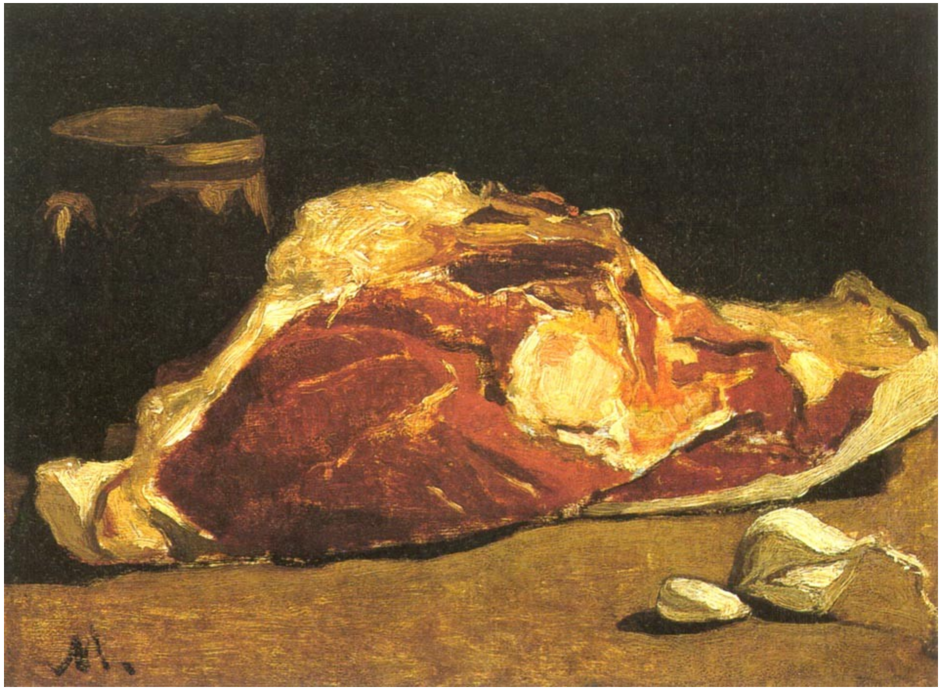
Maso

Keramika
Koprolity

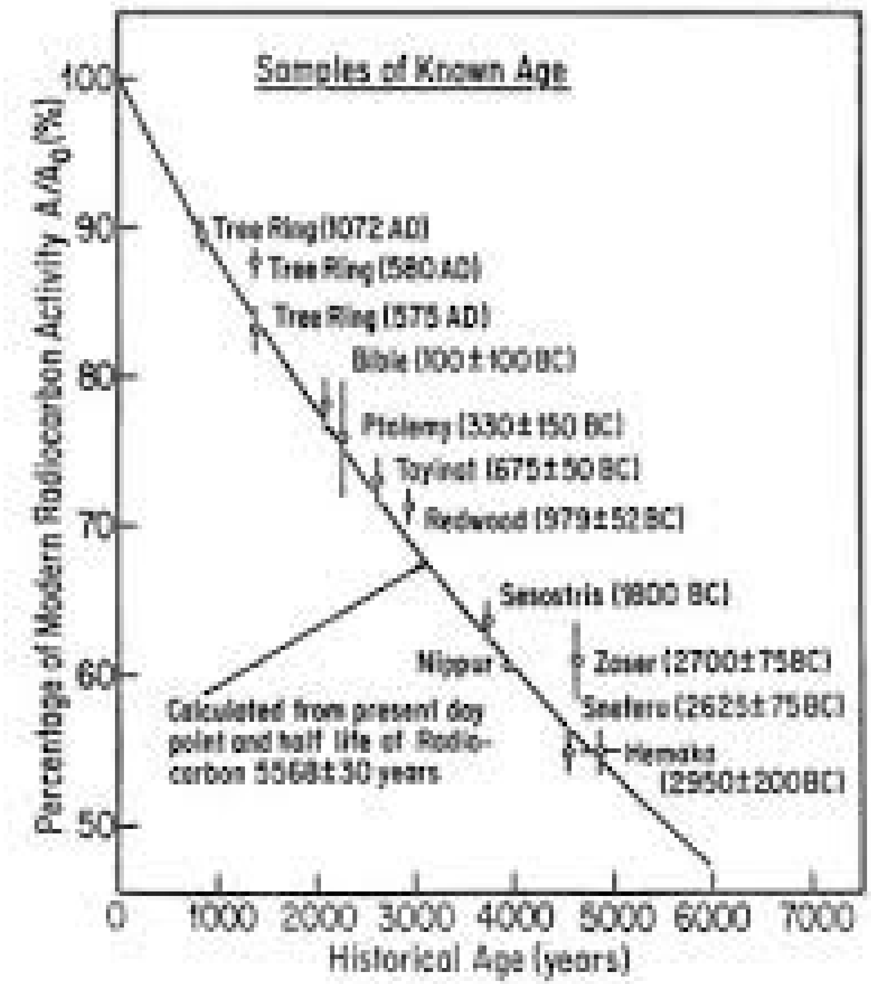
Tuk (nespecifický)

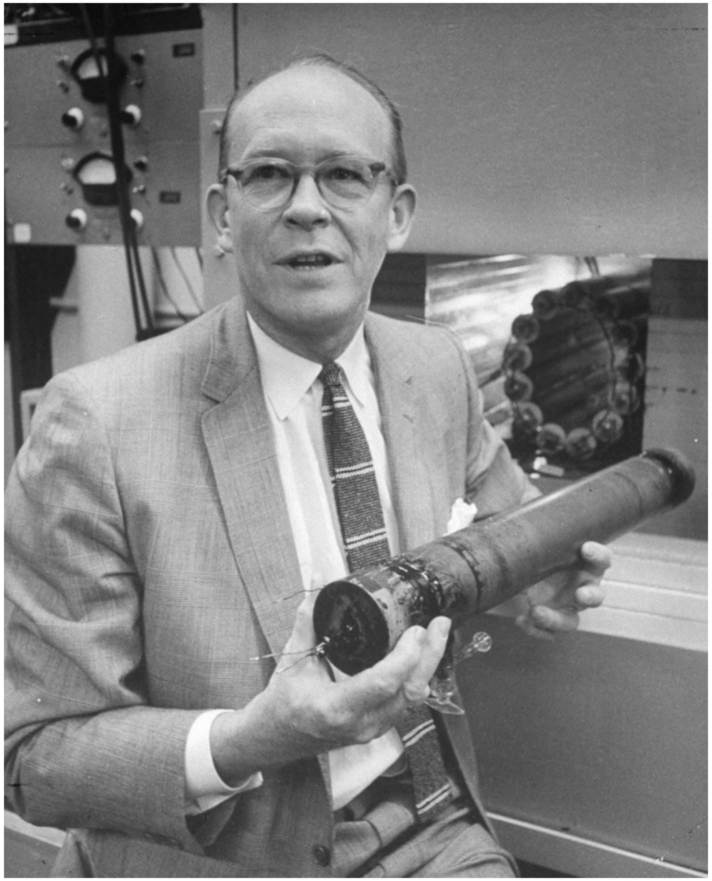
Myoglobin (druhově specifický)





Radiouhlíkové datování



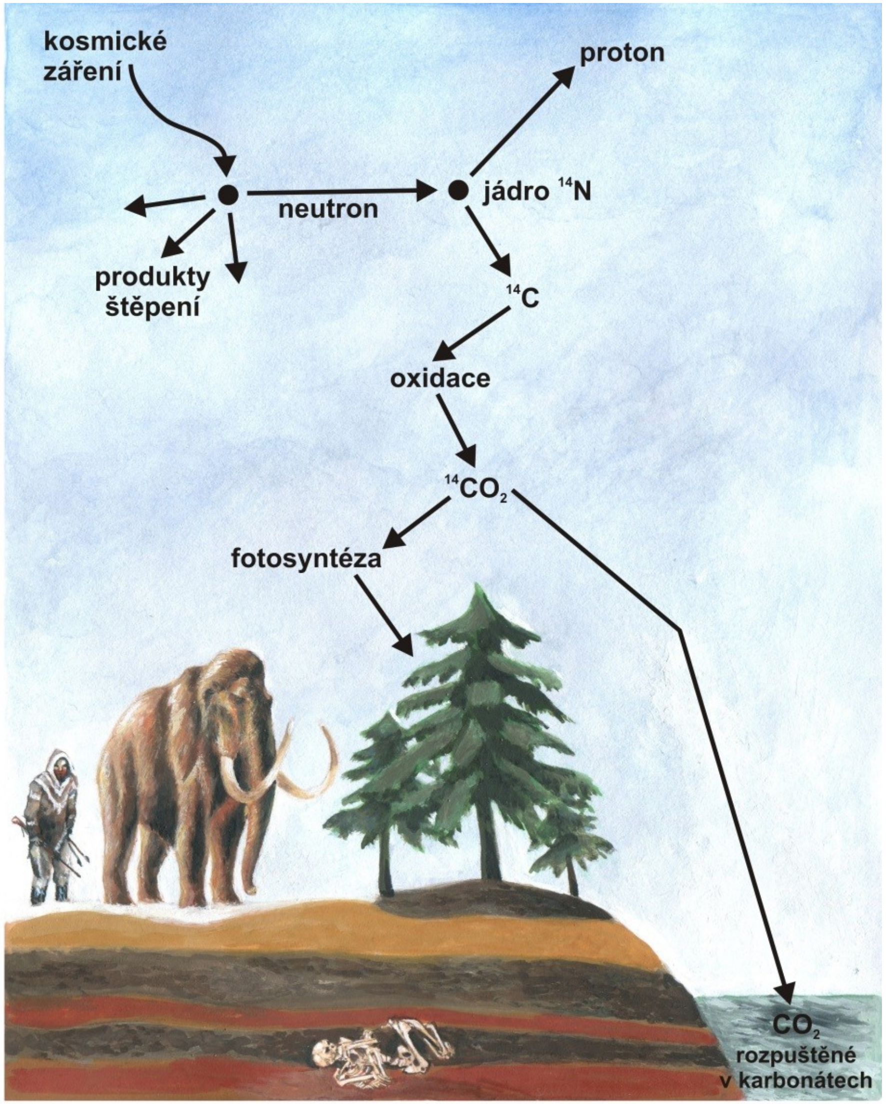


Willard Frank Libby

Alternativni chronologie: datování s využitím izotopu uhlíku ^{14}C
Alternative chronology: dating utilizing carbon isotope ^{14}C

PRODUKCE

DISTRIBUCE



ROZPAD

rovnovážná koncentrace: $\frac{^{14}C}{^{12}C} \approx 10^{-12}$

rozpad: $^{14}C \longrightarrow {}^{14}N + e^- + \nu^-$

poločas rozpadu: 5730 let

1 gram $\longrightarrow$ ~10 rozpadů za minutu

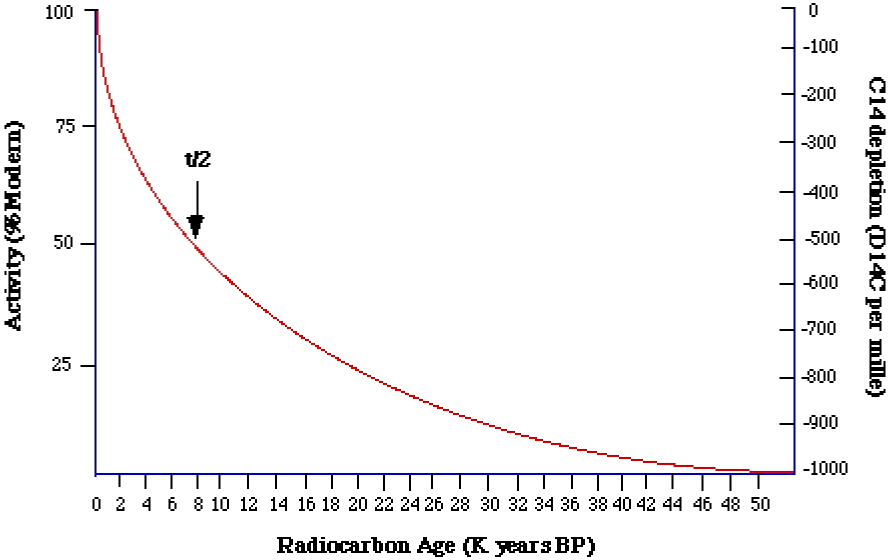
Fyzikální podstata:

Izotop ^{14}C vzniká v horních vrstvách atmosféry;

Odtud přechází do živých organismů a ukládá se v nich po dobu jejich života;

Do flóry vlivem fotosyntézy, do fauny stravou;

Po úmrtí organismu se v něm izotop ^{14}C přestane ukládat a dochází k jeho pozvolnému rozpadu;



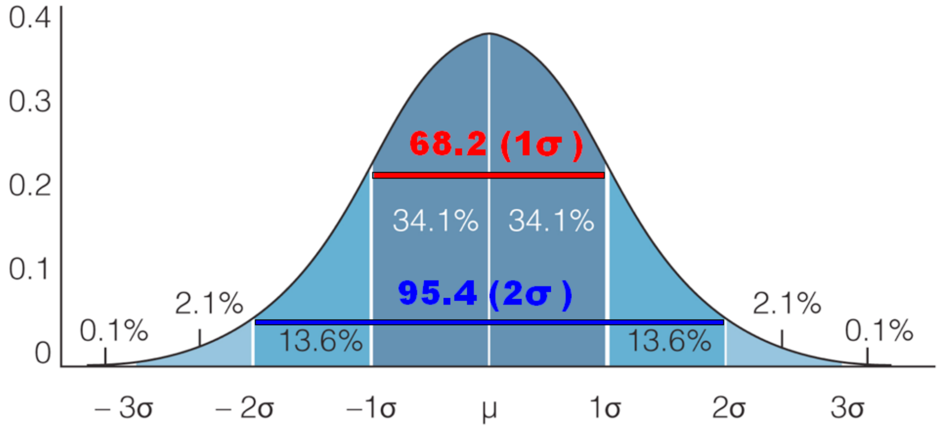
Výsledky měření a problematika kalibrace
Results and calibration issue

Laboratorní výsledek je udáván ve formě **střední hodnota ± směrodatná odchylka** (s předpokladem normálního rozdělení) v radiokarbonových letech (^{14}C BP nebo BC, vztažených k roku 1950);

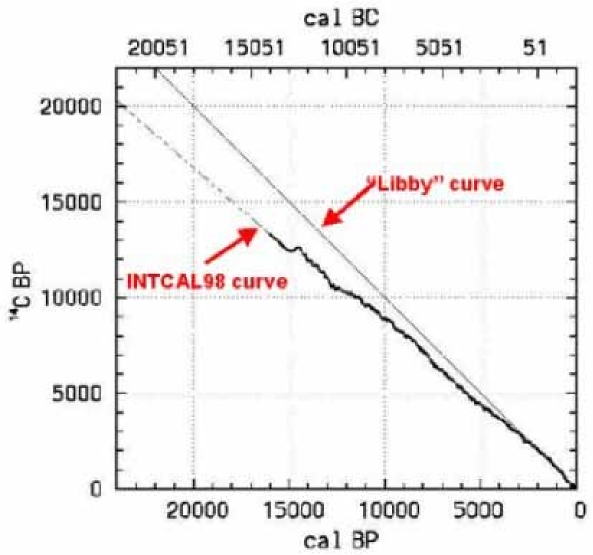
Jelikož radiokarbonové roky se liší od solárních let vlivem nehomogenní distribuce izotopu ^{14}C, je data třeba data kalibrovat. Používají se k tomu kalibrační softwary (CalPal, OxCal, Calib) a kalibrační sety (IntCal04, IntCal09). Pro období neolitu jsou základem kalibrace dendrodata. Výsledky jsou pak udávány v intervalech pravděpodobnosti 1σ (68,2 %) nebo 2σ (95,4 %).

