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Provenancing of unidentified corpses by stable isotope techniques – Presentation of case studies

Christine Lehn¹, Andreas Rossmann², Susanne Rummel³ and Matthias Graw¹

1 Dept. of Forensic Medicine, Ludwig-Maximilians University, Munich, Germany

2 Isolab GmbH, Laboratory for Stable Isotope Analyses, Schweitenkirchen, Germany

3 Bavarian State Collection for Palaeontology and Geology, Munich, Germany

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Methods for identification of unknown individuals:

- DNA investigation,
- investigation of clothes and jewellery, tattoos,
- odontological and physical characteristics,
- soft tissue reconstruction
- **isotope expert report**
(ordered by police/ prosecution)



Since 2002 at the Institute of Forensic Medicine in Munich:

> 70 adults, > 20 newborns, > 10 archaeological individuals

Aim: Indication of geographical origin and whereabouts of unknown persons.

Basic idea: Nutrition, drinks and environment lead to an incorporation of different isotope ratios of chemical elements into body tissues.

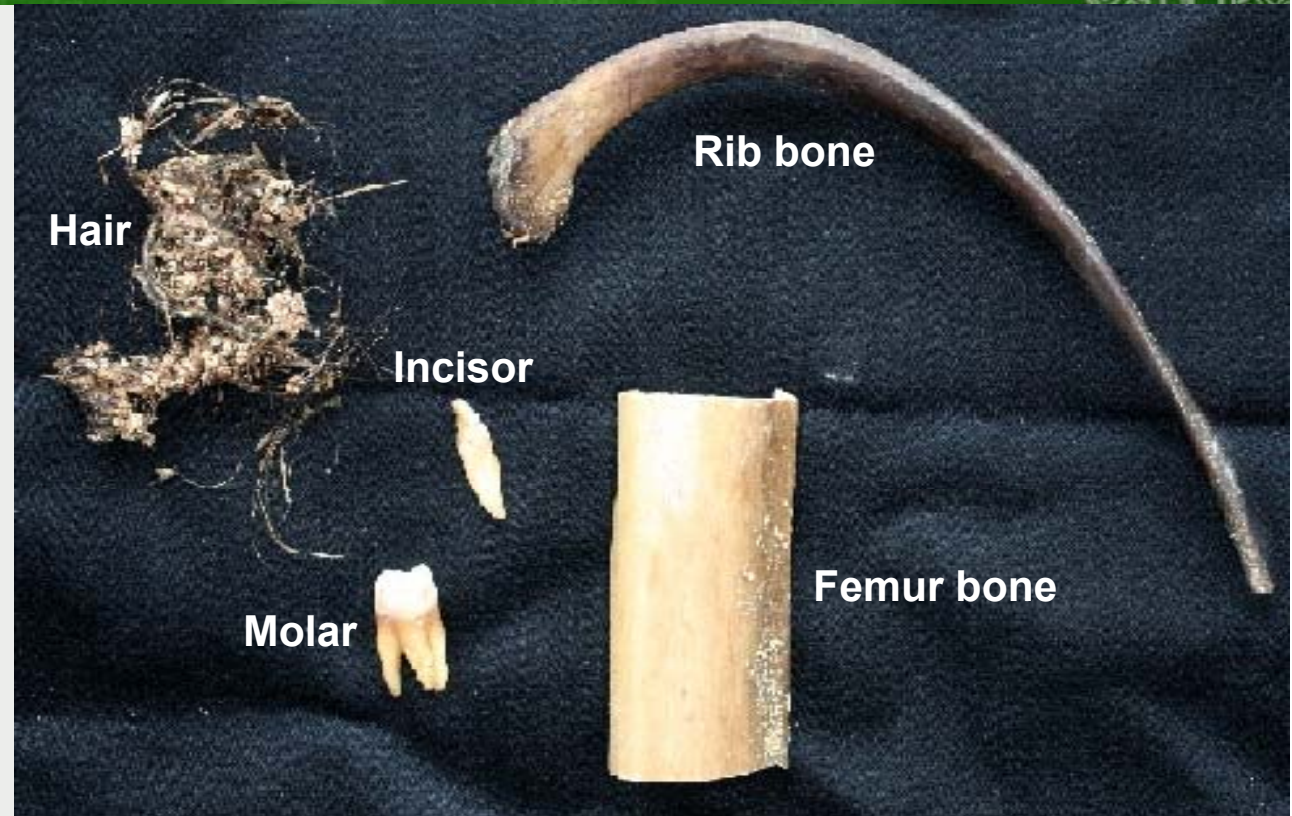
Stable isotope analysis: H, C, N, S (bio-elements), Sr / Pb (geo-elements)



Body tissues:

- Teeth (incisor, molar)
- Bones (e.g. rib, femur)
- Hair/ Nails
- Miscellaneous (e.g. blood, urine, muscle)

→ **characterization of the whole lifetime of an individual**



Stable isotope analysis of the **bio-elements** in proteins:

→ **keratin** (hair/ nails) or **collagen** (bone/ dentine)

→ multi-element isotope analysis of H, C, N and S

Isotope analysis of the **geo-elements** (Sr, Pb) in bone apatite, tooth enamel, hair/ nail and miscellaneous (by Peter Horn).