Gauss - Laplaceovo normální rozdělení

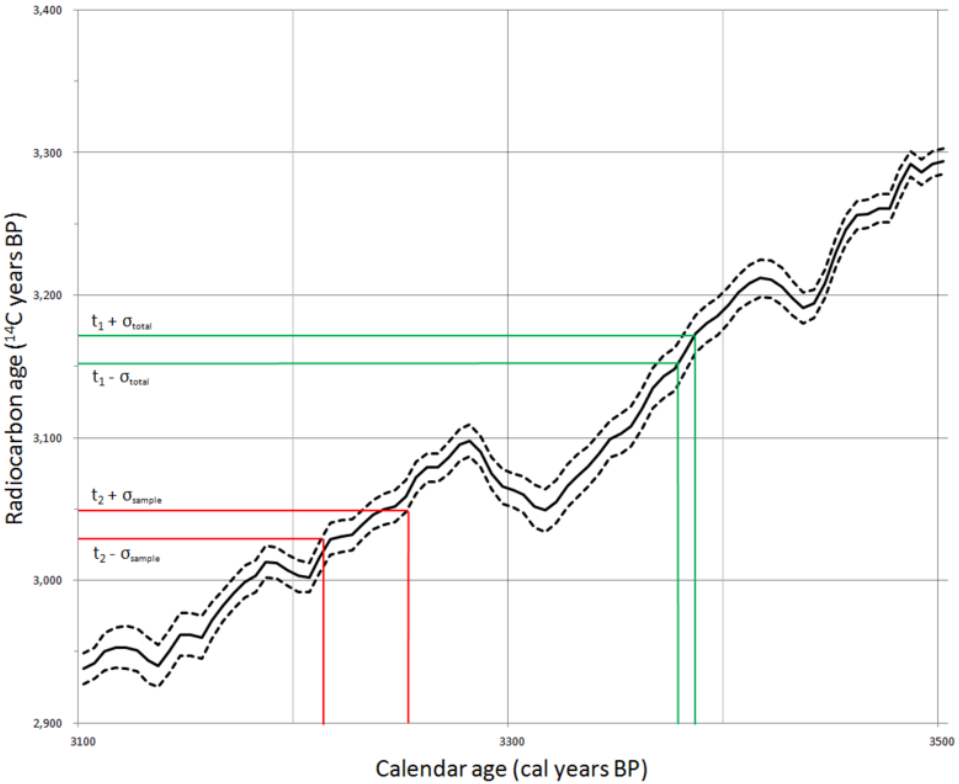
rozptyl pravděpodobnosti



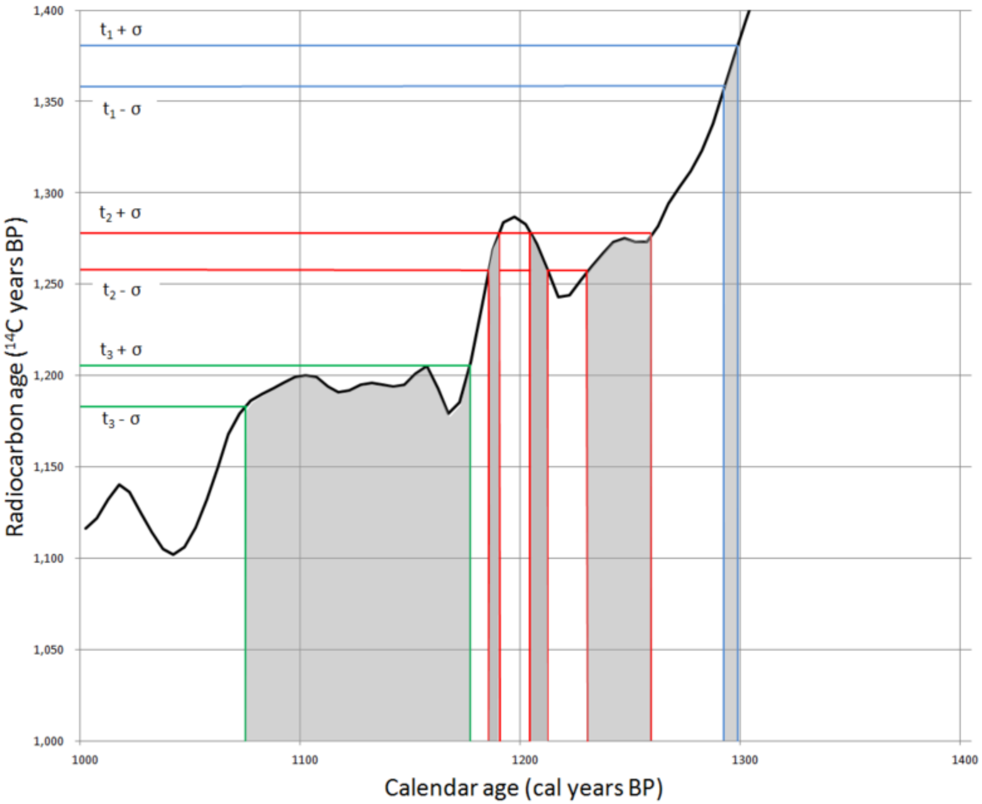
Kalibrace radiouhlíkových dat



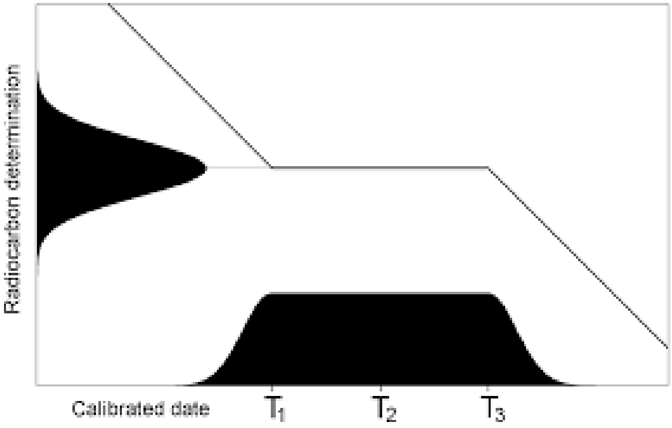
Calibration error and measurement error

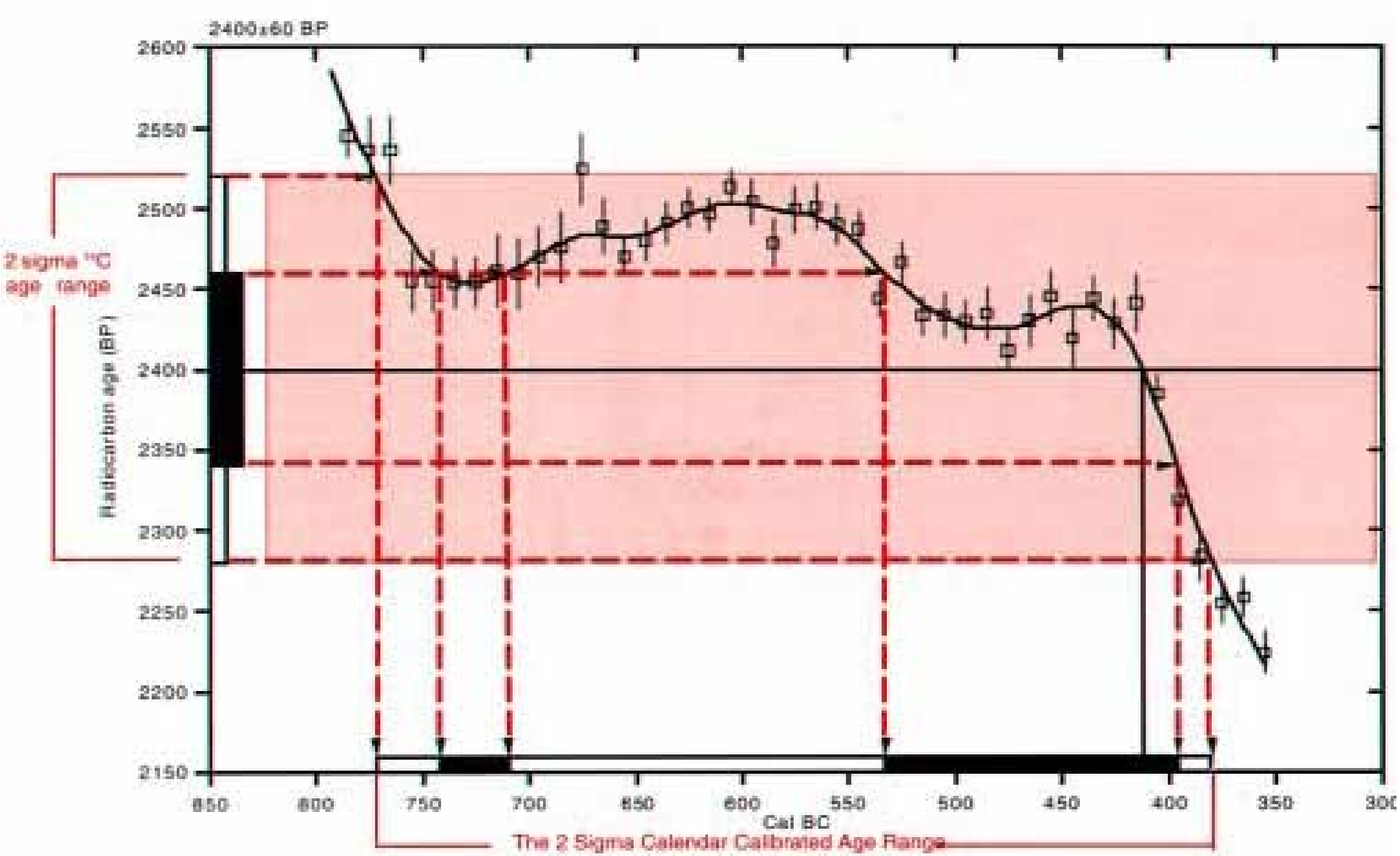


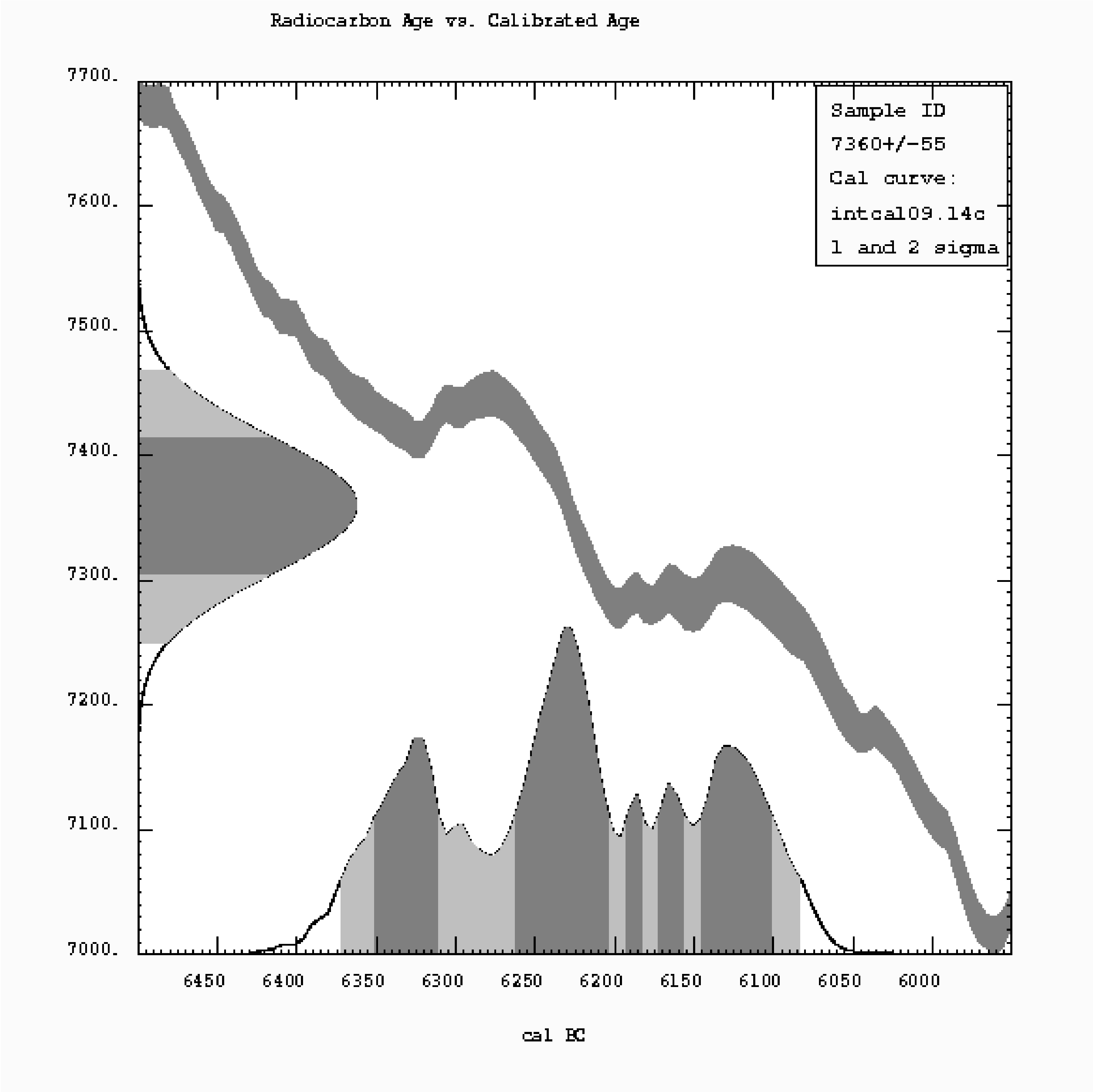
Variations in calibration results



Radiouhlíkové plató

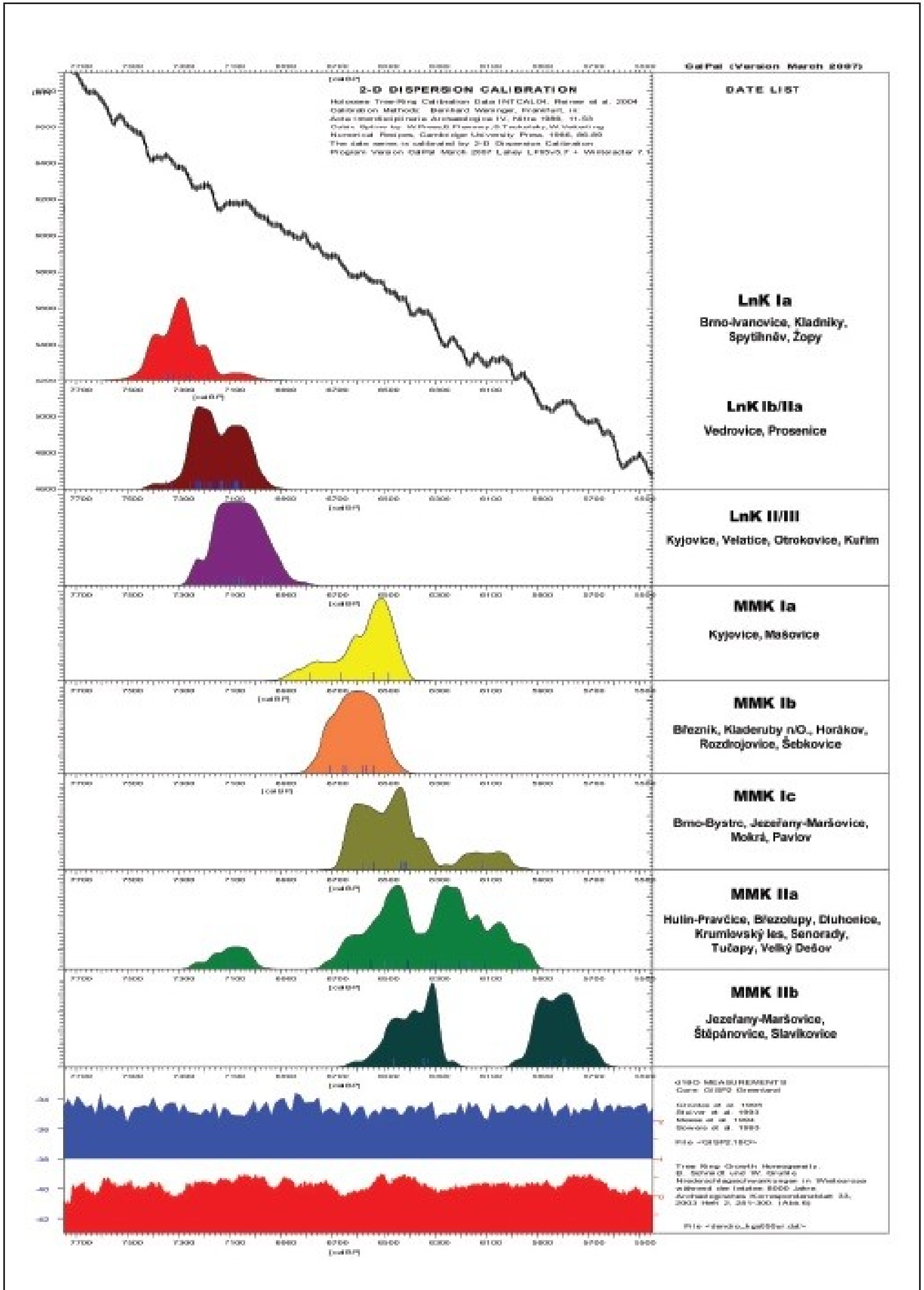





Radiocarbon Age vs. Calibrated Age
7700.
7600.
7500.
7400.
7300.
7200.
7100.
7000.
6450
6400
6350
6300
6250
6200
6150
6100
6050
6000
cal BC
Sample ID
7360+/-55
Cal curve:
intcal09.14c
1 and 2 sigma

Chronologie moravského neolitu

The chronology of the Moravian Neolithic

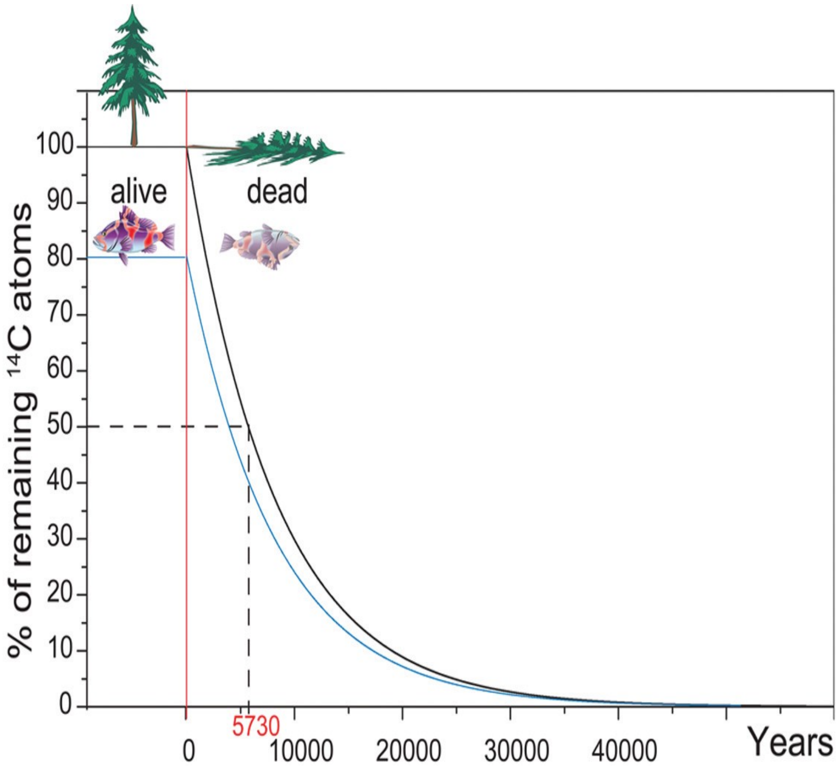


„Old wood“ problem

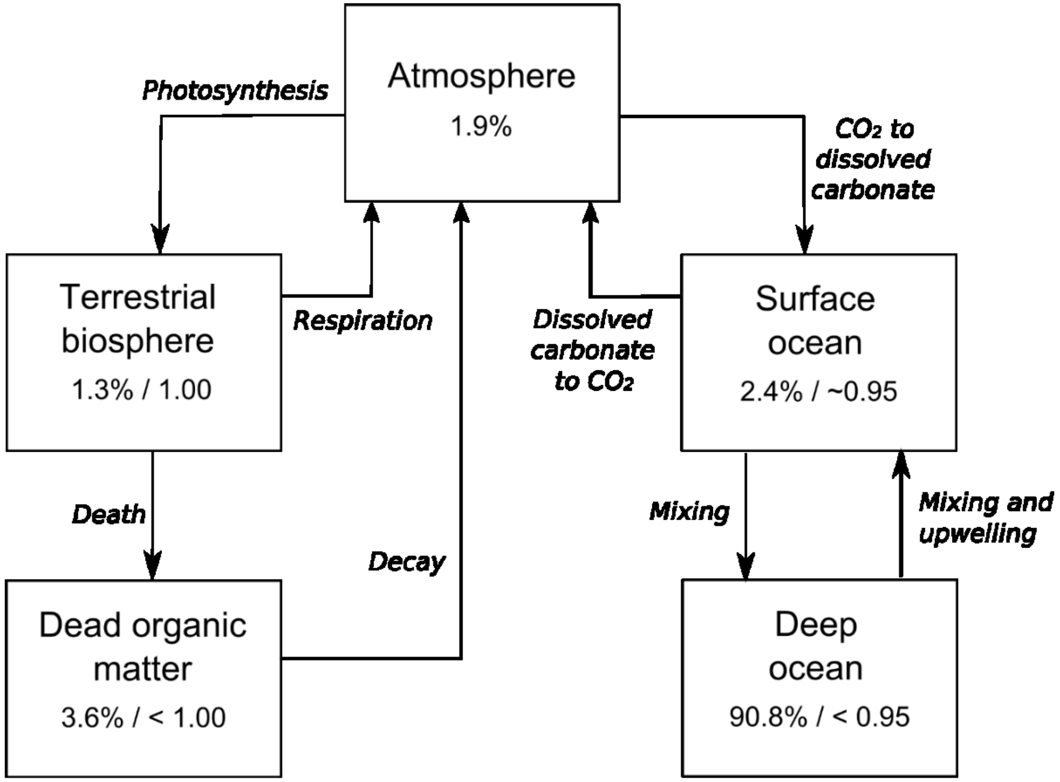
Materiál je mnohem starší než je doba jeho utilizace člověkem.

- dlouhověké dřeviny
- lidské pozůstatky
- lastury

Rezervoárový efekt



Carbon exchange reservoirs (simplified)


Atmosphere
1.9%

Photosynthesis

CO₂ to dissolved carbonate

Terrestrial biosphere
1.3% / 1.00

Respiration

Dissolved carbonate to CO₂

Surface ocean
2.4% / ~0.95

Death

Decay

Mixing

Mixing and upwelling

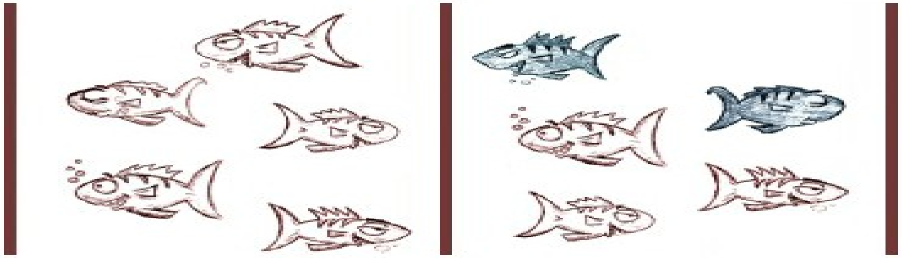
Dead organic matter
3.6% / < 1.00

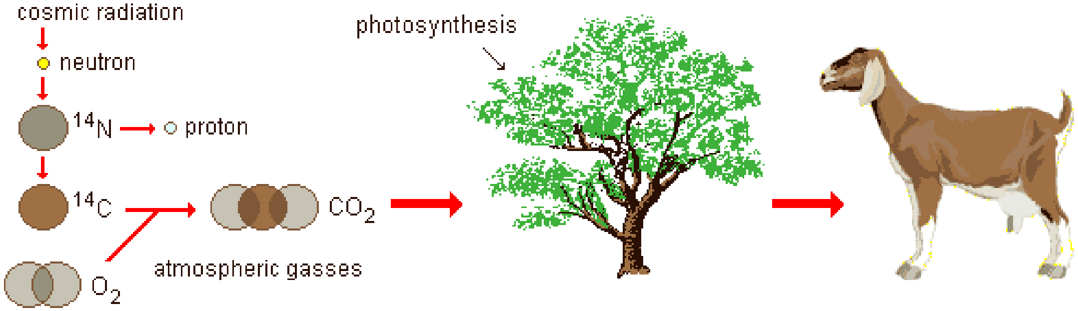
Deep ocean
90.8% / < 0.95

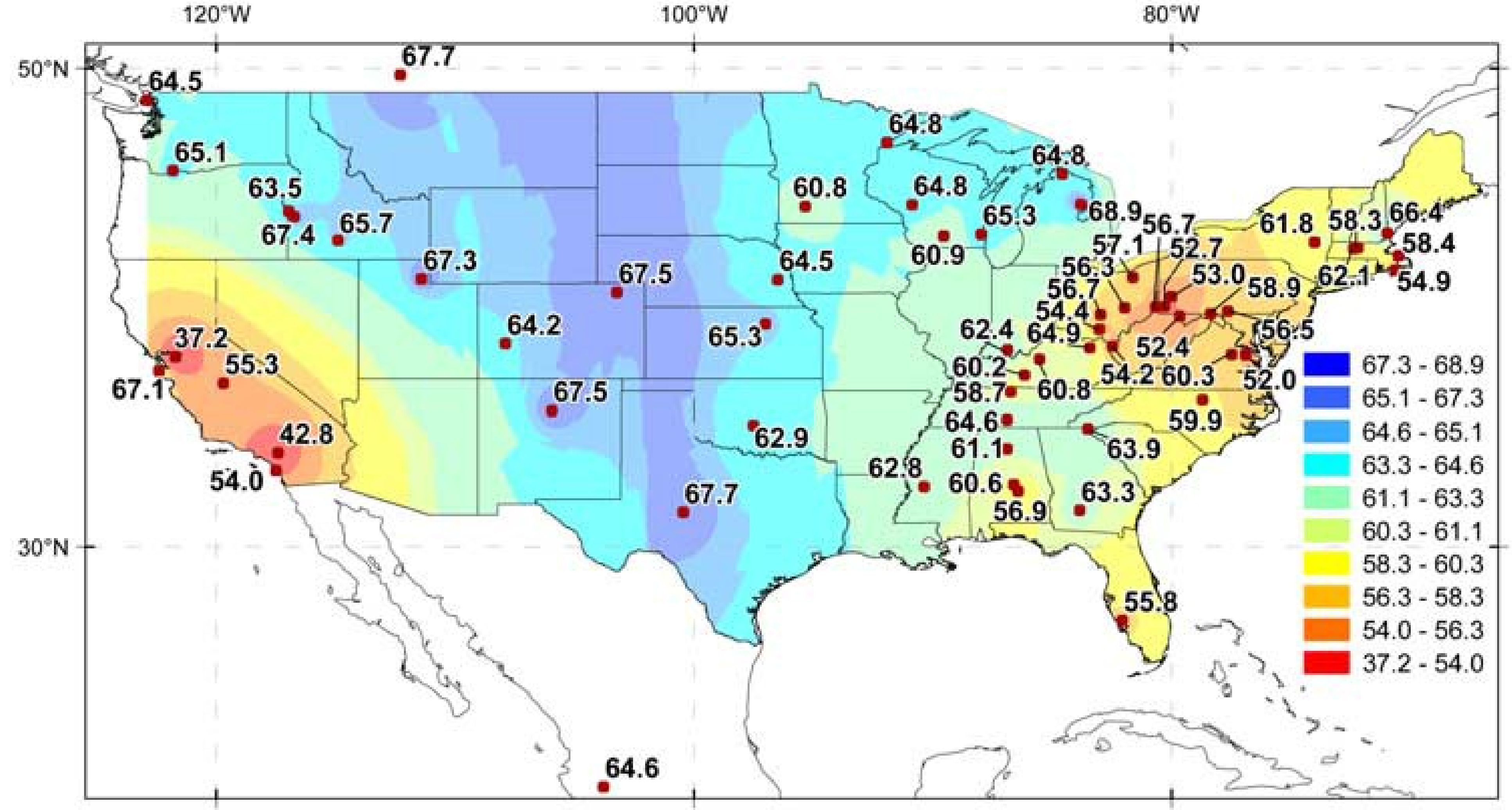
Percentages show the fraction of the total carbon reservoir of each type.
Numbers after slash show ratio of $_{14}$C to $_{12}$C as fraction of atmospheric ratio.

Fosilní paliva

Fosilní paliva neobsahují žádný radiouhlík, exhalacemi CO2 z jejich spalování dochází ke snižování relativního zastoupení radiouhlíku v atmosféře a vegetaci.

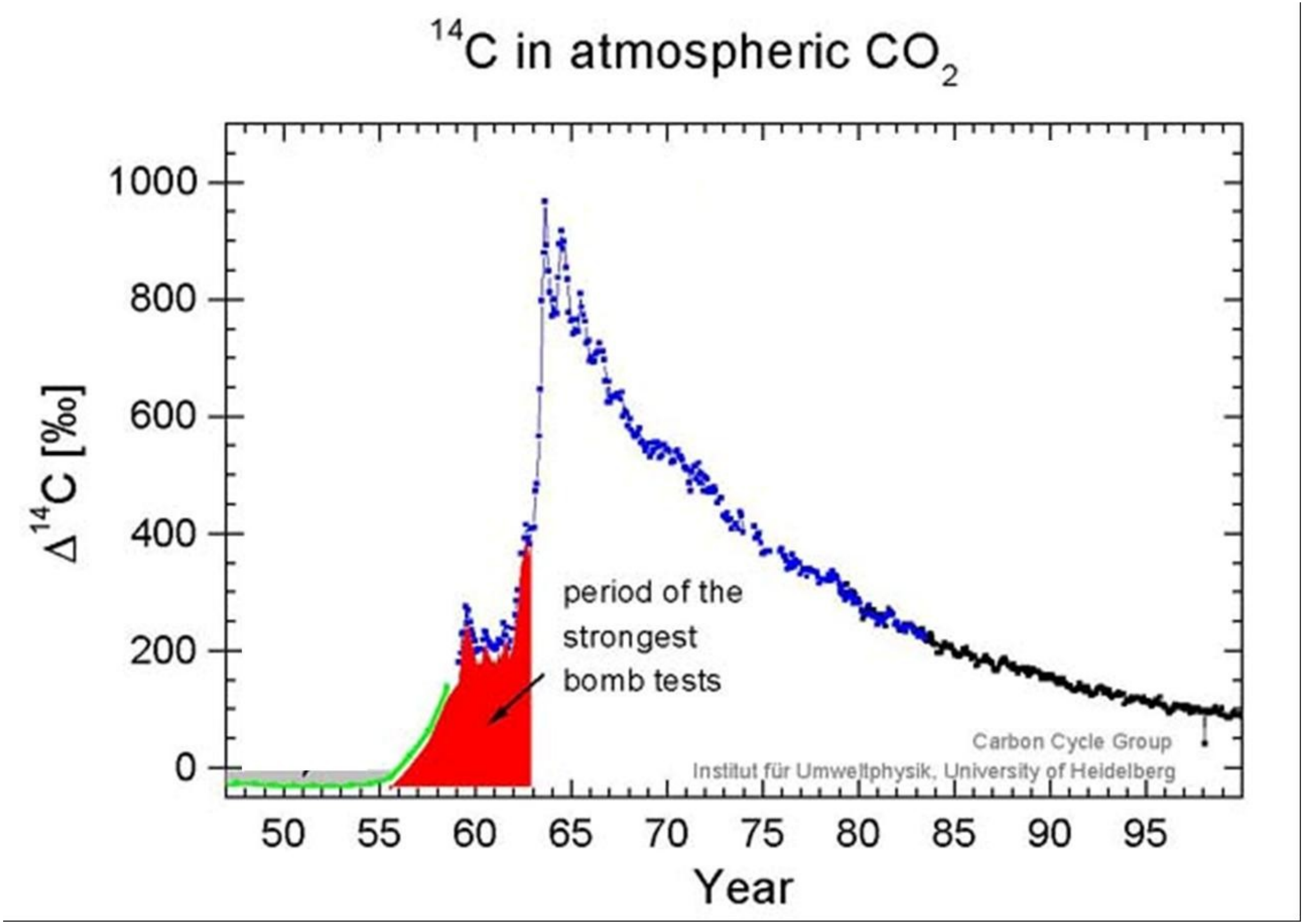




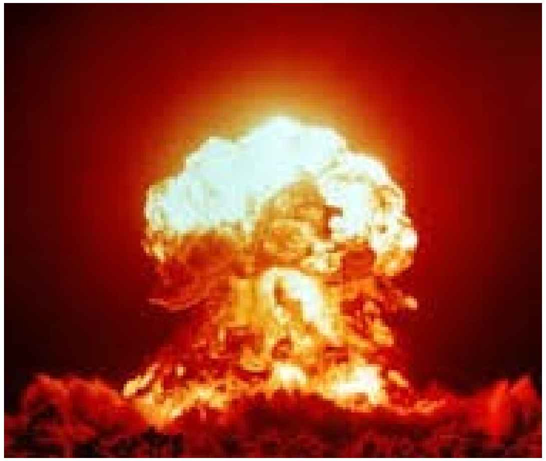


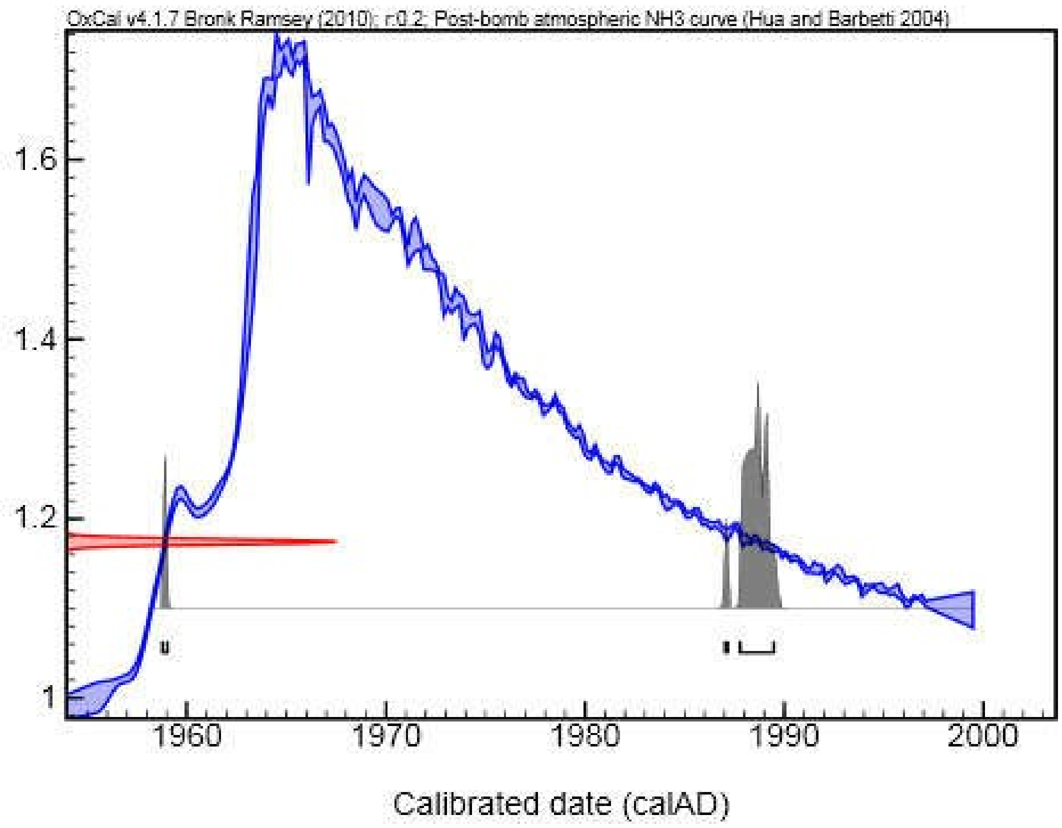
D14C measurements of corn (Zea mays) across North America during the summer of 2004 (in units of %). During this period, a decrease of 2.8% corresponded to approximately 1 ppm of added fossil fuel CO2.

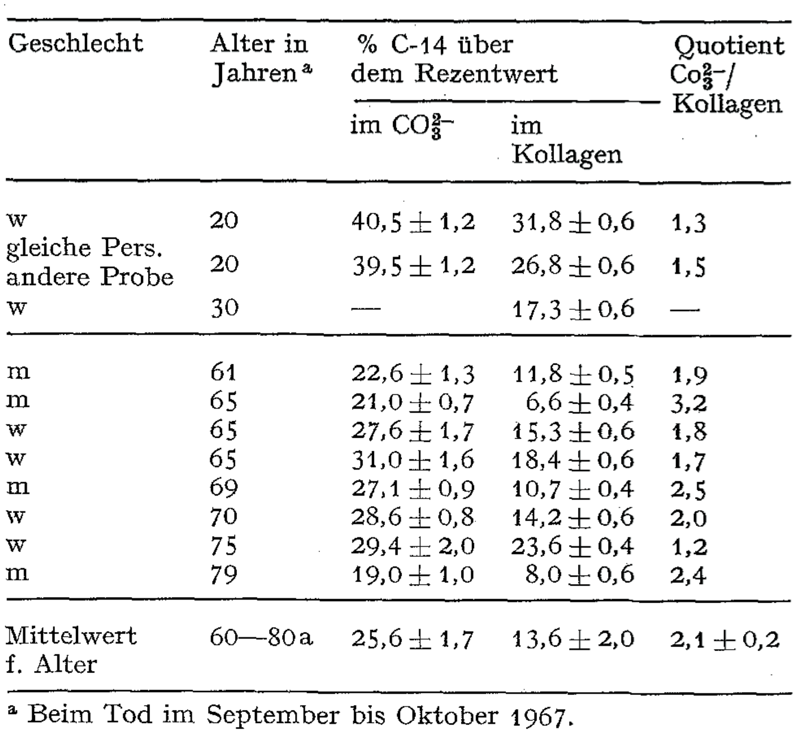
Bomb peak (bomb spike)



Bomb peak
(Bomb spike)







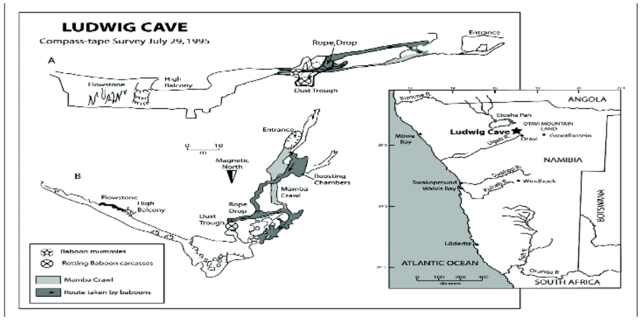
Geschlecht	Alter in Jahren[a]	% C-14 über dem Rezentwert im CO_3^{2-}	% C-14 über dem Rezentwert im Kollagen	Quotient CO_3^{2-}/ Kollagen
w	20	40,5 ± 1,2	31,8 ± 0,6	1,3
gleiche Pers. andere Probe	20	39,5 ± 1,2	26,8 ± 0,6	1,5
w	30	—	17,3 ± 0,6	—
m	61	22,6 ± 1,3	11,8 ± 0,5	1,9
m	65	21,0 ± 0,7	6,6 ± 0,4	3,2
w	65	27,6 ± 1,7	15,3 ± 0,6	1,8
w	65	31,0 ± 1,6	18,4 ± 0,6	1,7
m	69	27,1 ± 0,9	10,7 ± 0,4	2,5
w	70	28,6 ± 0,8	14,2 ± 0,6	2,0
w	75	29,4 ± 2,0	23,6 ± 0,4	1,2
m	79	19,0 ± 1,0	8,0 ± 0,6	2,4
Mittelwert f. Alter	60—80 a	25,6 ± 1,7	13,6 ± 2,0	2,1 ± 0,2

[a] Beim Tod im September bis Oktober 1967.

Ludwig Cave (Namibia)

Material	Laboratory ID	Fractionation-corrected pMC	δ13C (‰ PDB)
Bone collagen	UGAMS-0022	130.9 ± 0.4	-19.5 ± 0.1
Bone collagen	UGAMS-0022B	132.1 ± 0.7	-19.5 ± 0.1
Tendon	UGAMS-0112	136.4 ± 0.7	-19.4 ± 0.1
Skin	UGAMS-132	135.1 ± 0.7	-19.6 ± 0.1

Table 2. Percentage of modern carbon in bone, tendon, and skin from a mummified adult female baboon in Ludwig Cave, Namibia



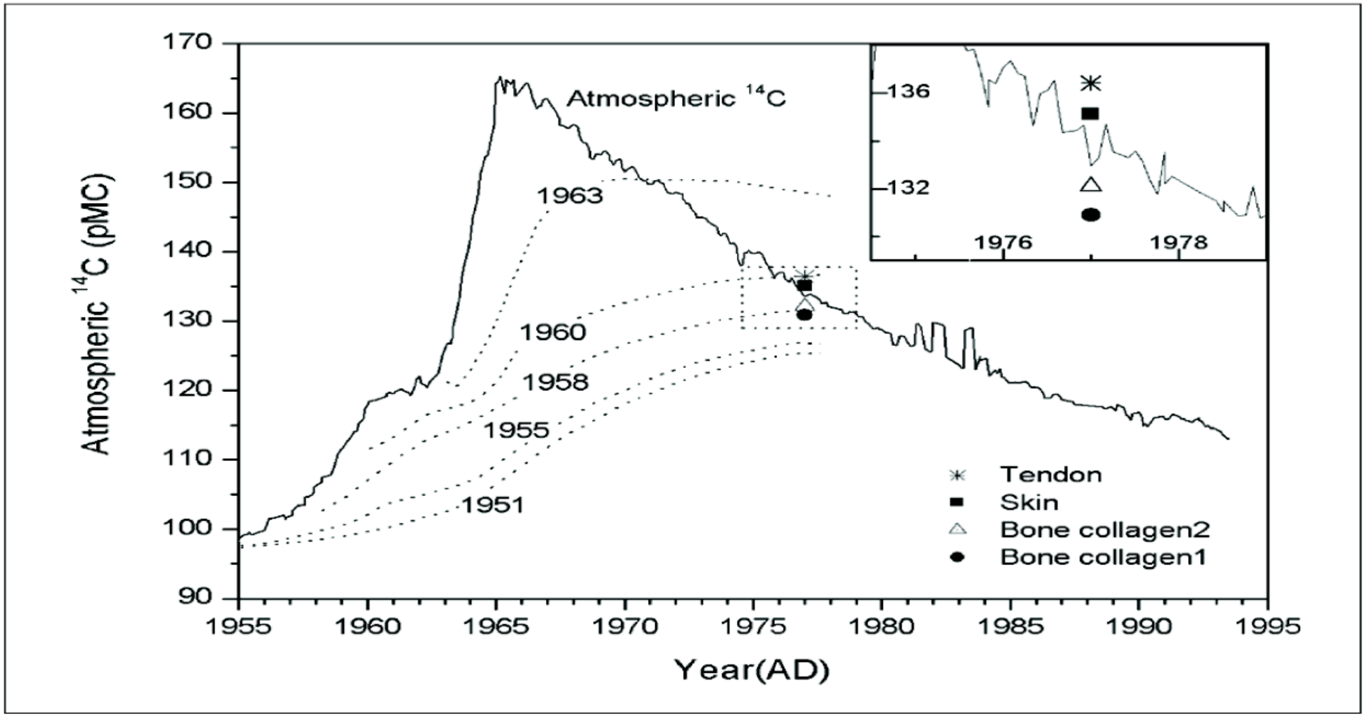
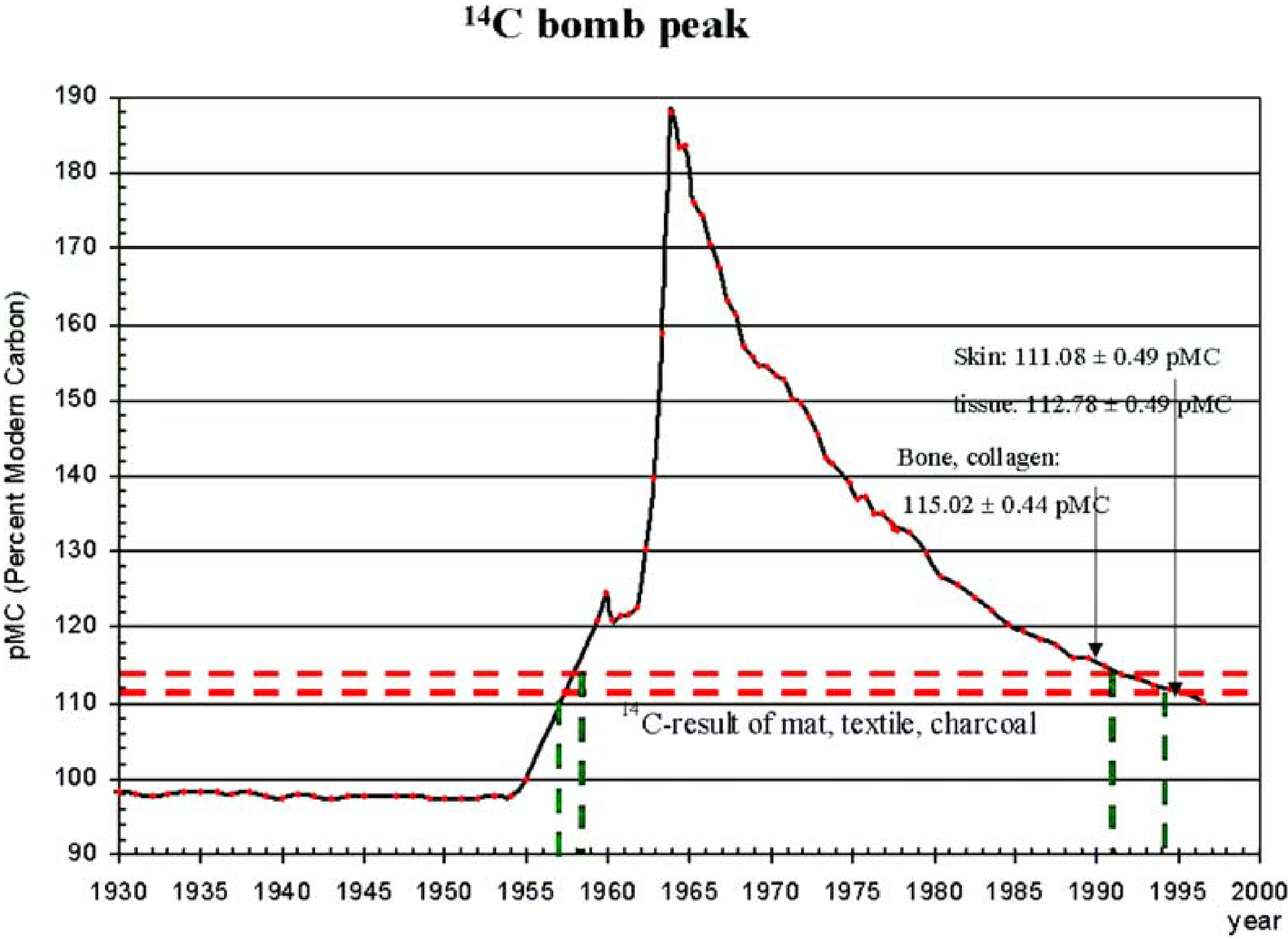


Fig. 3. Modeling changes in bone collagen radiocarbon content for different birth years based on atmospheric ^{14}C levels for the Southern Hemisphere 1955-1994. The ^{14}C data have been plotted as a 3 point running average of measurements made in Wellington, New Zealand and published in Manning et al. 1990, and Manning & Melhuish 1994. The bone, tendon, and skin ^{14}C measurements are plotted on the curve. The Y error bars are contained within the symbols used. Models assume that the adult female baboon died in 1977. The best model suggests that the baboon was born in 1958, indicating an age at death of 19 years.

Perská mumie

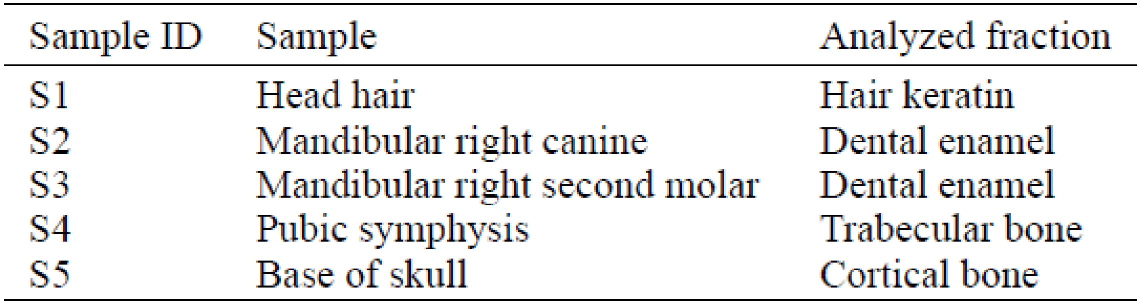


Konfiskována 2000 na černém trhu, podle nápisů by se mělo jednat o Ruduunu, dceru krále Xerxa (518-465 BC).

Jedinec zemřel AD 1994–1996, mumie je podvrh.

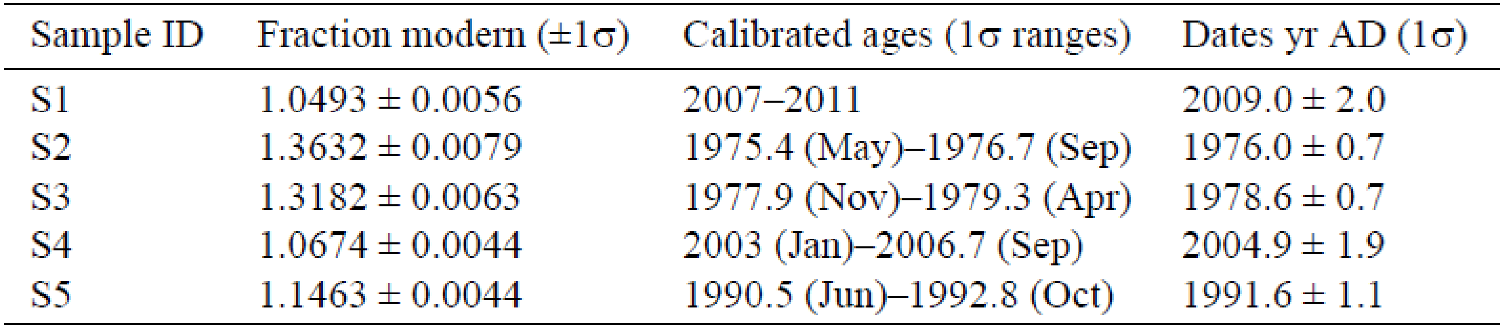
Male, 36 y
1973-2010

Table 1 Summary of the selected samples.



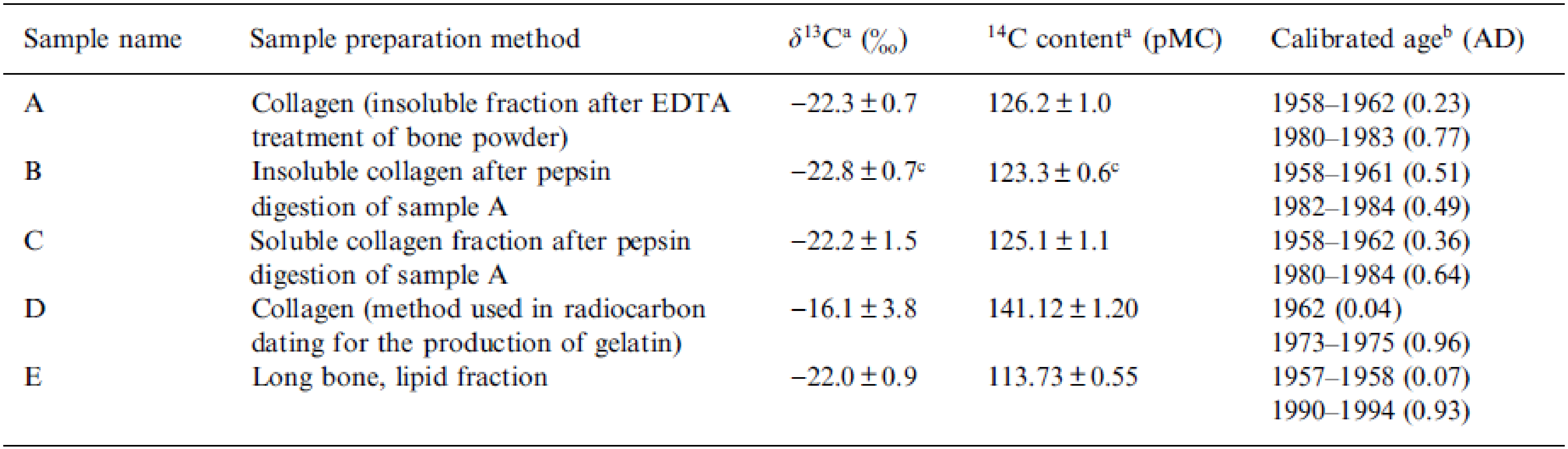
Sample ID	Sample	Analyzed fraction
S1	Head hair	Hair keratin
S2	Mandibular right canine	Dental enamel
S3	Mandibular right second molar	Dental enamel
S4	Pubic symphysis	Trabecular bone
S5	Base of skull	Cortical bone

Table 2 Results of AMS ^{14}C dating analyses.



Sample ID	Fraction modern (±1σ)	Calibrated ages (1σ ranges)	Dates yr AD (1σ)
S1	1.0493 ± 0.0056	2007–2011	2009.0 ± 2.0
S2	1.3632 ± 0.0079	1975.4 (May)–1976.7 (Sep)	1976.0 ± 0.7
S3	1.3182 ± 0.0063	1977.9 (Nov)–1979.3 (Apr)	1978.6 ± 0.7
S4	1.0674 ± 0.0044	2003 (Jan)–2006.7 (Sep)	2004.9 ± 1.9
S5	1.1463 ± 0.0044	1990.5 (Jun)–1992.8 (Oct)	1991.6 ± 1.1

Summary of the first radiocarbon results from collagen fractions extracted from human bone (30-year old man, deceased in 1995) with the soft chemical method displayed in Fig. 2



Sample name	Sample preparation method	$\delta^{13}C^{a}$ (‰)	^{14}C content^{a} (pMC)	Calibrated age^{b} (AD)
A	Collagen (insoluble fraction after EDTA treatment of bone powder)	−22.3 ± 0.7	126.2 ± 1.0	1958–1962 (0.23) 1980–1983 (0.77)
B	Insoluble collagen after pepsin digestion of sample A	−22.8 ± 0.7^{c}	123.3 ± 0.6^{c}	1958–1961 (0.51) 1982–1984 (0.49)
C	Soluble collagen fraction after pepsin digestion of sample A	−22.2 ± 1.5	125.1 ± 1.1	1958–1962 (0.36) 1980–1984 (0.64)
D	Collagen (method used in radiocarbon dating for the production of gelatin)	−16.1 ± 3.8	141.12 ± 1.20	1962 (0.04) 1973–1975 (0.96)
E	Long bone, lipid fraction	−22.0 ± 0.9	113.73 ± 0.55	1957–1958 (0.07) 1990–1994 (0.93)

	Raw ^{14}C data		Calibrated results (calendar year)				Police Invest.
	Lens	Nail	Lens	Nail	Span	Combined	
Baby #1	1.054(5)	1.078(4)	2006	2000–2004	2000	2003–2007	2004
Baby #2	1.165(5)	1.186(4)	1988–1990	1985–1988	1985–1990	1986–1988	1988
Baby #3	1.185(4)	1.194(4)	1986–1988	1985–1987	1985–1989	1985–1987	n.d.

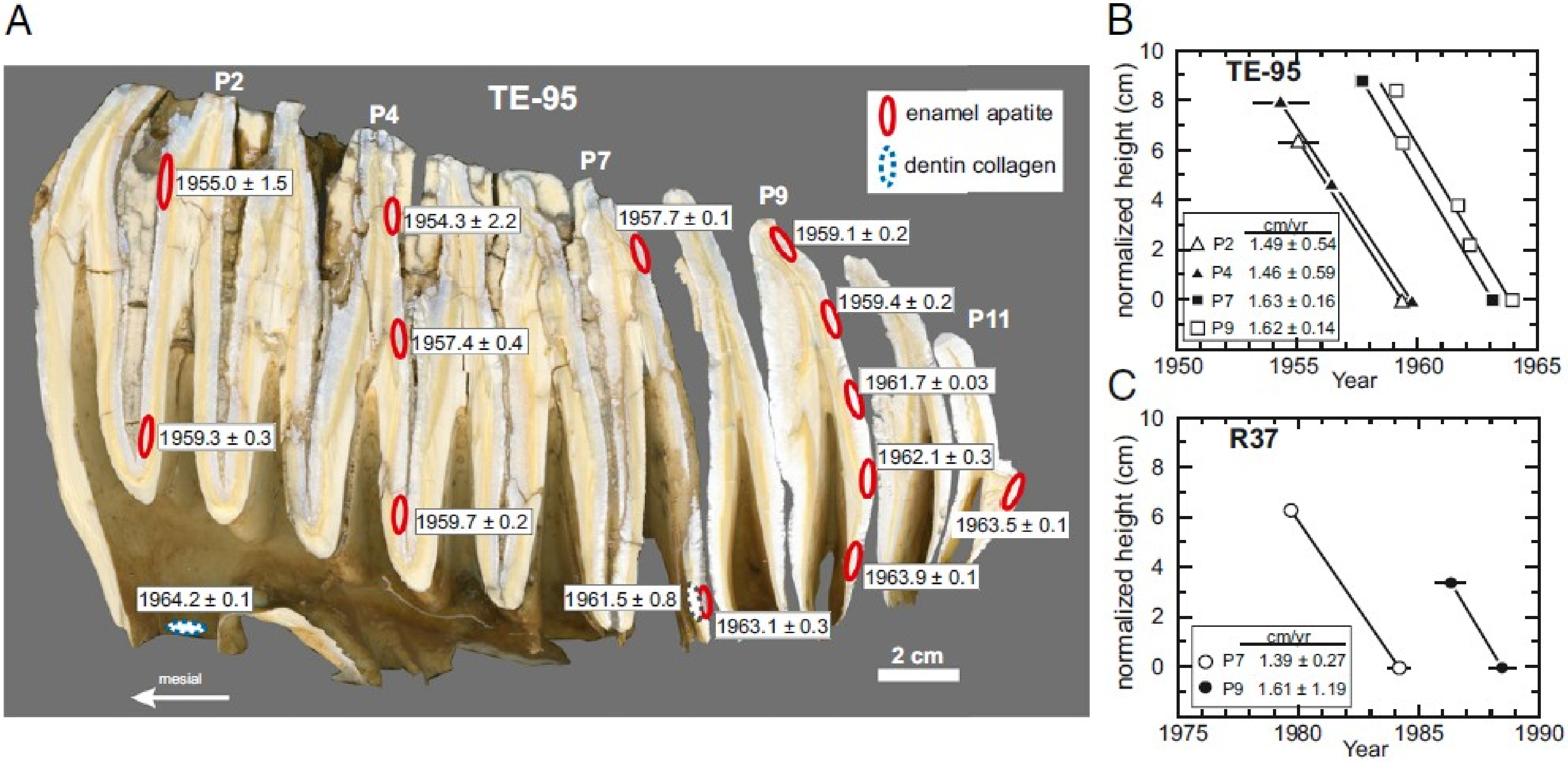
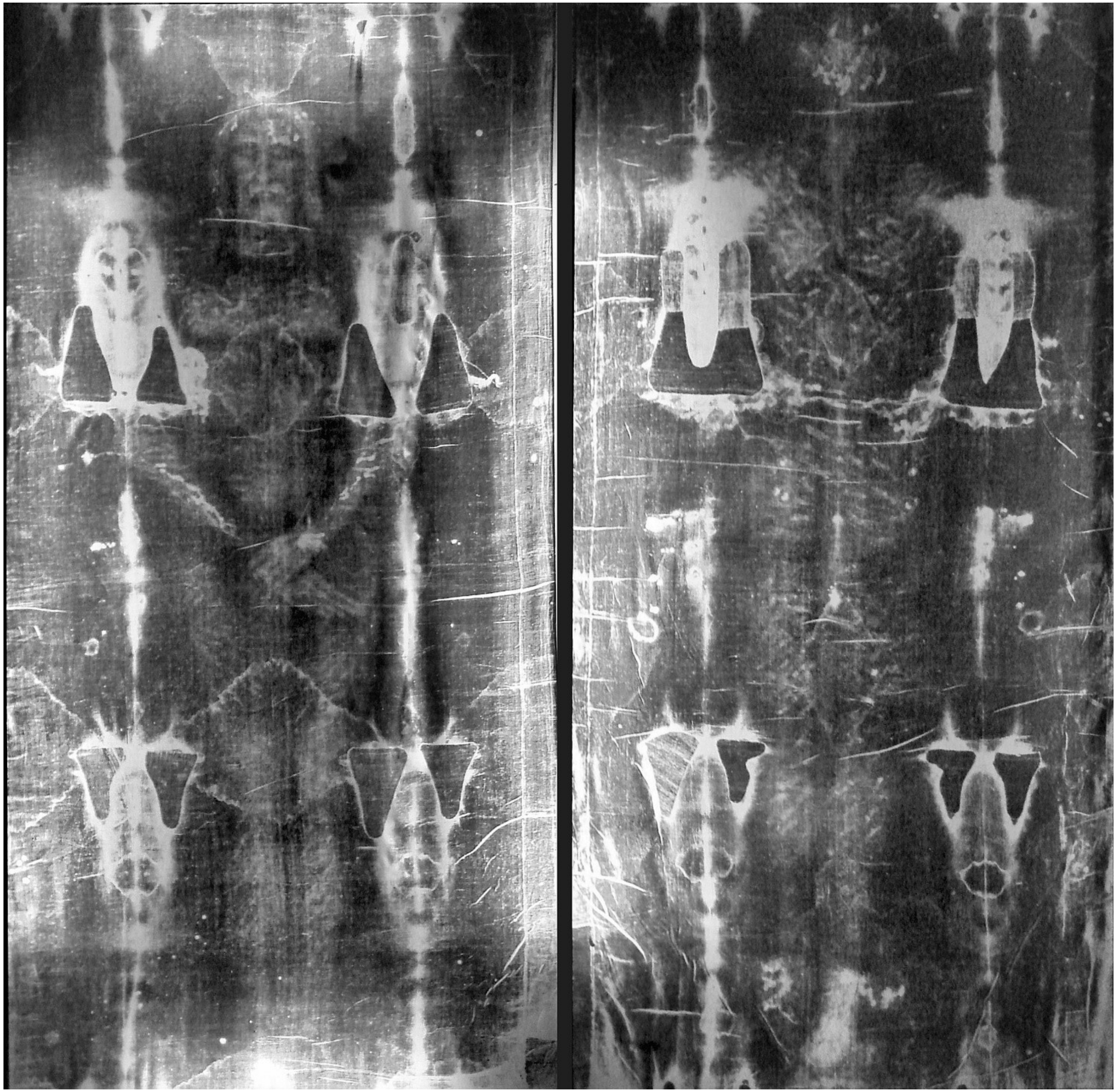


Fig. 3. (*A*) Longitudinally cut elephant molar (m3) from individual TE-95 showing calibrated ^{14}C ages ($\pm 2\sigma$) for 13 enamel apatite and 2 dentin collagen samples. Sample locations are outlined as ellipses. The molar consists of 11 enamel-covered plates (P1 to P11). (*B*) Vertical growth rates from four TE-95 molar plates shown in *A* are calculated from ^{14}C ages. (*C*) Vertical growth rates in two molar plates from a lower third molar belonging to R37 (see text). Growth rates ($\pm 2\sigma$) are calculated from slopes; height along a plate is normalized to the lowest sample location. Age uncertainty is 2σ and if not shown is smaller than the symbol.

Turínské plátno



Datování pomocí radiouhlíku problematické

Fluorový test

Určení relativního stáří fosilních a subfosilních kostí n základě obsahu fluoru, jehož obsah se se stářím kostí zvyšuje.

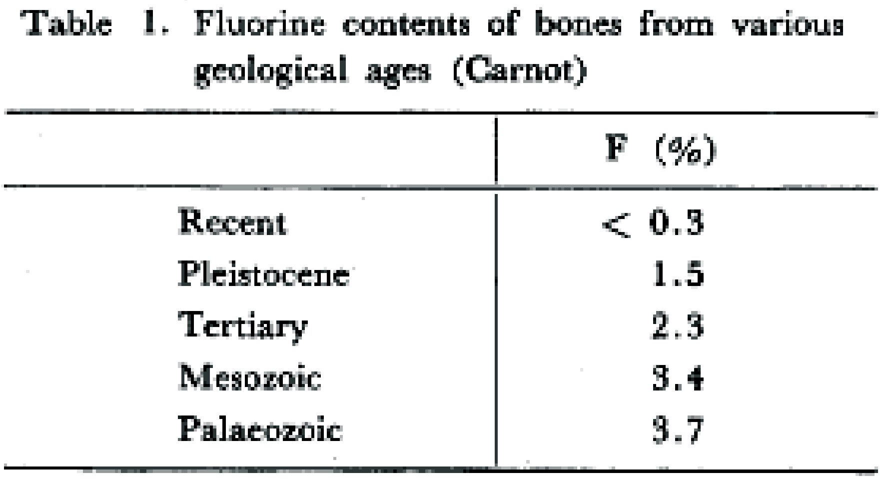


Table 1. Fluorine contents of bones from various geological ages (Carnot)

	F (%)
Recent	< 0.3
Pleistocene	1.5
Tertiary	2.3
Mesozoic	3.4
Palaeozoic	3.7

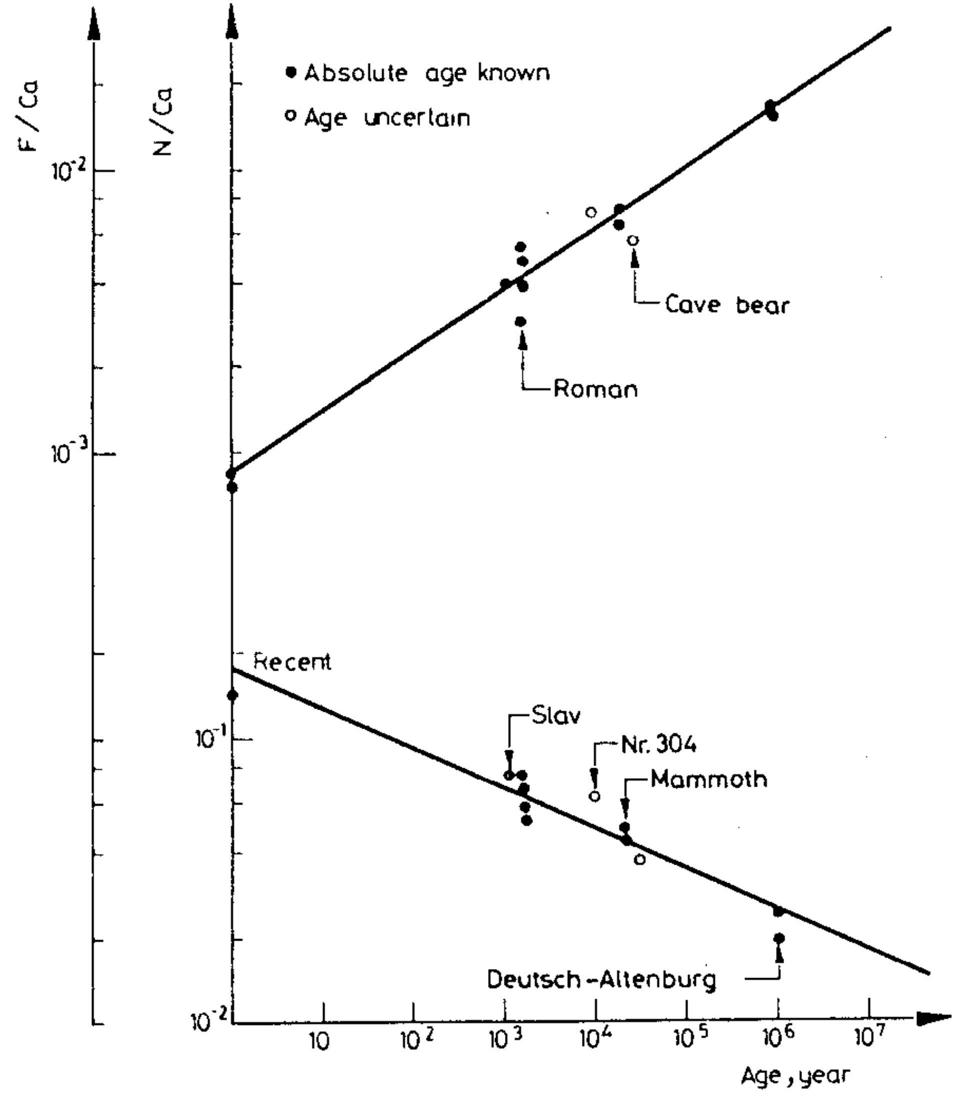


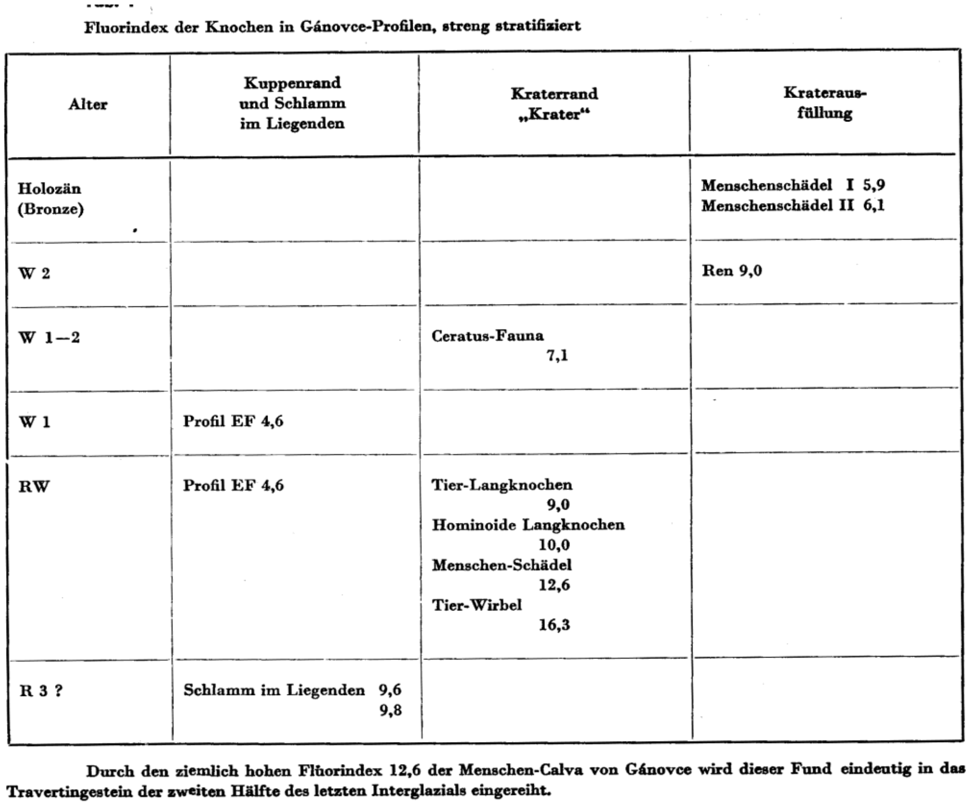
Fig. 3. Dependence of F/Ca and N/Ca-ratios on age

Gánovce

Nález přirozeného travertinového výlitku mozku neandertálce.

Obsah fluoru může být ovlivněn prostředím – termálním pramenem.

Index = C_F/C_{PO4}



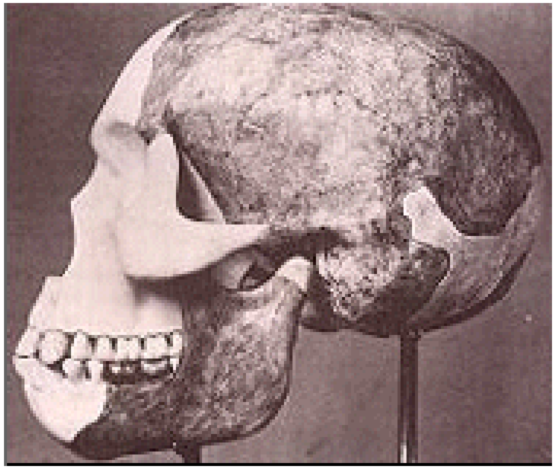
Fluorindex der Knochen in Gánovce-Profilen, streng stratifiziert

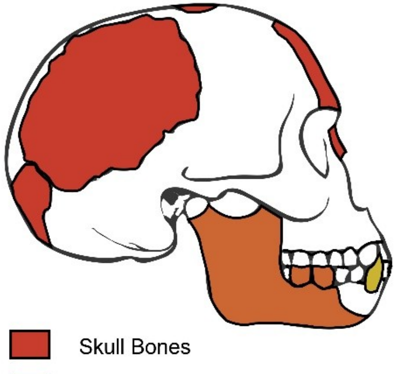
Alter	Kuppenrand und Schlamm im Liegenden	Kraterrand „Krater“	Krateraus-füllung
Holozän (Bronze)			Menschenschädel I 5,9 Menschenschädel II 6,1
W 2			Ren 9,0
W 1—2		Ceratus-Fauna 7,1	
W 1	Profil EF 4,6		
RW	Profil EF 4,6	Tier-Langknochen 9,0 Hominoide Langknochen 10,0 Menschen-Schädel 12,6 Tier-Wirbel 16,3	
R 3 ?	Schlamm im Liegenden 9,6 9,8		

Durch den ziemlich hohen Fluorindex 12,6 der Menschen-Calva von Gánovce wird dieser Fund eindeutig in das Travertingestein der zweiten Hälfte des letzten Interglazials eingereiht.

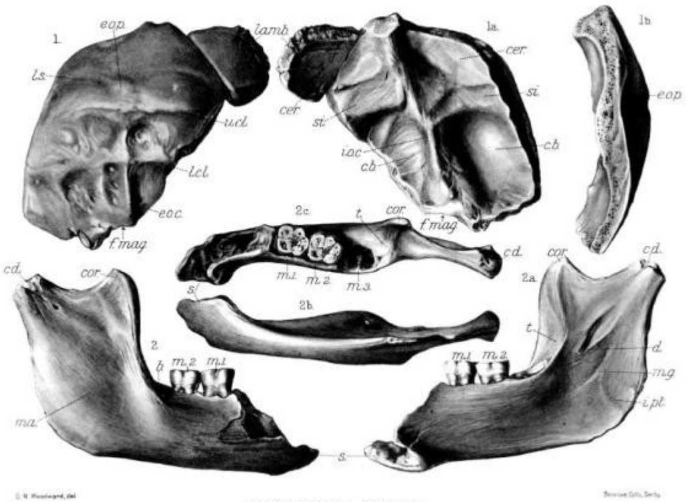
Eoanthropus dawsoni

Fosilní pozůstatky, objevené v Anglii v roce 1910–12, později odhaleny jako padělek.

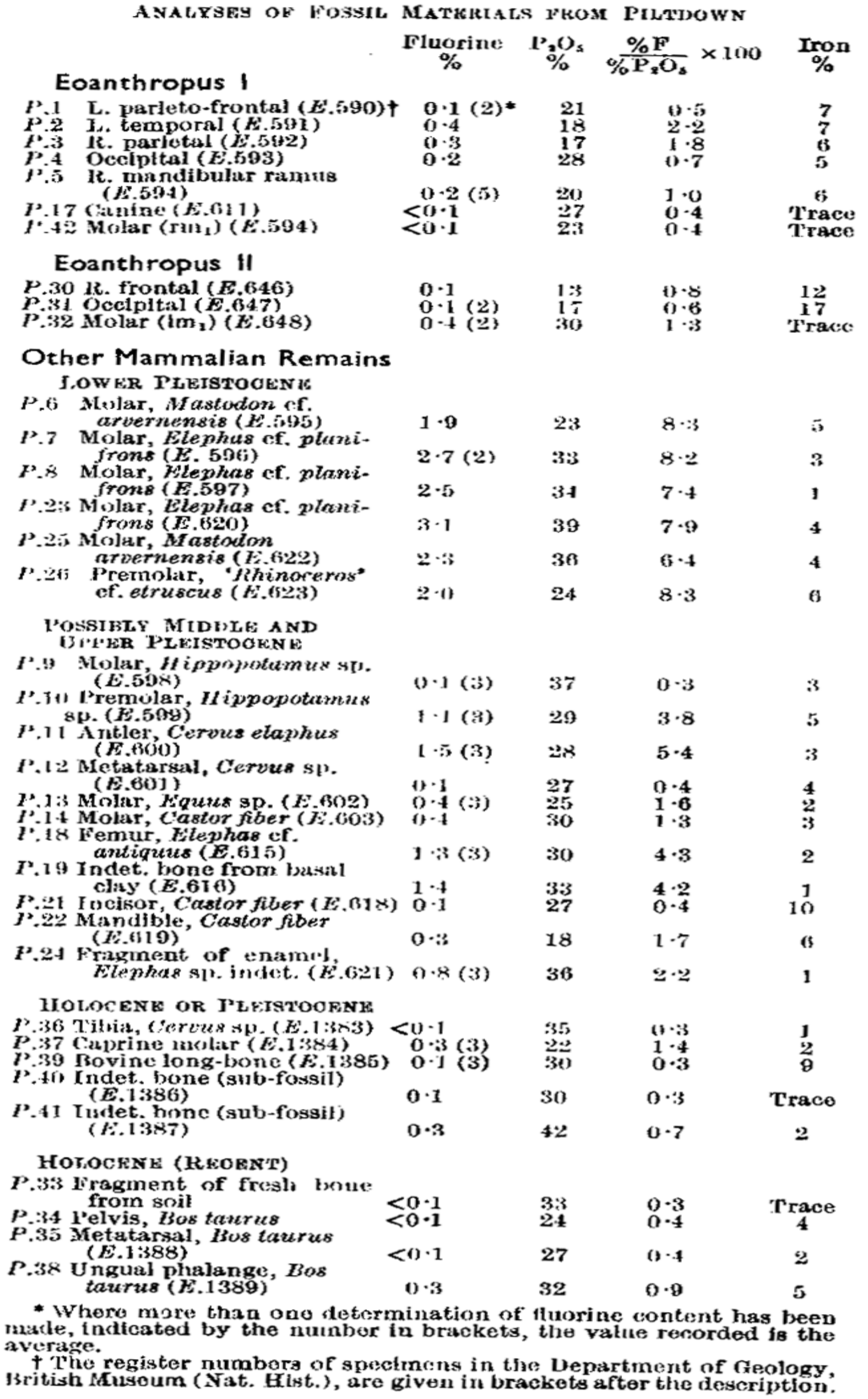




Quart. Journ. Geol. Soc. Vol. LXIX, Pl. XX.



EOANTHROPUS DAWSONI.



ANALYSES OF FOSSIL MATERIALS FROM PILTDOWN

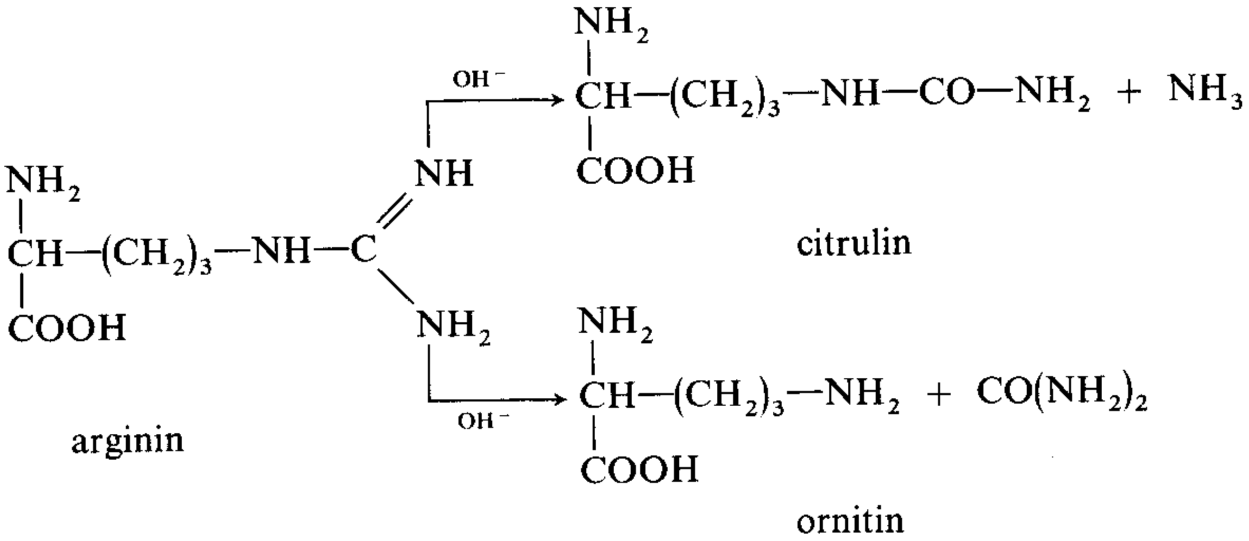
		Fluorine %	P_2O_5 %	$\frac{\%F}{\%P_2O_5} \times 100$	Iron %
Eoanthropus I					
P.1	L. parieto-frontal (*E*.590)†	0·1 (2)*	21	0·5	7
P.2	L. temporal (*E*.591)	0·4	18	2·2	7
P.3	R. parietal (*E*.592)	0·3	17	1·8	6
P.4	Occipital (*E*.593)	0·2	28	0·7	5
P.5	R. mandibular ramus (*E*.594)	0·2 (5)	20	1·0	6
P.17	Canine (*E*.611)	<0·1	27	0·4	Trace
P.42	Molar (m_1) (*E*.594)	<0·1	23	0·4	Trace
Eoanthropus II					
P.30	R. frontal (*E*.646)	0·1	13	0·8	12
P.31	Occipital (*E*.647)	0·1 (2)	17	0·6	17
P.32	Molar (m_1) (*E*.648)	0·4 (2)	30	1·3	Trace
Other Mammalian Remains					
LOWER PLEISTOCENE					
P.6	Molar, *Mastodon* cf. *arvernensis* (*E*.595)	1·9	23	8·3	5
P.7	Molar, *Elephas* cf. *planifrons* (*E*. 596)	2·7 (2)	33	8·2	3
P.8	Molar, *Elephas* cf. *planifrons* (*E*.597)	2·5	34	7·4	1
P.23	Molar, *Elephas* cf. *planifrons* (*E*.620)	3·1	39	7·9	4
P.25	Molar, *Mastodon arvernensis* (*E*.622)	2·3	36	6·4	4
P.26	Premolar, '*Rhinoceros*' cf. *etruscus* (*E*.623)	2·0	24	8·3	6
POSSIBLY MIDDLE AND UPPER PLEISTOCENE					
P.9	Molar, *Hippopotamus* sp. (*E*.598)	0·1 (3)	37	0·3	3
P.10	Premolar, *Hippopotamus* sp. (*E*.599)	1·1 (3)	29	3·8	5
P.11	Antler, *Cervus elaphus* (*E*.600)	1·5 (3)	28	5·4	3
P.12	Metatarsal, *Cervus* sp. (*E*.601)	0·1	27	0·4	4
P.13	Molar, *Equus* sp. (*E*.602)	0·4 (3)	25	1·6	2
P.14	Molar, *Castor fiber* (*E*.603)	0·4	30	1·3	3
P.18	Femur, *Elephas* cf. *antiquus* (*E*.615)	1·3 (3)	30	4·3	2
P.19	Indet. bone from basal clay (*E*.616)	1·4	33	4·2	1
P.21	Incisor, *Castor fiber* (*E*.618)	0·1	27	0·4	10
P.22	Mandible, *Castor fiber* (*E*.619)	0·3	18	1·7	6
P.24	Fragment of enamel, *Elephas* sp. indet. (*E*.621)	0·8 (3)	36	2·2	1
HOLOCENE OR PLEISTOCENE					
P.36	Tibia, *Cervus* sp. (*E*.1383)	<0·1	35	0·3	1
P.37	Caprine molar (*E*.1384)	0·3 (3)	22	1·4	2
P.39	Bovine long-bone (*E*.1385)	0·1 (3)	30	0·3	9
P.40	Indet. bone (sub-fossil) (*E*.1386)	0·1	30	0·3	Trace
P.41	Indet. bone (sub-fossil) (*E*.1387)	0·3	42	0·7	2
HOLOCENE (RECENT)					
P.33	Fragment of fresh bone from soil	<0·1	33	0·3	Trace
P.34	Pelvis, *Bos taurus*	<0·1	24	0·4	4
P.35	Metatarsal, *Bos taurus* (*E*.1388)	<0·1	27	0·4	2
P.38	Ungual phalange, *Bos taurus* (*E*.1389)	0·3	32	0·9	5

* Where more than one determination of fluorine content has been made, indicated by the number in brackets, the value recorded is the average.

† The register numbers of specimens in the Department of Geology, British Museum (Nat. Hist.), are given in brackets after the description.

Rozklad argininu v alkalickém prostředí

V alkalickém prostředí dochází k rozkladu argininu na ornithin (za vzniku močoviny) a/nebo, méně často, na citrulin (za vzniku amoniaku). Reakce je významná hlavně v pozdějším stupni alkalické degradace kolagenu.



Reakce se uplatňuje m.j. i při loužení usně.

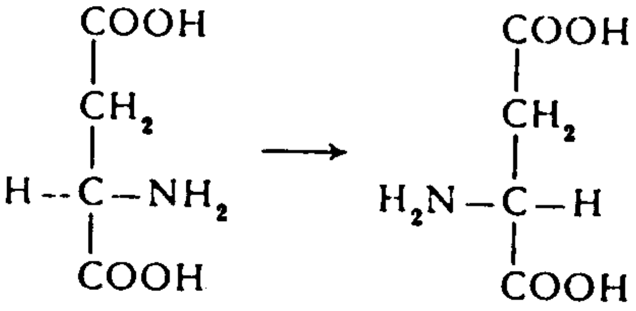
Horka-Ondrej

Existují pokusy o využití reakce k datování kostí. Metoda selhala při datování lebky z paleolitické lokality Skalka u obce Horka-Ondrej na Spiši. Vysoký obsah ornitinu indikoval paleolitické stáří, radiokarbonové datování ukázalo, že jde o novověký materiál.

V roce 1988 v travertinu u Hôrky-Ondreje našla lidská lebka. Objev však hned od počátku budil u mnoha archeologů podezření, protože šlo o lebku zcela moderního typu. Jak se nakonec ukázalo, pochyby byly zcela na místě – šlo o podvod. Roku 2003 se k němu v televizi přiznali dva brigádníci, v době vykopávek teprve patnáctiletí. Vedoucí archeologické brigády jim prý slíbila, že najdou-li něco „velkého“, dostanou volno a navíc i nějakou tu korunu odměny. A tak se snažili. Na starém hřbitově ukradli lebku, čtyři dny ji máčeli v termálním prameni, pak ji zakopali na lokalitě a další den opatrně „objevili“.

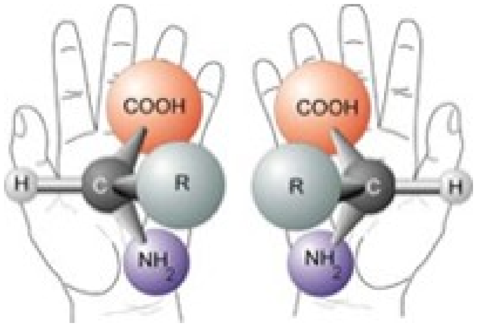
Racemizace aminokyselin

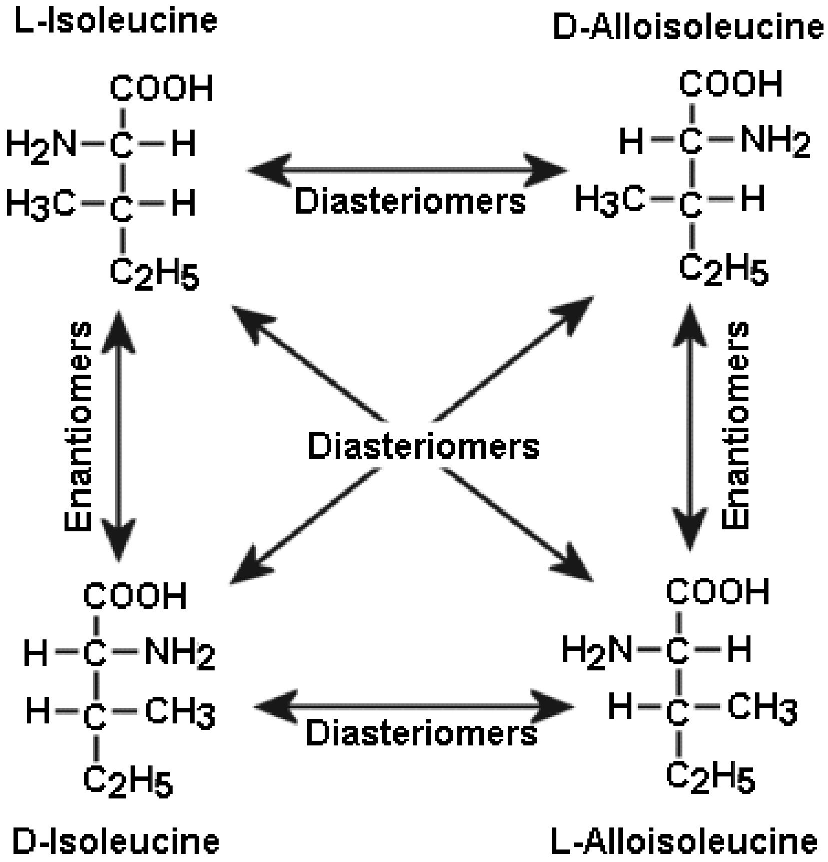
Počet chirálních center



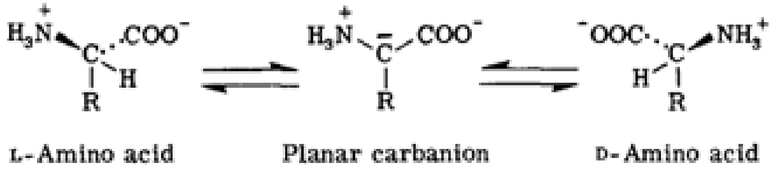
L-aspartic acid D-aspartic acid

$$\ln\left\{\frac{1 + \mathrm{D/L}}{1 - K \cdot \mathrm{D/L}}\right\} - \ln\left\{\frac{1 + \mathrm{D/L}}{1 - K \cdot \mathrm{D/L}}\right\}_{t=0} = (1 + K)k_i t$$





Racemizace aminokyselin



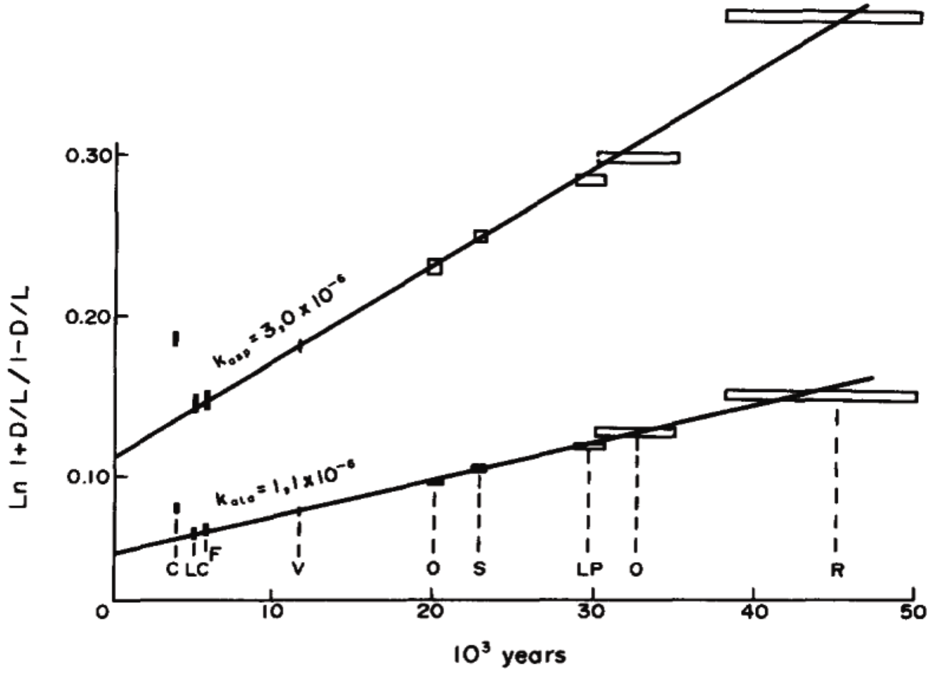
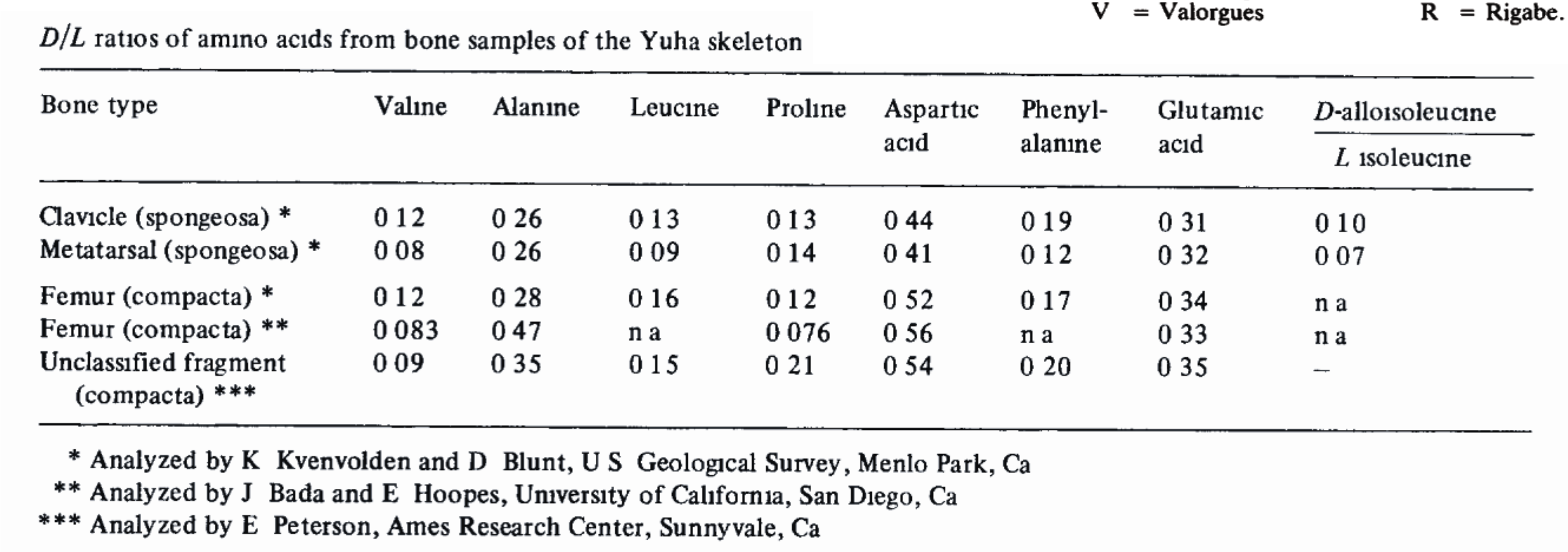


FIG. 2. Rate of racemization of Asp and Ala versus fossil bone age.

Legend:
C = La Couronne
LC = Les Cohons
F = Fontbrégoua
V = Valorgues
O = Oullins
S = Salpêtrière
LP = Abri des Pêcheurs
R = Rigabe.



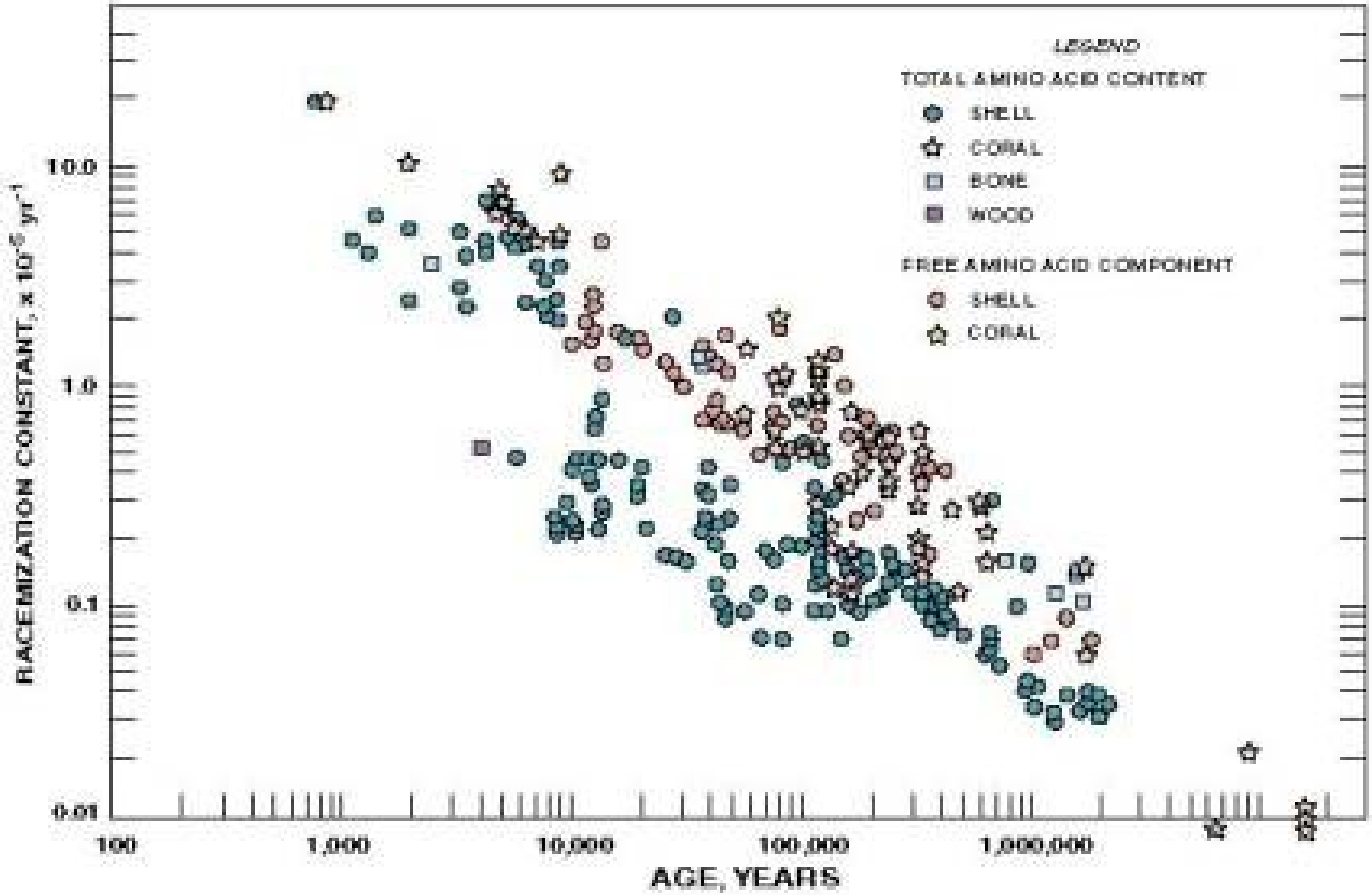
D/L ratios of amino acids from bone samples of the Yuha skeleton

Bone type	Valine	Alanine	Leucine	Proline	Aspartic acid	Phenyl-alanine	Glutamic acid	*D*-alloisoleucine / *L* isoleucine
Clavicle (spongeosa) *	0.12	0.26	0.13	0.13	0.44	0.19	0.31	0.10
Metatarsal (spongeosa) *	0.08	0.26	0.09	0.14	0.41	0.12	0.32	0.07
Femur (compacta) *	0.12	0.28	0.16	0.12	0.52	0.17	0.34	n.a.
Femur (compacta) **	0.083	0.47	n.a.	0.076	0.56	n.a.	0.33	n.a.
Unclassified fragment (compacta) ***	0.09	0.35	0.15	0.21	0.54	0.20	0.35	–

* Analyzed by K. Kvenvolden and D. Blunt, U.S. Geological Survey, Menlo Park, Ca.

** Analyzed by J. Bada and E. Hoopes, University of California, San Diego, Ca.

*** Analyzed by E. Peterson, Ames Research Center, Sunnyvale, Ca.



Isoleucine Racemization Rate Constant versus Associated Fossil Age. Data from Bada 1981, Bada and Protsch 1973, Bada and Schroeder 1972, Bada et al. 1973, Bischoff and Childers 1979, Blake 1980, Hare and Mitterer 1966, King and Neville 1977, Kvenvolden 1980, Kvenvolden et al. 1973, Lee et al. 1976, Masters and Bada 1977, Miller and Hare 1980, Mitterer 1975, Stafford et al. 1984, Szabo et al. 1981, Wehmiller 1977, Wehmiller and Hare 1971, Wehmiller et al. 1976.
[R. H. Brown, Amino Acid Dating, Origins 12(1):8-25 (1985)]

Přítomnost vody

V bezvodém prostředí racemizace
téměř neprobíhá

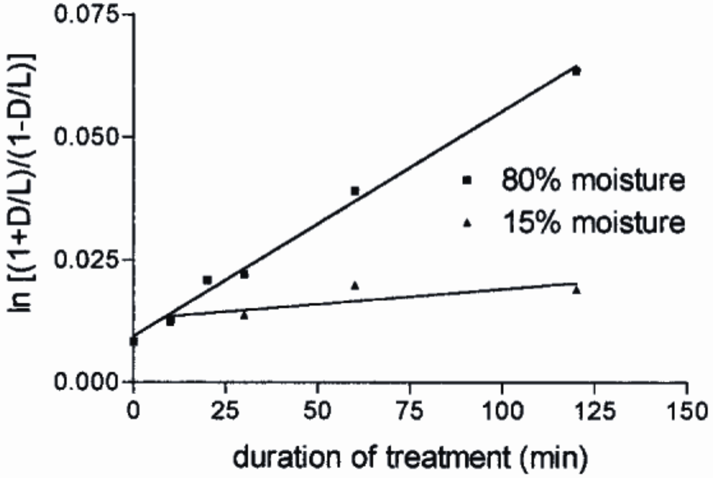


Figure 5. First-order rate plots for the racemization of aspartic acid in fish material treated at 95 °C, normal oxygen pressure, and pH 7.0 under different moisture conditions. The equations for the lines are $Y = 0.000062 + 0.000033X$ ($R^2 = 0.6413$) and $Y = 0.00046 + 0.00939X$ ($R^2 = 0.9929$) for 15% and 80% moisture, respectively.

Rancho la Brea (Kalifornie, USA) – anomálně nízké hodnoty epimerace isoleucinu (Ile) – bezvodé prostředí.

Určení věku

- u historického materiálu se uplatňuje i vliv postmortální racemizace

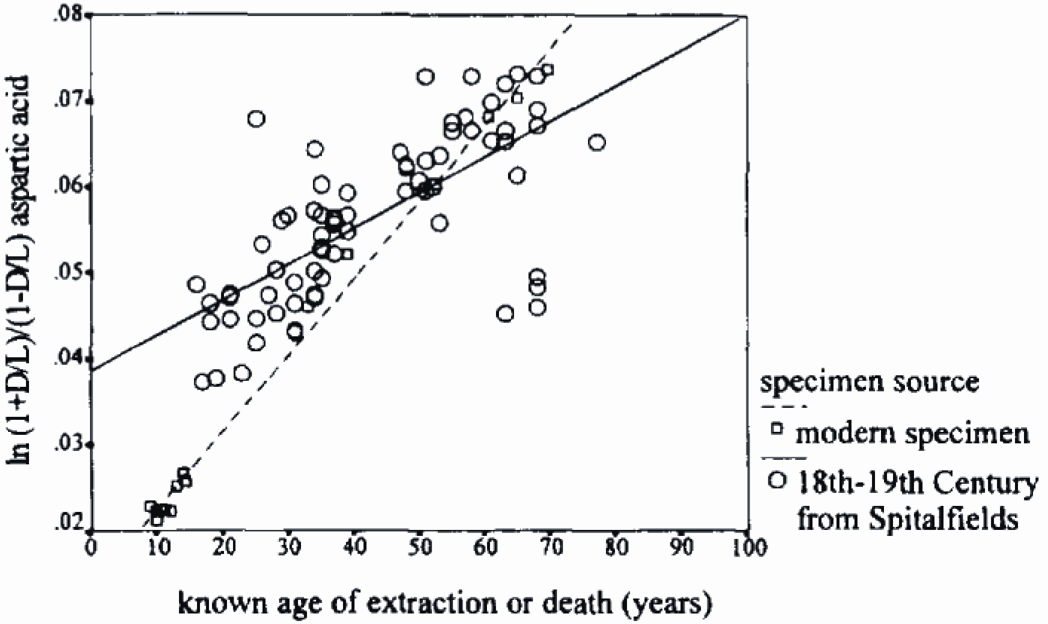


FIG. 5—*Plot of ln{(1 + (D/L))/(1 − (D/L))} aspartic acid with regression lines depicted for 18th C. specimens (Spitalfields) and modern specimens.*

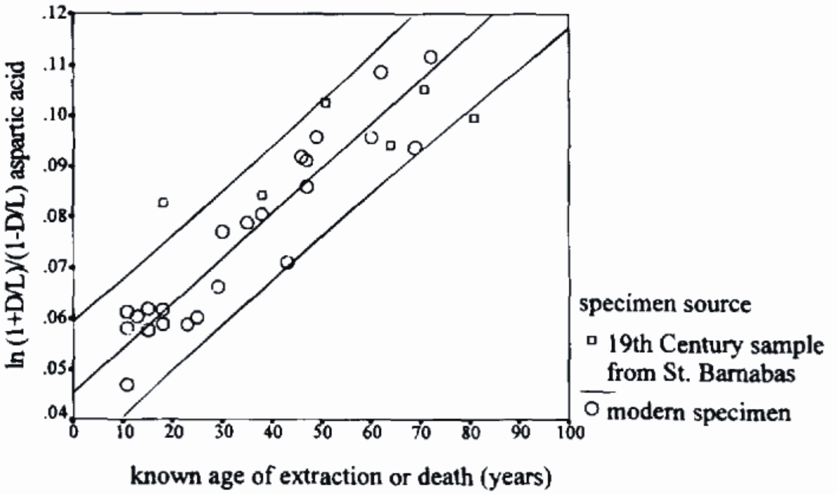


FIG. 1—*Plot of ln{(1 + (D/L))/(1 − (D/L))} aspartic acid against age with 95% confidence bands for St. Barnabas (19th C.) and modern dental samples.*

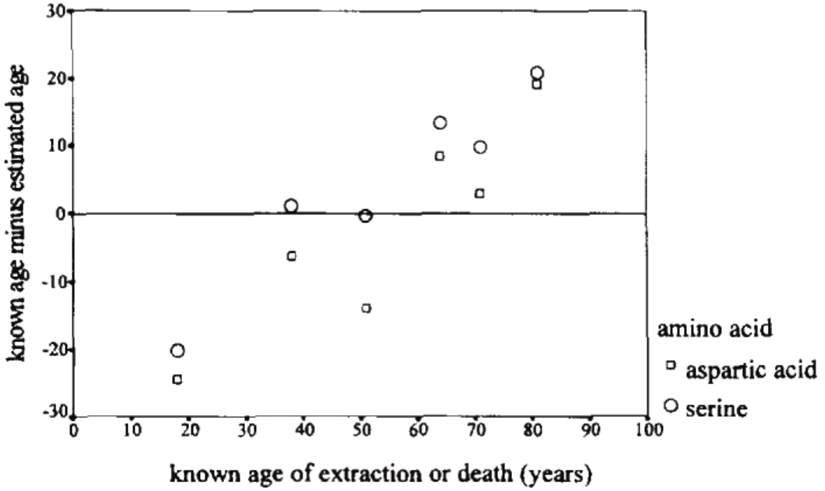
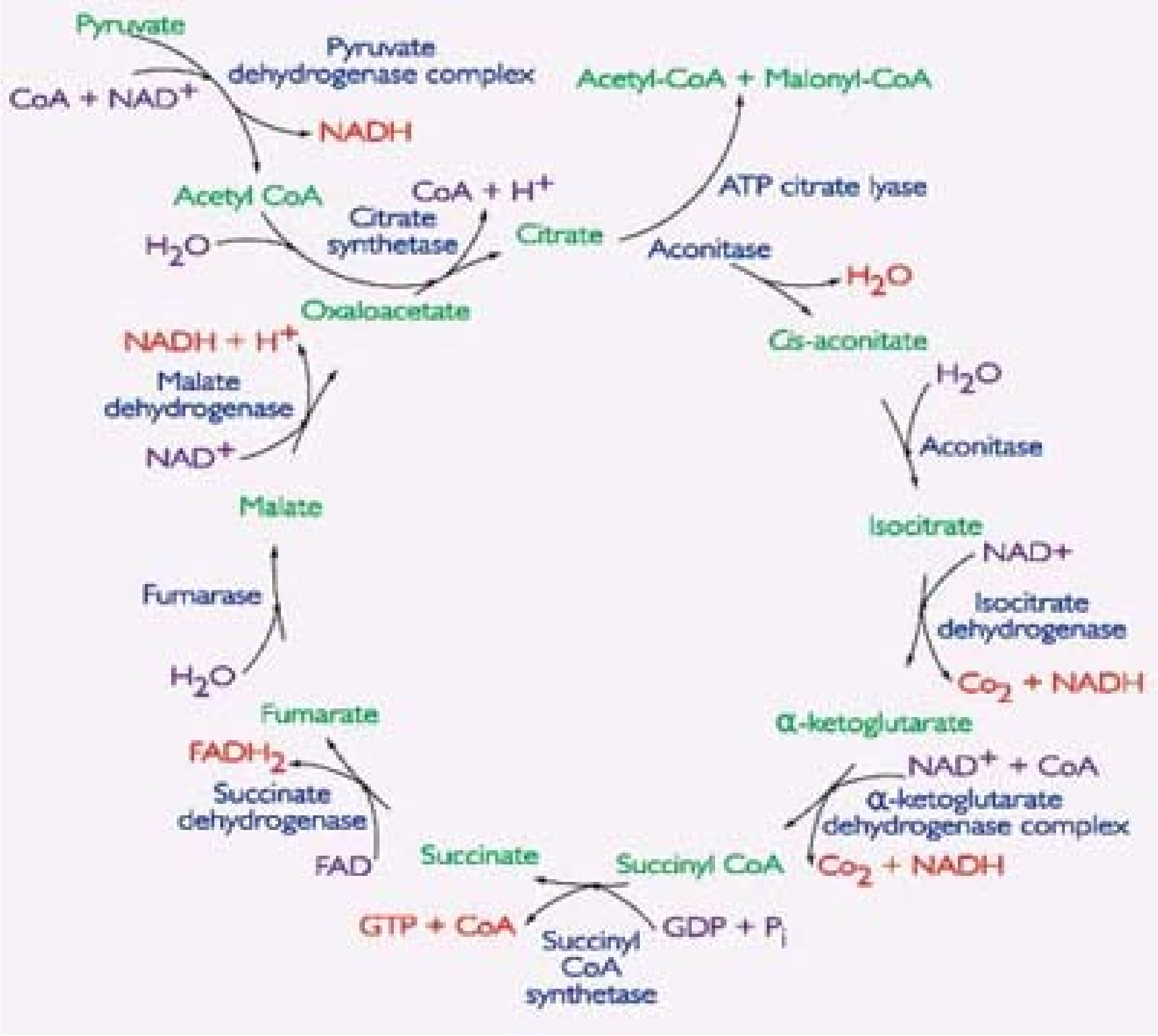


FIG. 4—*Plot of known age against true error in estimated age for aspartic acid and serine for six 19th Century specimens. (Estimated age obtained by using the modern data as a calibration curve for the 19th C. samples. True error is difference between estimated age and known age).*

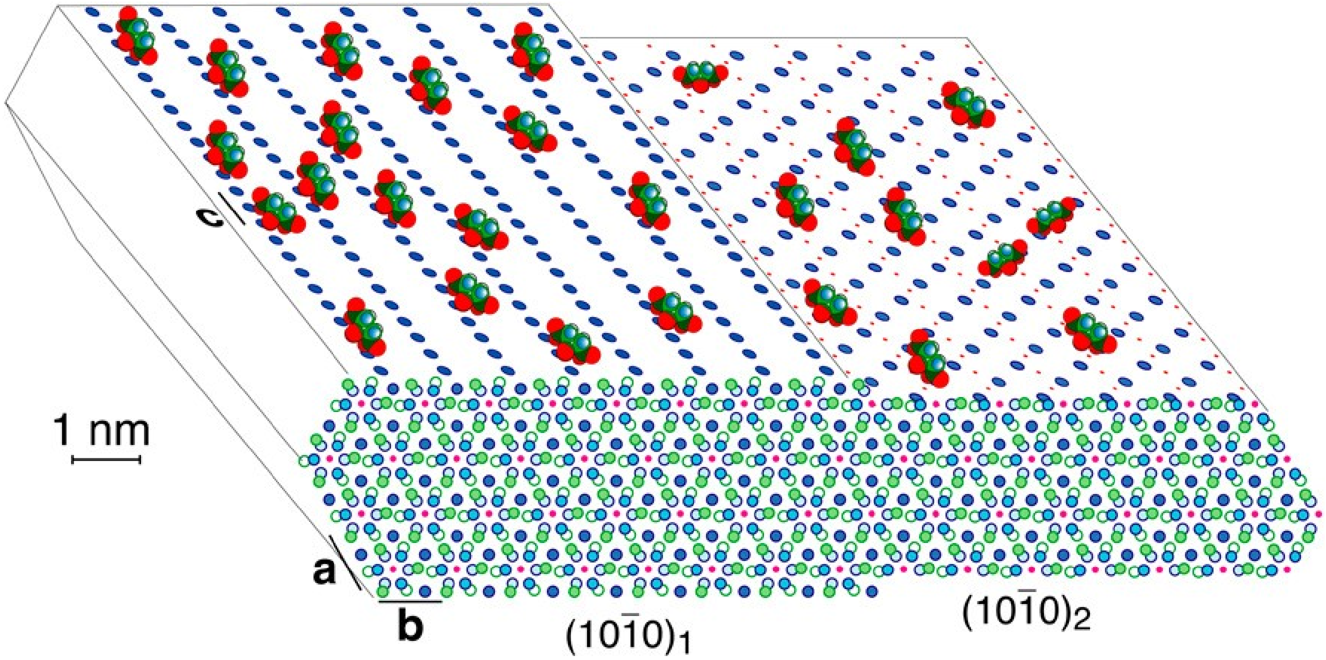
L-methionin nepodléhá racemizaci in vivo, lze ho použít jako vnitřní standard: poměr D-Asp/D-Met eliminuje efekt racemizace během přípravy vzorku.

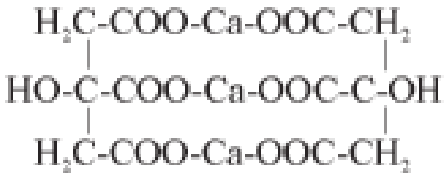
Cca 1600 let stará (14C 370-390 90 let) zmrzlá „mumie“ eskymácké ženy, nalezená 1972 na St. Lawrence Island (Aljaška). Morfologicky (atrofie prsou a vaječníků, otření zubů, choroba koronárních cév) byl věk odhadnut na 50-60 let. Analýza racemizace Asp v dentinu indikovala věk 53 5 let. Mrtvola ležela ve věčně zmrzlé půdě, vliv postmortálních změn na racemizaci je minimální.

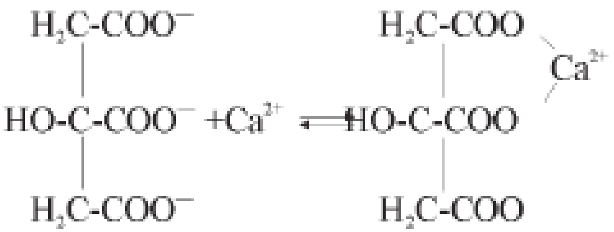
Metabolismus kyseliny citronové



Vazba citrátu v kosti







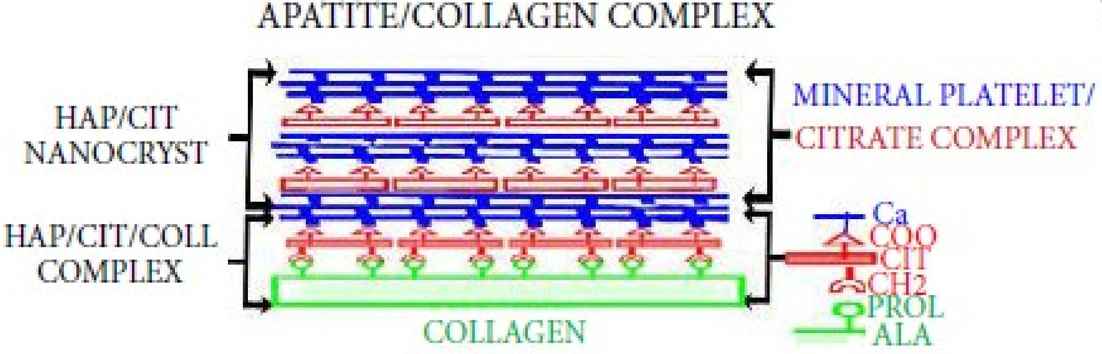
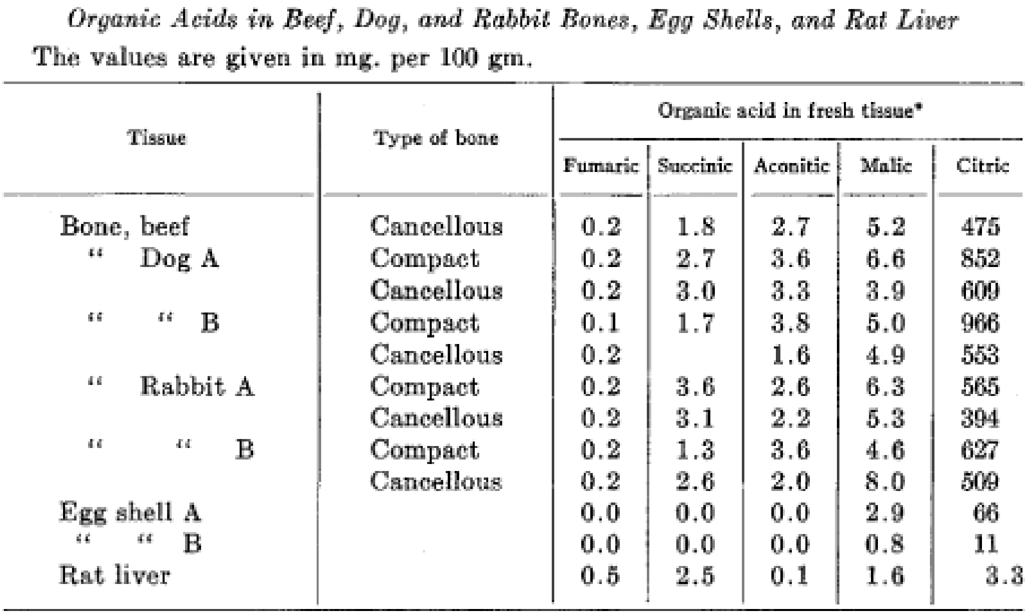


Figure 3. Concept of the incorporation of two pools of citrate in the structure of the apatite nanocrystal/collagen complex.

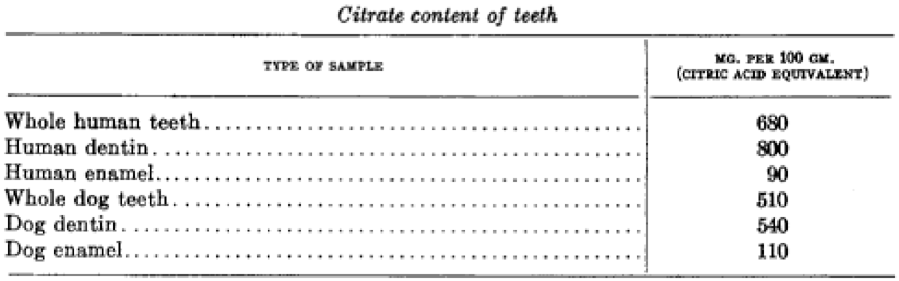
Distribuce citrátu v tkáních



Organic Acids in Beef, Dog, and Rabbit Bones, Egg Shells, and Rat Liver

The values are given in mg. per 100 gm.

Tissue	Type of bone	Organic acid in fresh tissue*				
		Fumaric	Succinic	Aconitic	Malic	Citric
Bone, beef	Cancellous	0.2	1.8	2.7	5.2	475
“ Dog A	Compact	0.2	2.7	3.6	6.6	852
	Cancellous	0.2	3.0	3.3	3.9	609
“ “ B	Compact	0.1	1.7	3.8	5.0	966
	Cancellous	0.2		1.6	4.9	553
“ Rabbit A	Compact	0.2	3.6	2.6	6.3	565
	Cancellous	0.2	3.1	2.2	5.3	394
“ “ B	Compact	0.2	1.3	3.6	4.6	627
	Cancellous	0.2	2.6	2.0	8.0	509
Egg shell A		0.0	0.0	0.0	2.9	66
“ “ B		0.0	0.0	0.0	0.8	11
Rat liver		0.5	2.5	0.1	1.6	3.3



Citrate content of teeth

TYPE OF SAMPLE	MG. PER 100 GM. (CITRIC ACID EQUIVALENT)
Whole human teeth	680
Human dentin	800
Human enamel	90
Whole dog teeth	510
Dog dentin	540
Dog enamel	110

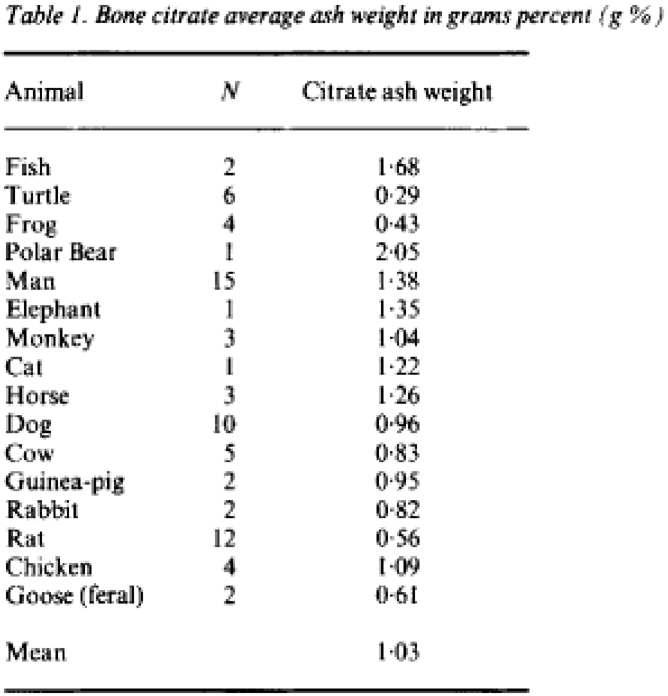


Table 1. Bone citrate average ash weight in grams percent (g %)

Animal	*N*	Citrate ash weight
Fish	2	1·68
Turtle	6	0·29
Frog	4	0·43
Polar Bear	1	2·05
Man	15	1·38
Elephant	1	1·35
Monkey	3	1·04
Cat	1	1·22
Horse	3	1·26
Dog	10	0·96
Cow	5	0·83
Guinea-pig	2	0·95
Rabbit	2	0·82
Rat	12	0·56
Chicken	4	1·09
Goose (feral)	2	0·61
Mean		1·03

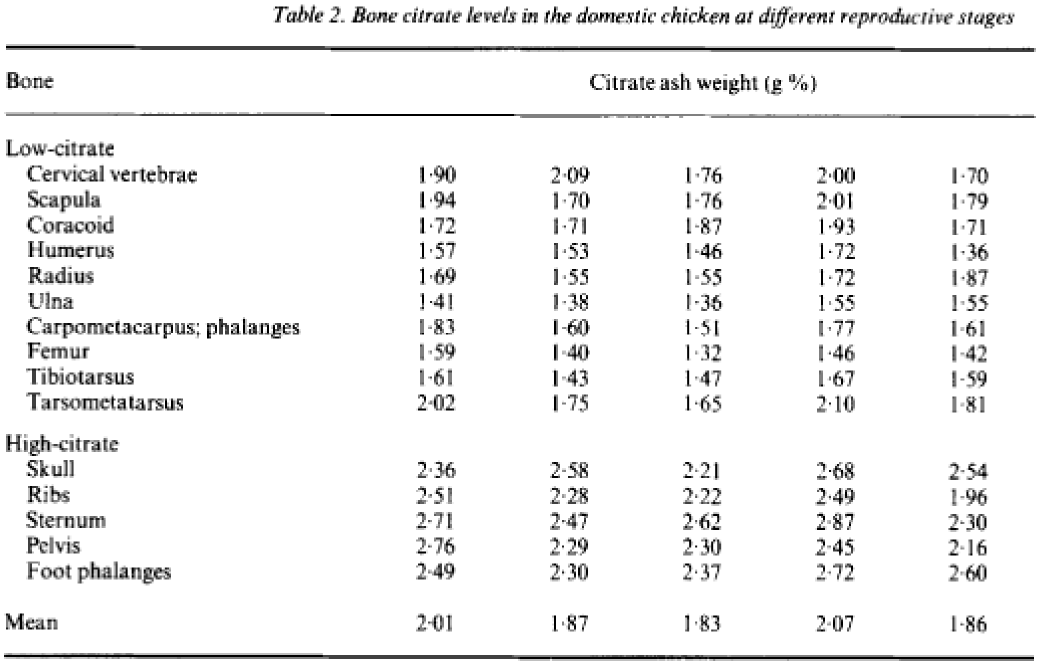
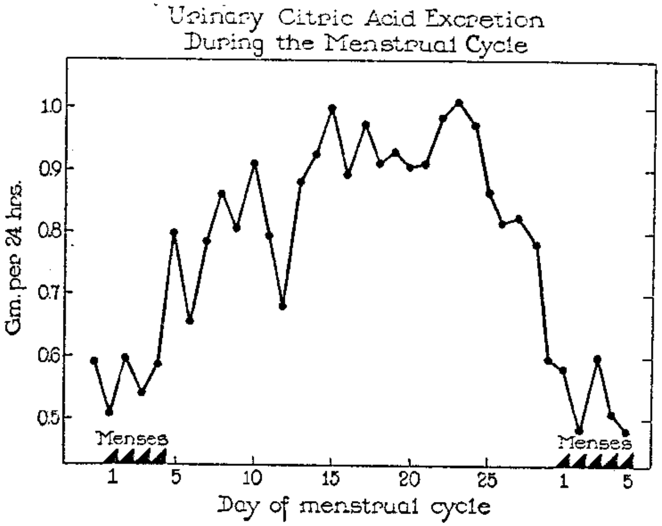
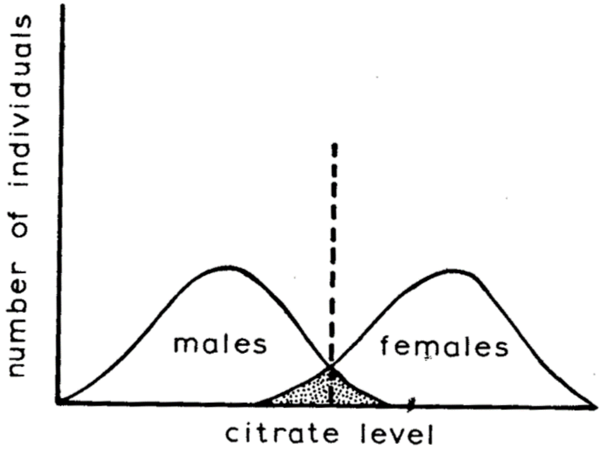


Table 2. Bone citrate levels in the domestic chicken at different reproductive stages

Bone	Citrate ash weight (g %)				
Low-citrate					
Cervical vertebrae	1·90	2·09	1·76	2·00	1·70
Scapula	1·94	1·70	1·76	2·01	1·79
Coracoid	1·72	1·71	1·87	1·93	1·71
Humerus	1·57	1·53	1·46	1·72	1·36
Radius	1·69	1·55	1·55	1·72	1·87
Ulna	1·41	1·38	1·36	1·55	1·55
Carpometacarpus; phalanges	1·83	1·60	1·51	1·77	1·61
Femur	1·59	1·40	1·32	1·46	1·42
Tibiotarsus	1·61	1·43	1·47	1·67	1·59
Tarsometatarsus	2·02	1·75	1·65	2·10	1·81
High-citrate					
Skull	2·36	2·58	2·21	2·68	2·54
Ribs	2·51	2·28	2·22	2·49	1·96
Sternum	2·71	2·47	2·62	2·87	2·30
Pelvis	2·76	2·29	2·30	2·45	2·16
Foot phalanges	2·49	2·30	2·37	2·72	2·60
Mean	2·01	1·87	1·83	2·07	1·86

Pohlavní rozdíly v obsahu citrátů


Urinary Citric Acid Excretion During the Menstrual Cycle



-Normal distribution curves of citrate levels (g.%) showing sexual separation.

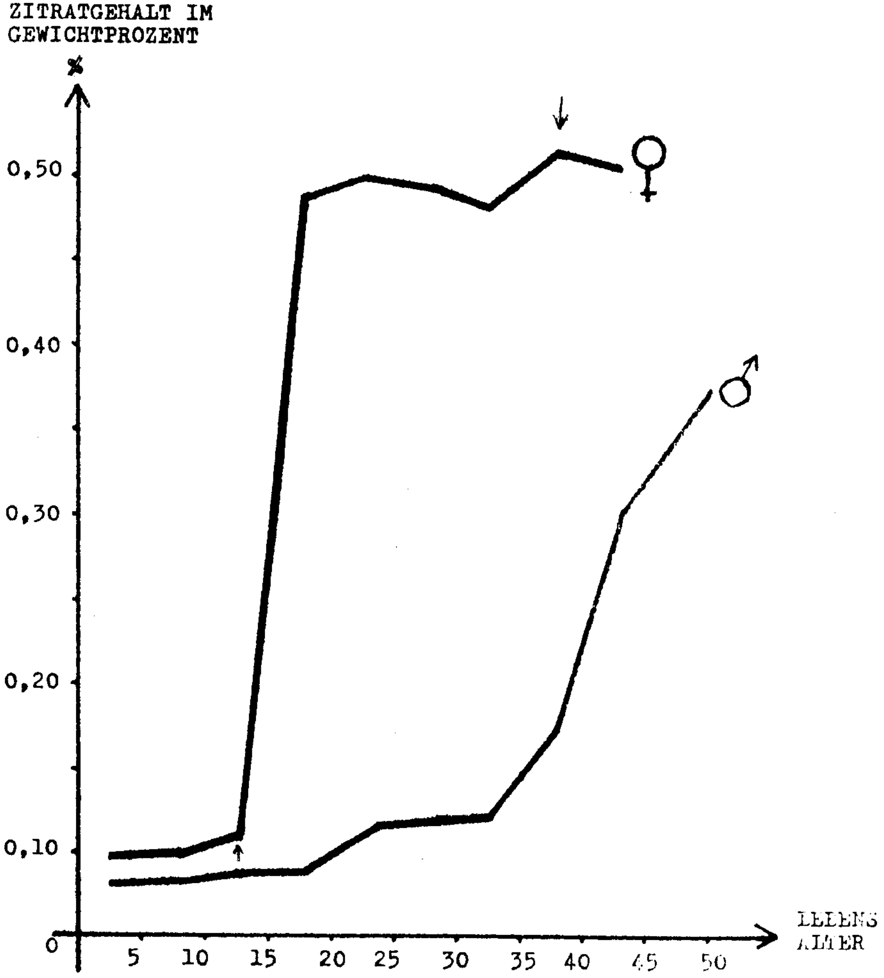


Abb. 2.

Änderungen des Zitratgehaltes vom Knochengewebe in der Verteilung nach Geschlechtes und Altersunterschieden.

Vliv diageneze

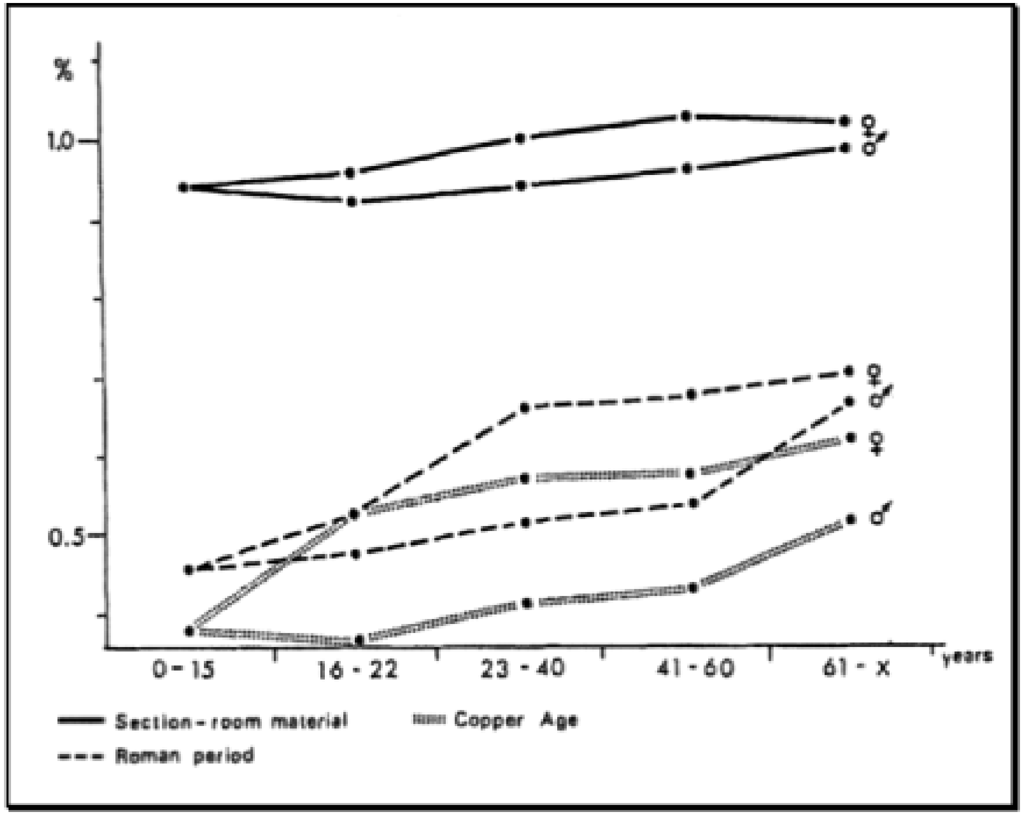


Abbildung 1: Veränderungen des Zitratgehaltes in Abhängigkeit von Geschlecht, Lebensalter, Herkunft und Liegezeit (aus LENGYEL, in BROTHWELL 1968)

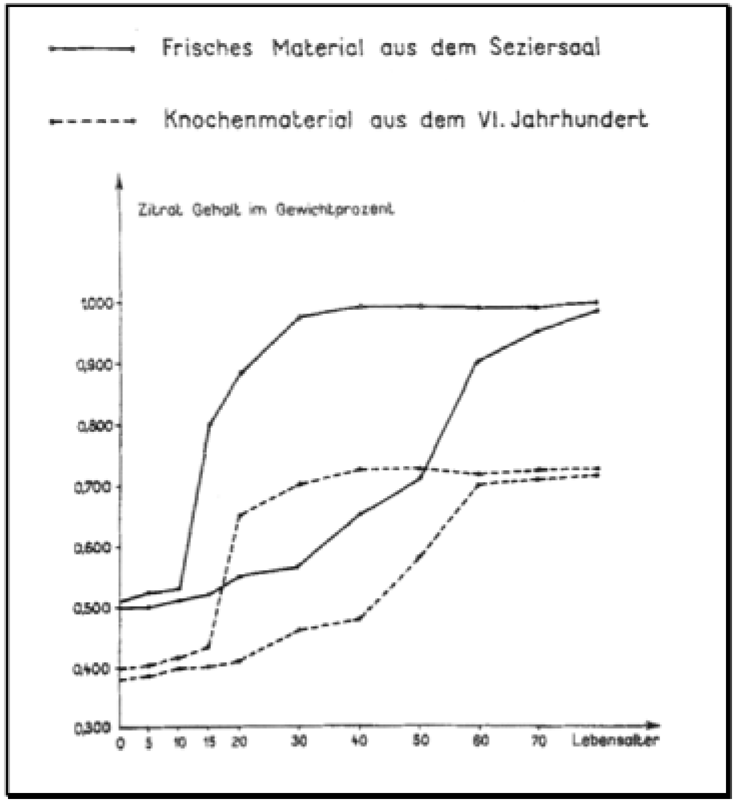


Abbildung 3: Veränderungen des Zitratgehaltes in Abhängigkeit von Geschlecht, Lebensalter und Liegezeit (aus LENGYEL 1972)

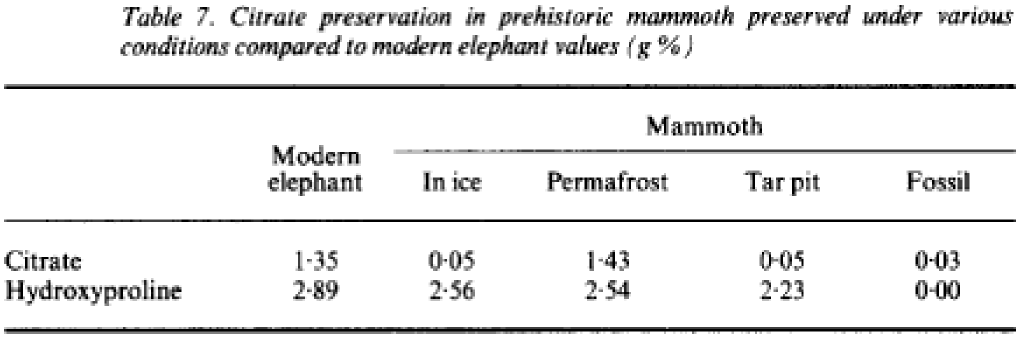
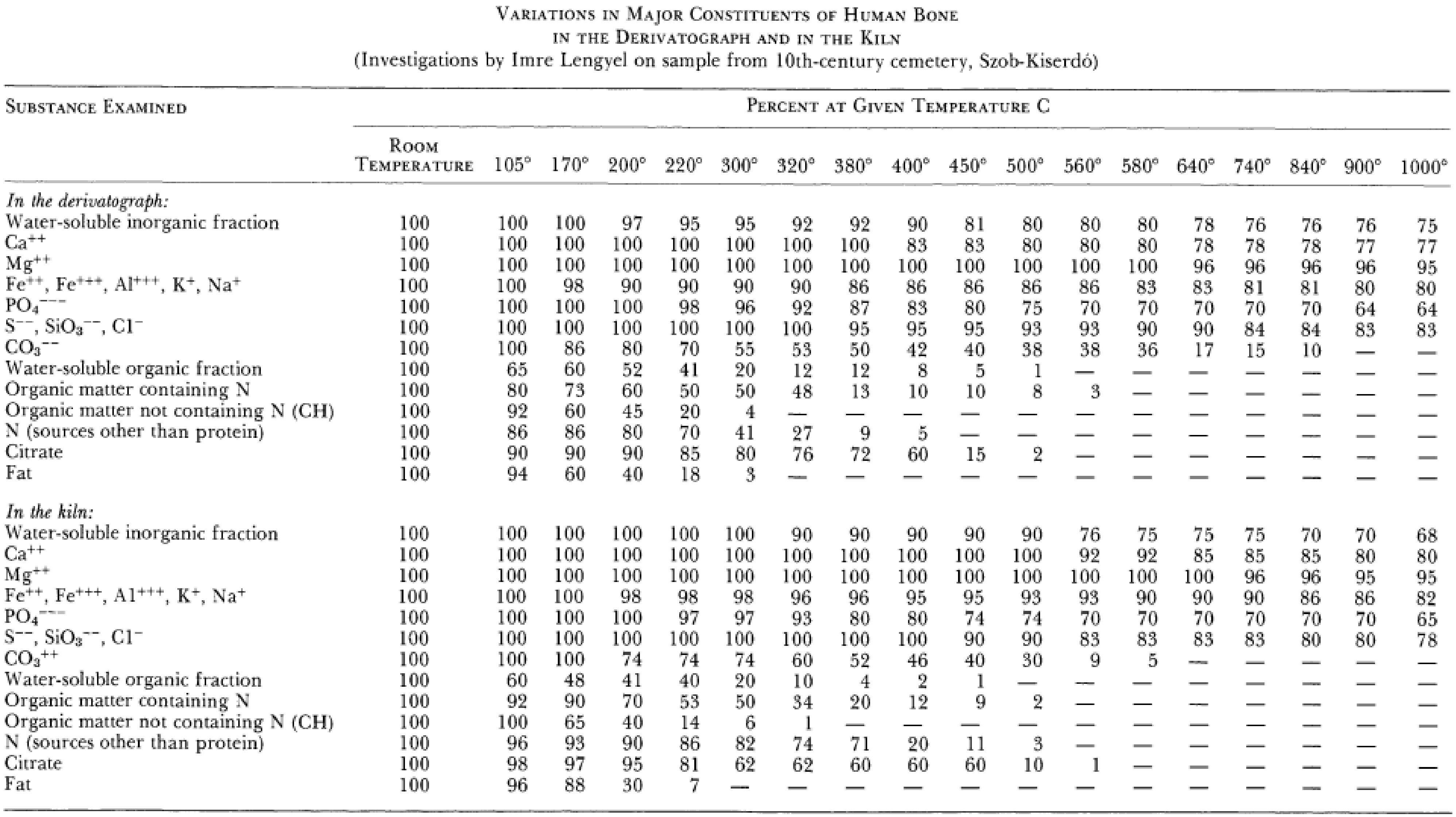


Table 7. Citrate preservation in prehistoric mammoth preserved under various conditions compared to modern elephant values (g %)

	Modern elephant	Mammoth			
		In ice	Permafrost	Tar pit	Fossil
Citrate	1·35	0·05	1·43	0·05	0·03
Hydroxyproline	2·89	2·56	2·54	2·23	0·00

Vliv vysoké teploty na obsah citrátu v kosti



Variations in Major Constituents of Human Bone
in the Derivatograph and in the Kiln
(Investigations by Imre Lengyel on sample from 10th-century cemetery, Szob-Kiserdó)

Substance Examined	Percent at Given Temperature C																	
	Room Temperature	105°	170°	200°	220°	300°	320°	380°	400°	450°	500°	560°	580°	640°	740°	840°	900°	1000°
In the derivatograph:																		
Water-soluble inorganic fraction	100	100	100	97	95	95	92	92	90	81	80	80	80	78	76	76	76	75
Ca^{++}	100	100	100	100	100	100	100	100	83	83	80	80	80	78	78	78	77	77
Mg^{++}	100	100	100	100	100	100	100	100	100	100	100	100	100	96	96	96	96	95
Fe^{++}, Fe^{+++}, Al^{+++}, K^{+}, Na^{+}	100	100	98	90	90	90	90	86	86	86	86	86	83	83	81	81	80	80
PO$_4^{---}$	100	100	100	100	98	96	92	87	83	80	75	70	70	70	70	70	64	64
S^{--}, SiO$_3^{--}$, C1^{-}	100	100	100	100	100	100	100	95	95	95	93	93	90	90	84	84	83	83
CO$_3^{--}$	100	100	86	80	70	55	53	50	42	40	38	38	36	17	15	10	—	—
Water-soluble organic fraction	100	65	60	52	41	20	12	12	8	5	1	—	—	—	—	—	—	—
Organic matter containing N	100	80	73	60	50	50	48	13	10	10	8	3	—	—	—	—	—	—
Organic matter not containing N (CH)	100	92	60	45	20	4	—	—	—	—	—	—	—	—	—	—	—	—
N (sources other than protein)	100	86	86	80	70	41	27	9	5	—	—	—	—	—	—	—	—	—
Citrate	100	90	90	90	85	80	76	72	60	15	2	—	—	—	—	—	—	—
Fat	100	94	60	40	18	3	—	—	—	—	—	—	—	—	—	—	—	—
In the kiln:																		
Water-soluble inorganic fraction	100	100	100	100	100	100	90	90	90	90	90	76	75	75	75	70	70	68
Ca^{++}	100	100	100	100	100	100	100	100	100	100	100	92	92	85	85	85	80	80
Mg^{++}	100	100	100	100	100	100	100	100	100	100	100	100	100	100	96	96	95	95
Fe^{++}, Fe^{+++}, A1^{+++}, K^{+}, Na^{+}	100	100	100	98	98	98	96	96	95	95	93	93	90	90	90	86	86	82
PO$_4^{---}$	100	100	100	100	97	97	93	80	80	74	74	70	70	70	70	70	70	65
S^{--}, SiO$_3^{--}$, C1^{-}	100	100	100	100	100	100	100	100	100	90	90	83	83	83	83	80	80	78
CO$_3^{++}$	100	100	100	74	74	74	60	52	46	40	30	9	5	—	—	—	—	—
Water-soluble organic fraction	100	60	48	41	40	20	10	4	2	1	—	—	—	—	—	—	—	—
Organic matter containing N	100	92	90	70	53	50	34	20	12	9	2	—	—	—	—	—	—	—
Organic matter not containing N (CH)	100	100	65	40	14	6	1	—	—	—	—	—	—	—	—	—	—	—
N (sources other than protein)	100	96	93	90	86	82	74	71	20	11	3	—	—	—	—	—	—	—
Citrate	100	98	97	95	81	62	62	60	60	60	10	1	—	—	—	—	—	—
Fat	100	96	88	30	7	—	—	—	—	—	—	—	—	—	—	—	—	—

Určení pohlaví spálených kosterních pozůstatků

Frisches Material	2.Jt.n.Chr.	Deutschland	0,52%	1,04%
Grödig	6./7.Jh.n.Chr.	Österreich	0,56%	0,86%
Pleidelsheim	5.-7.Jh.n.Chr.	Deutschland	0,42%	0,77%
Kamid el-Loz	5./4.Jh.n.Chr.	Libanon	0,33%	0,58%
Münster-Gittrup	ca. 1Jt.v.Chr.	Deutschland	0,26%	0,53%
Trebur-Hinkelstein	5.Jt.v.Chr.	Deutschland	0,21%	0,40%
Trebur-Großgartach	5.Jt.v.Chr.	Deutschland	0,24%	0,42%

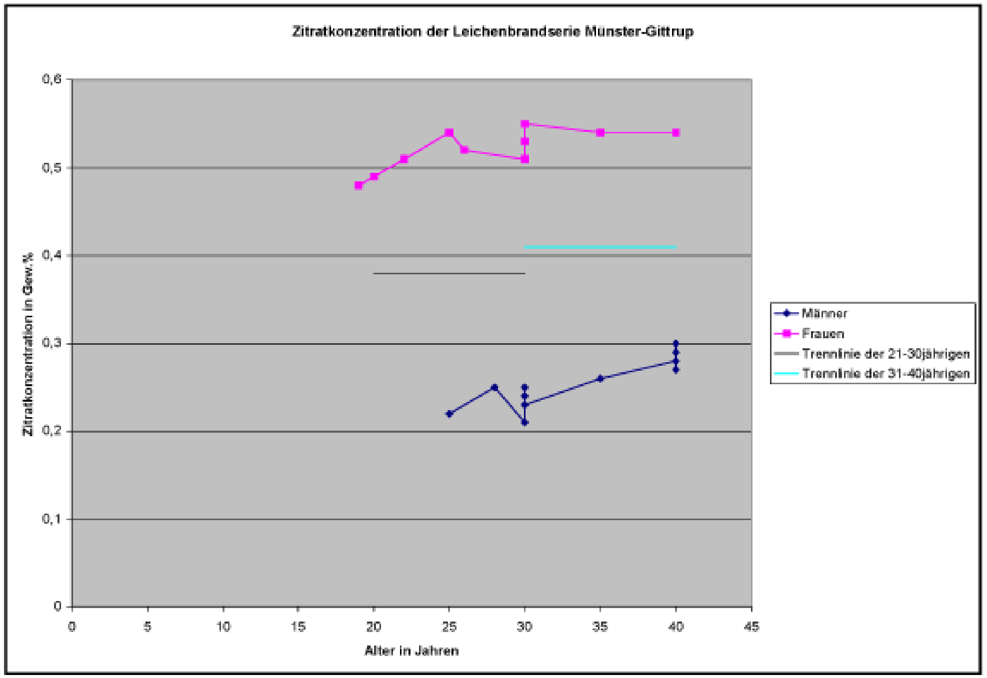


Abbildung 26: Zitratkonzentration des Knochenmaterials der Leichenbrandserie Münster-Gittrup in Abhängigkeit von Lebensalter und Geschlecht

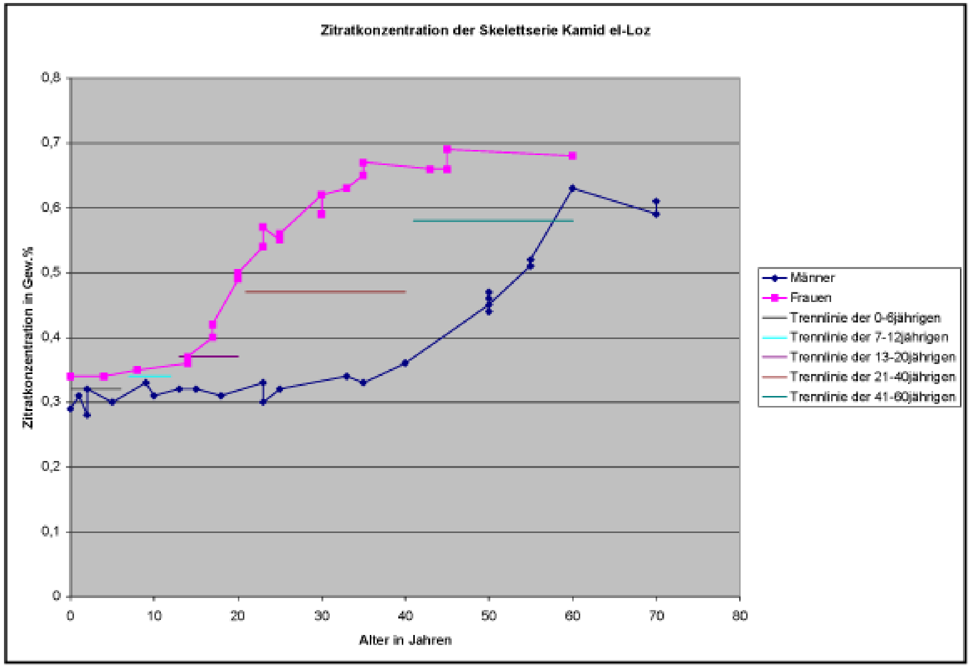
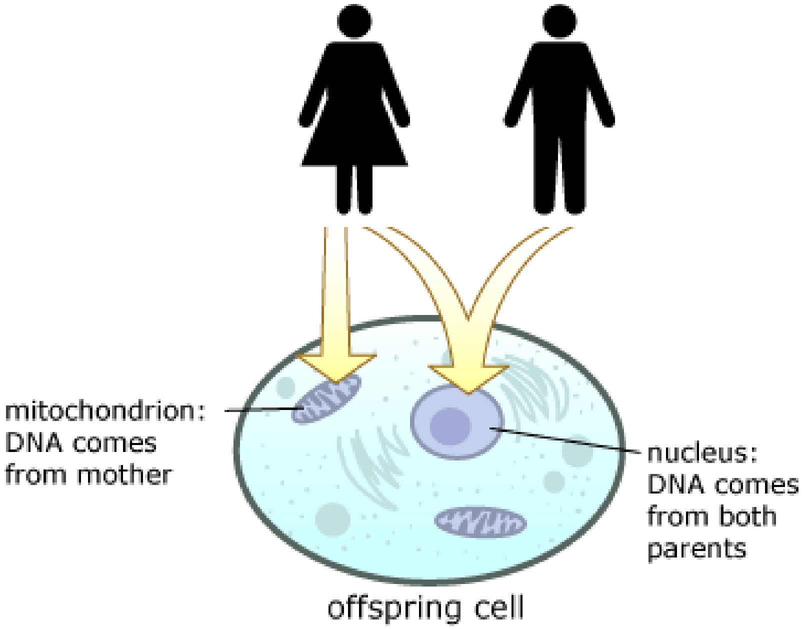


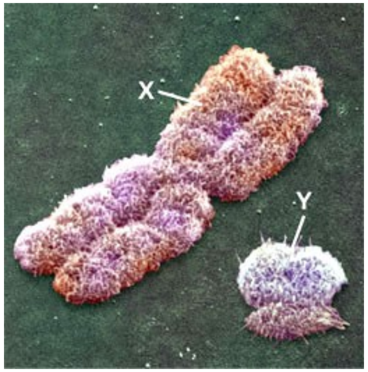
Abbildung 25: Zitratkonzentration des Knochenmaterials der Skelettserie Kamid el-Loz in Abhängigkeit von Lebensalter und Geschlecht

Porównanie wyników określenia płci i wieku szczątków ciałopalnych metodą morfologiczną i biochemiczną

Lp.	Stopień spalenia kości	Nr grobu	Całkowita ilość materiału	Kompleks białkowo-wielocukrowy w mg%	Grupy krwi	Zawartość kwasu cytrynowego w mg%	Płeć	Płeć (morfolog.)	CO_3 g%	Ca g%	PO_4^{3-} P g% (x 3)	Kollagen kostny g%	Wiek biologiczny	Wiek określony metodą morfologiczną
1	2	3	4	5	5	7	8	9	10	11	12	13	14	15
1	miernie	1	11,5	Tylko ślady, poniżej 0,010 mg%	Brak pozytywnej reakcji we wszystkich przypadkach	0,61	K	?	1,65	23,90	4,10	2,15	40—50	Ad/Mt?
2	d. silnie	2	2,1			0,18	?	?	0,60	22,15	5,40	2,00	5—10	Inf. I.
3	d. silnie	3	5,5			0,20	?	?	0,55	21,10	6,50	1,70	0—5	Inf. I.
4	miernie	4-a	11,0			0,67	K	M	0,90	22,60	5,00	2,05	25—35	Ad?
	miernie	4-b	4,3											
5	miernie	5	10,2			0,23	M	K?	1,15	23,15	3,90	2,10	45—55	Jv?
6	d. silnie	6	6,4			0,63	K	?	0,65	21,60	5,15	1,85	5—15	Inf. I.
7	d. silnie	8	10,6			0,16	?	?	0,60	22,00	5,35	1,80	5—10	Inf. I.
8	miernie	12	9,6			0,54	?	?	0,95	22,05	4,80	2,00	30—40	Inf. I.
9	d. silnie	13	7,0			0,60	K	?	0,75	23,15	5,05	2,00	15—20	Inf. I.
10	d. silnie	15	14,2			0,65	K	?	0,90	23,50	4,95	2,10	25—35	Jv/Ad?
11	miernie	16	12,1			0,35	M	M	0,85	22,80	5,10	2,05	20—30	Jv
12	miernie	17-a	5,3			0,30	M	?	0,80	23,30	5,05	2,30	20—30	Inf. I.
	miernie	17-b	4,5											
13	miernie	18	7,3			0,40	M	K	0,95	23,45	4,60	2,10	35—45	Jv?
14	d. silnie	19	14,1			0,60	?	?	1,60	23,85	4,15	2,00	40—50	Jv
	miernie	20-1	11,0											
15	miernie	20-2	6,5			0,31	M	M	1,95	23,60	3,90	1,90	45—55	Jv/Ad
	miernie	20-3	8,2											
16	miernie	21-1	9,5			0,68	K	K?	0,95	23,95	4,50	2,15	35—45	Inf. II/Jv
	miernie	21-2	7,2											
17	miernie	22-1	5,1			0,37	M	K	0,80	23,20	4,75	2,10	30—40	Ad
	miernie	22-2	8,3				?	?						Inf. I.
18	miernie	24	7,0			0,62	K	K?	0,75	22,90	4,90	2,10	25—35	Ad
19	słabo	26	12,2			0,41	M	K?	1,95	21,60	3,60	2,00	50—60	Jv/Ad
20	słabo	27	14,2			0,43	M	M	1,90	21,45	3,40	1,80	50—60	Ad?
21	miernie	30	17,1			0,44	M	?	0,70	23,30	5,00	2,60	25—35	Inf. I.
22	miernie	31	10,5			0,67	K	K?	1,10	22,90	4,00	2,00	45—55	Inf. II/Jv
23	miernie	32	8,3			0,64	K	?	1,90	21,85	3,45	2,00	50—60	Inf. I.
24	miernie	33	16,1			0,40	M	M	1,85	21,50	3,60	1,70	50—60	Jv

DNA v paleodemografii





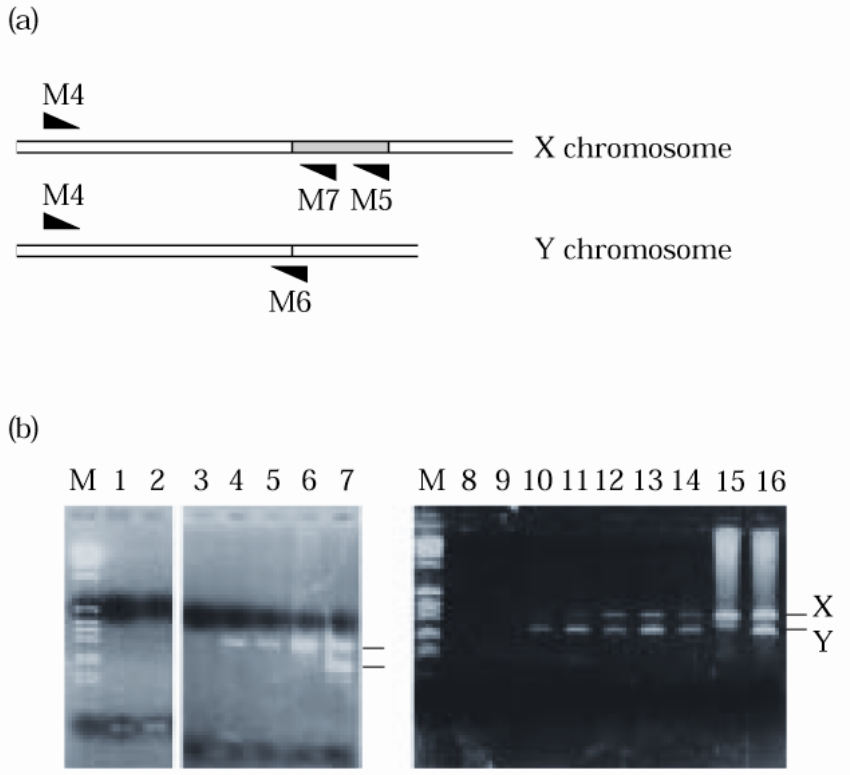


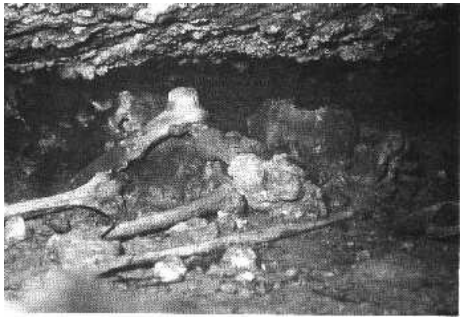
Figure 2. (a) Part of the amelogenin encoding gene showing the location of the PCR primers. Fragment deleted in the Y chromosome is indicated. (b) Sex identification of Ashkelon infants: M—size marker (1 kb DNA ladder); lanes 1, 8, ‘‘no DNA’’ PCR control; lane 2, ‘‘blank extraction’’ control; lanes 3–5, specimen No. 100; lanes 9–11, specimen No. 94; lanes 12–14, specimen No. 96; positive controls: lanes 6, 15, modern female DNA; lanes 7, 16, modern male DNA.

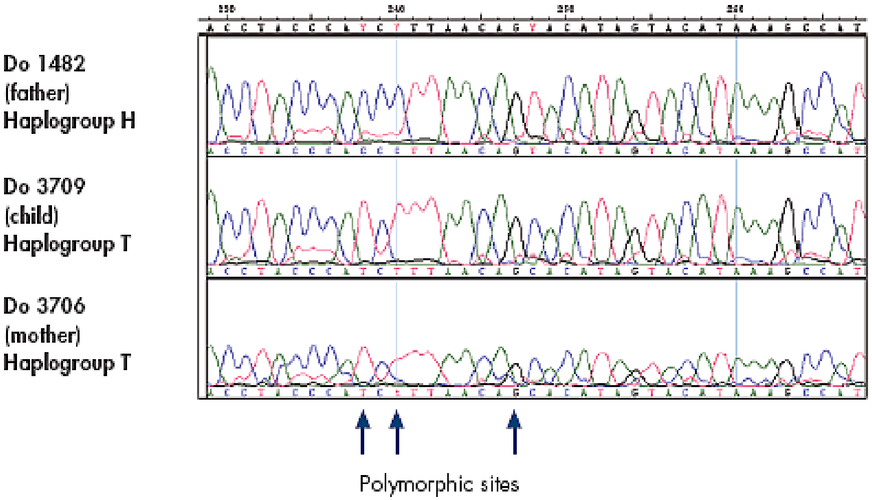
Určování příbuznosti

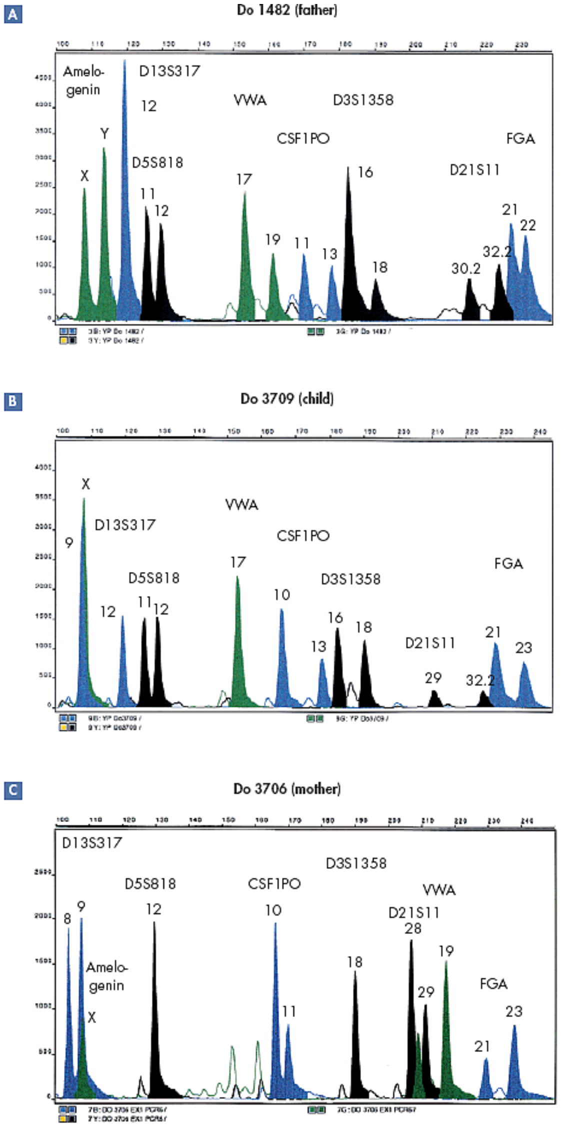
Liechtenstein Höhle

Dorste, Dolní Sasko, mladší doba bronzová

Kultiště? Rodová hrobka?







Archeozoologie

Dudley Castle, Leceistershire

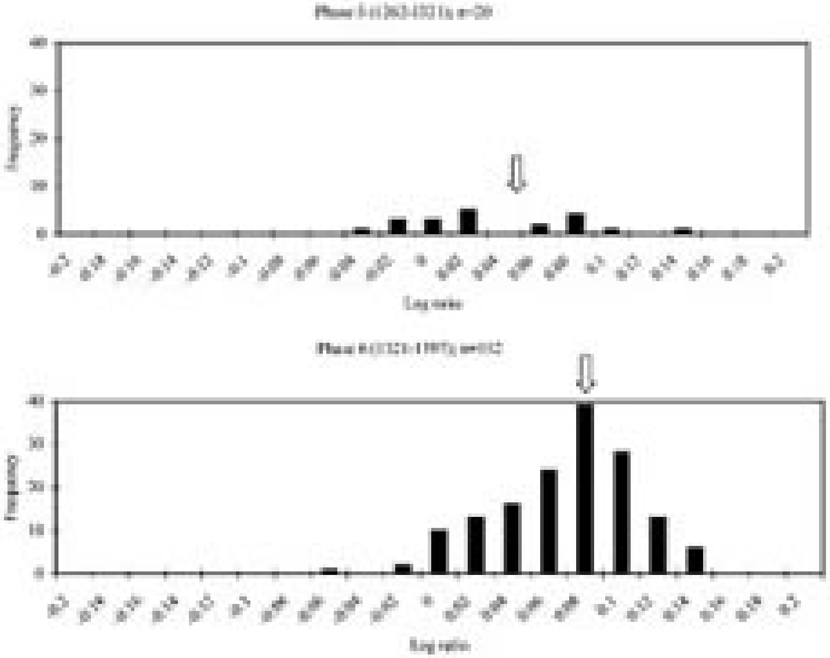
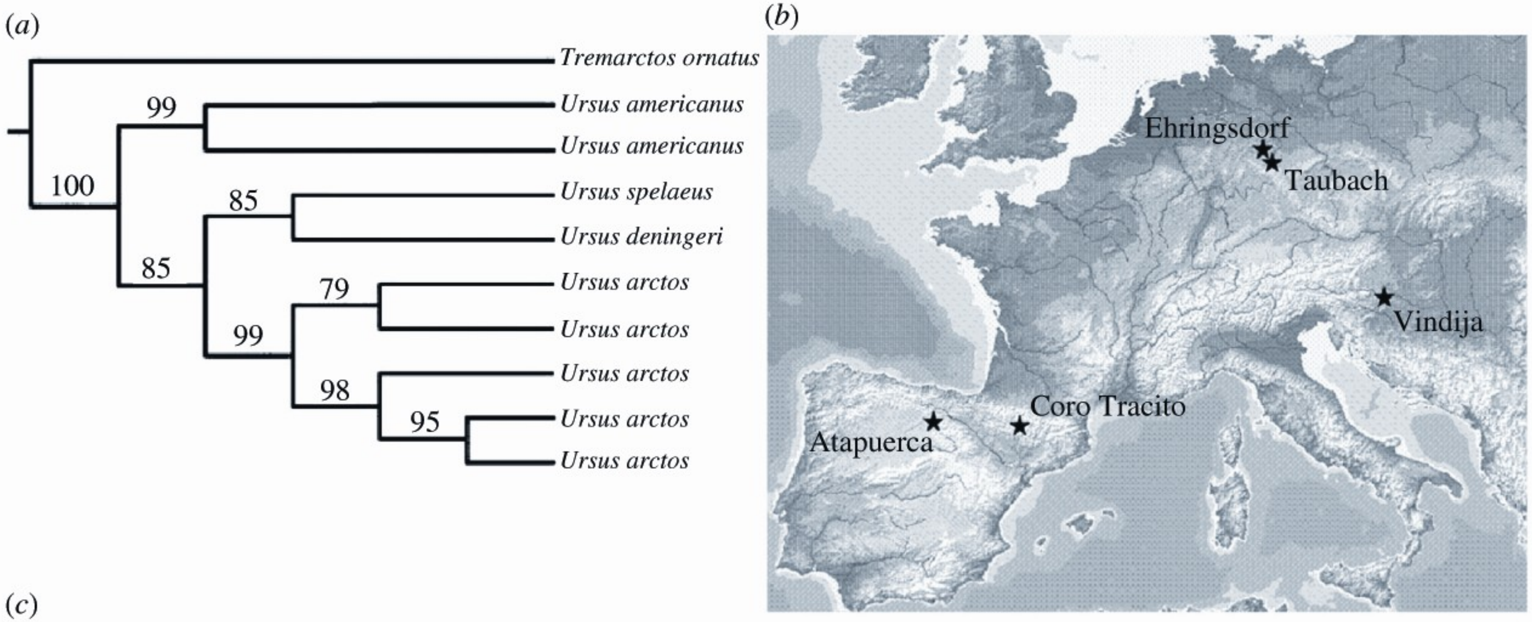


Fig. 2. Log ratios of cattle width measurements at Dudley Castle by phase. The standard is derived from measurements taken on fifteenth-century cattle bones from Launceston Castle (Albarella and Davis, 1996). An arrow indicates the mean of each dataset. Measurements included: tibia Bd; astragalus GL1, Bd, Dl (after von den Driesch, 1976); humerus BT, HTC (after Bull and Payne, 1982); metapodial GL, SD, Bd, a, b, 1, 3, 4 (after Davis, 1992).

From Thomas *et al.* 2005: 77

Fylogenetická příbuznost pleistocénních medvědů



(c)

site	type	age	*n*	yielding DNA	all 16 substitutions
Atapuerca	*U.deningeri*	~400.000	5	5	2
Ehringsdorf	*U.spelaeus*	230.000–110.000	1	1	0
Vindija	*U.spelaeus*	~30.000	6	3	0
Coro Tracito	*U.spelaeus*	upper Pleistocene	3	3	3
Ehringsdorf / Taubach	*U.arctos*	230.00–110.000	10	8	0

Figure 1. (*a*) Phylogenetic position of *Ursus deningeri*. Maximum parsimony tree using molecular data from cytochrome *b*. The grouping of *U. deningeri* and *U. spelaeus* was well supported (1000 replicates). (*b*) Sites for the caves with bear samples. (*c*) Out of 25 samples, 20 yielded bear DNA, out of which 5 yielded all 16 polymorphic sites.

„Molekulární hodiny“

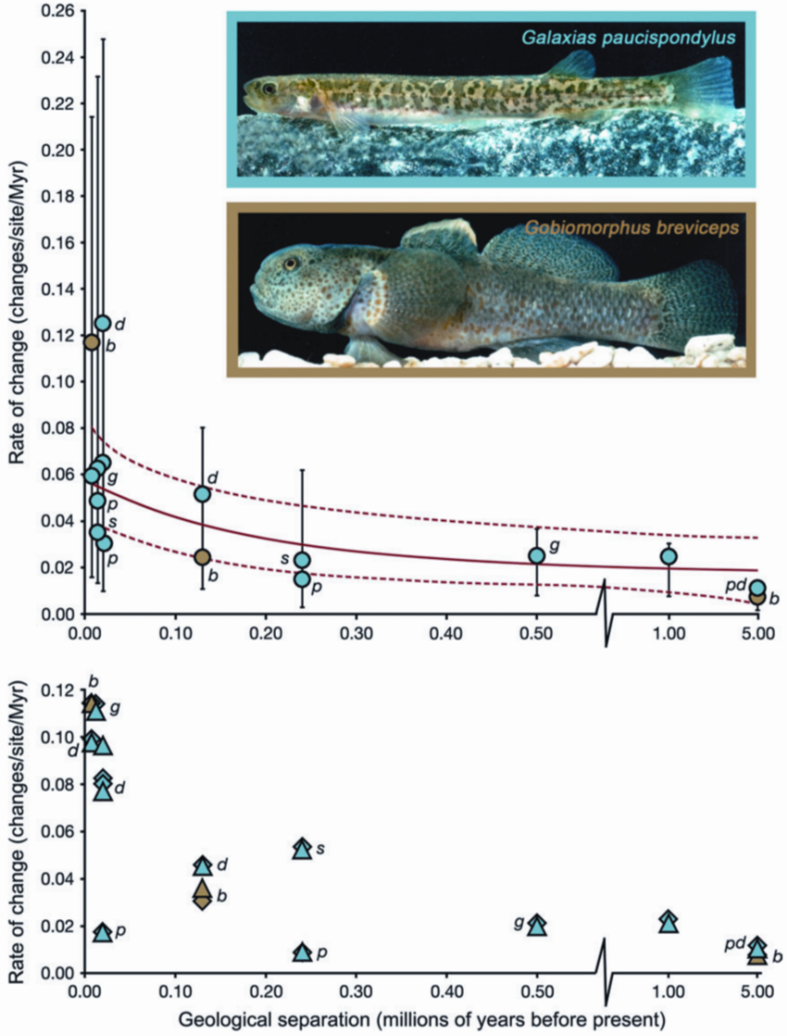
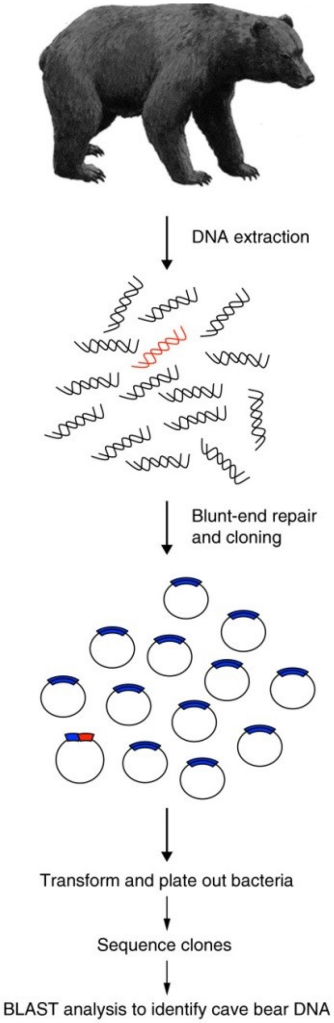
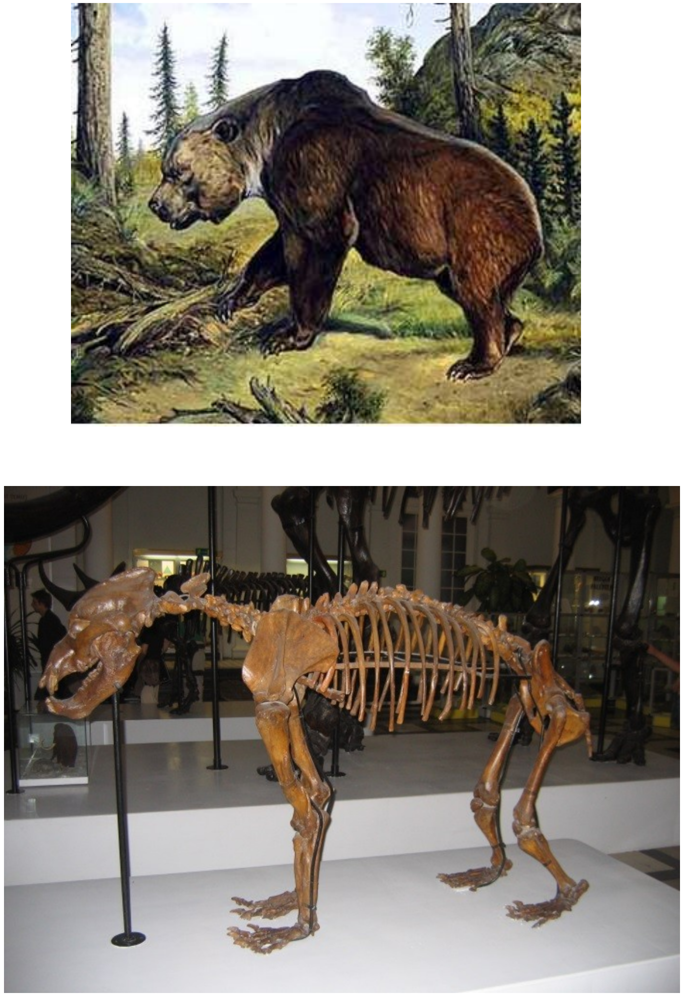


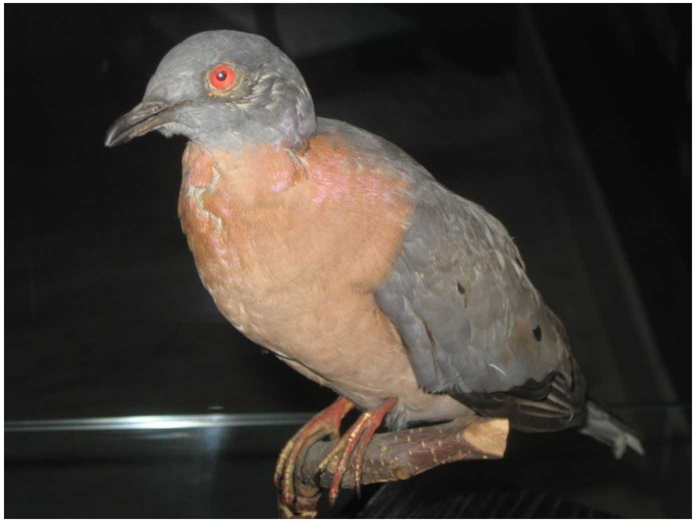
FIG. 3.—Molecular clock calibrations (nucleotide changes/site/Myr) derived from dated isolation events of New Zealand freshwater fish populations. Blue symbols represent galaxiid divergences (Galaxiidae), and brown symbols represent *Gobiomorphus breviceps* (Eleotridae). Letters indicate rates derived from multiple events for the same species (g, *Galaxias gollumoides*; d, *Galaxias divergens*; s, *Galaxias 'southern'*; p, *Galaxias paucispondylus*; b, *Gobiomorphus breviceps*). Where ages are represented by both minimum and maximum estimates (table 1), we employed the latter, yielding minimum estimates of rates. The top graph represents coalescent-based estimates (error bars are the 90% highest posterior density). The red lines are vertically translated exponential decay curves for galaxiid data representing best-fit estimates (solid line, $y = 0.01876 + 0.03911 \times e^{-5.25878x}$) and upper and lower 95% confidence intervals of model parameters (supplementary text S1, Supplementary Material online). The bottom graph represents "simple" rates based on net sequence divergences under either uncorrected (*p* distance, triangles) or HKY (diamonds) models of nucleotide substitution. Two young calibration events yielded negative simple rates (maximum intracatchment divergence exceeded intercatchment divergence, table 1) and are not shown on the lower graph.

Klonování vyhynulých živočichů

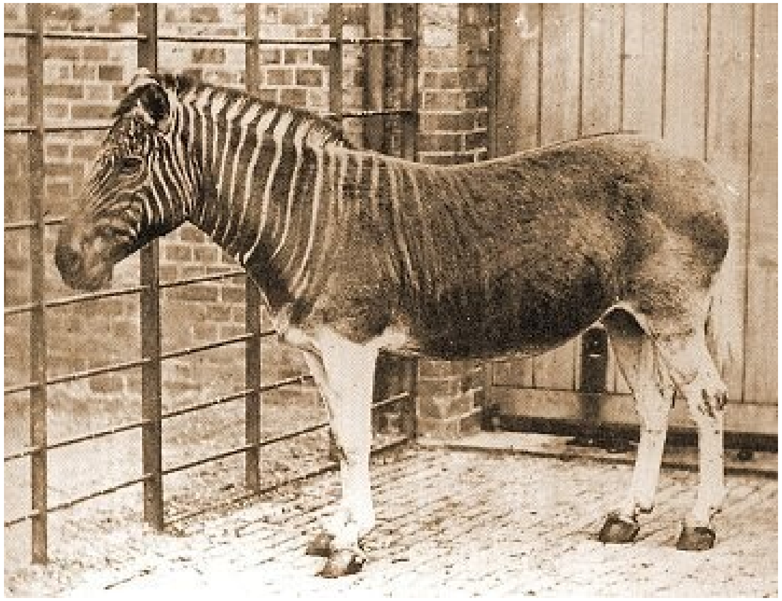




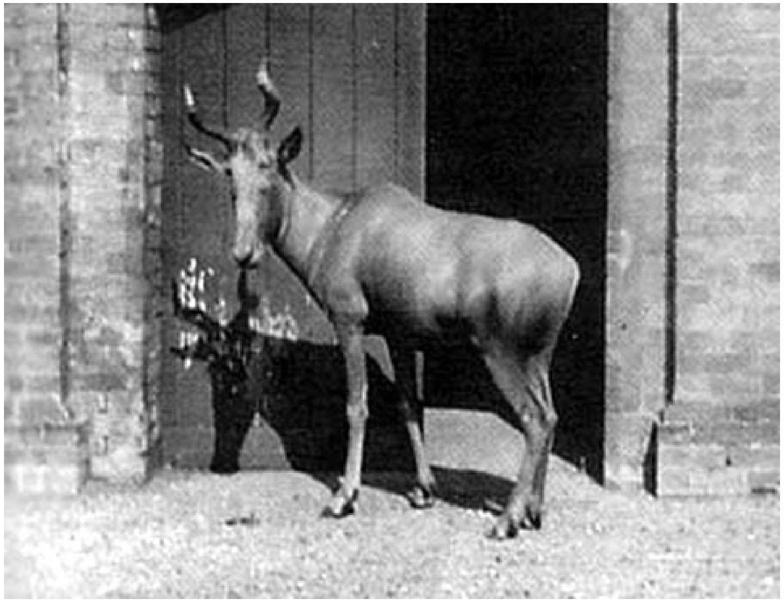
Medvěd jeskynní



Holub stěhovavý (1914)



Zebra qagga (1883)



Buvolec stepní (1923)

Vakovlk (tasmánský tygr) (1930)

Poslední pyrenejský kozorožec, samice Celia, byla nalezena mrtvá pod padlým stromem v lednu 2000.

Kozorožec pyrenejský (2000)

Jedná se o první druh, který byl klonován, ale mládě uhynulo pouhých 7 minut po narození na defekt plic.

Analýza výživy z koprolitů

Analýza DNA koprolitů obřího lenochoda
Nothrotheriops shastensis

Nature Reviews | Genetics