Reference Hair Database - HCNS

(June 2013, N = 679)

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Europe:

Northern Germany	55
Southern Germany	98
Austria	22
Switzerland	18
France/ Luxembourg	29
Spain	3
Denmark	12
Norway/ Finland/ Island	10
Sweden	1
Lithuania	19
Poland	19
Czech Republic/Slovakia	13
Ukraine	7
Hungary	6
Romania	14
Bulgaria	3
Greece/ Cyprus	4
Italy	34
Serbia/ Montenegro/ Slovenia	11
Turkey	3
Netherlands	7

UK/ Ireland	28
Russia	37

Asia:

Japan	14
Western China	12
Eastern China	11
India	6
Nepal	1
Indonesia/ Malaysia	8
Saudi Arabia	1
Lebanon	10
Philippines	2
Vietnam	1
Thailand	11
Pakistan	6
Iran	8

Australia/ New Zealand:

Australia	9
New Zealand	14

Northern Africa:

Ethiopia	3
Nigeria	1

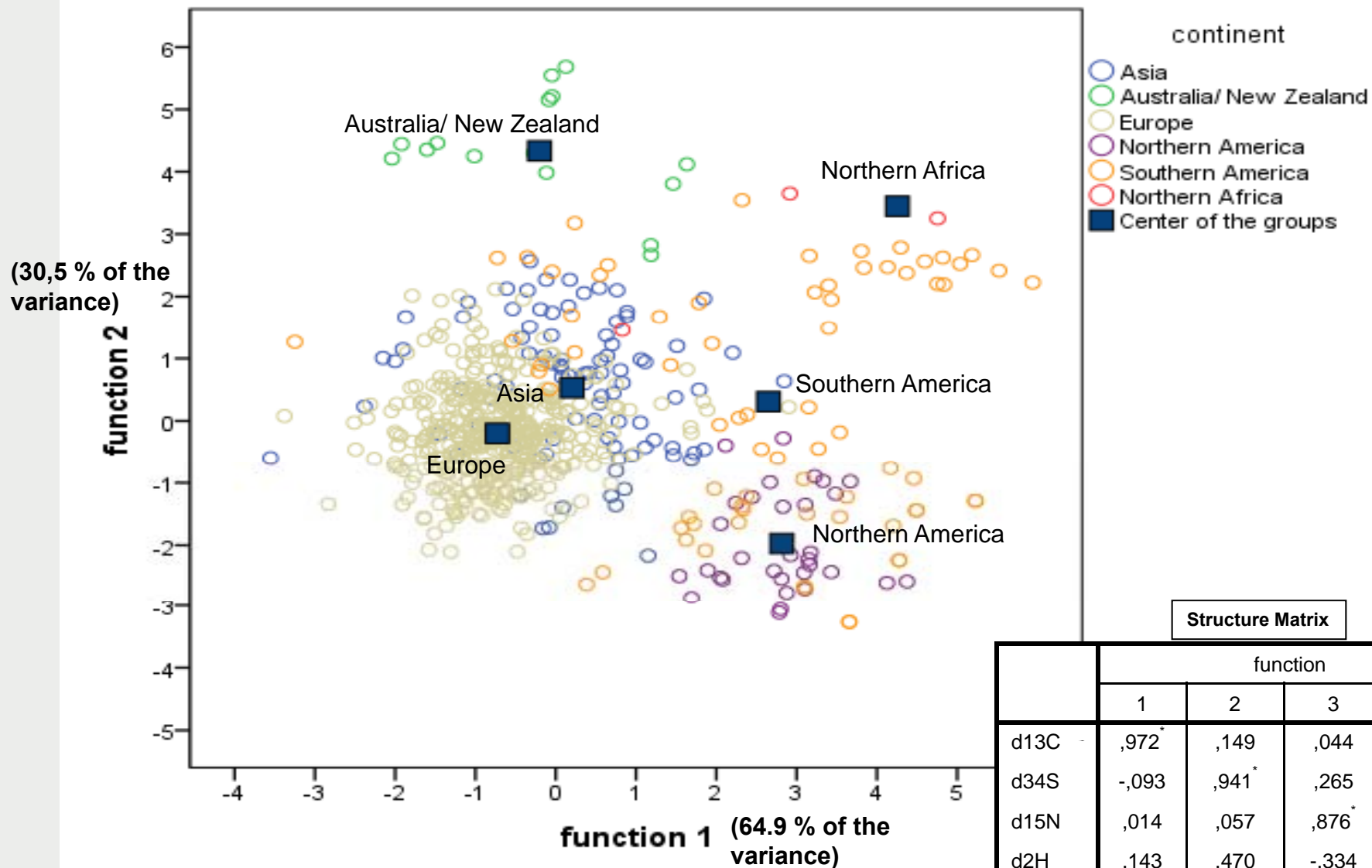
Northern America:

Arizona	3
Canada	15
Illinois	8
Michigan	3
Utah	3

Southern America:

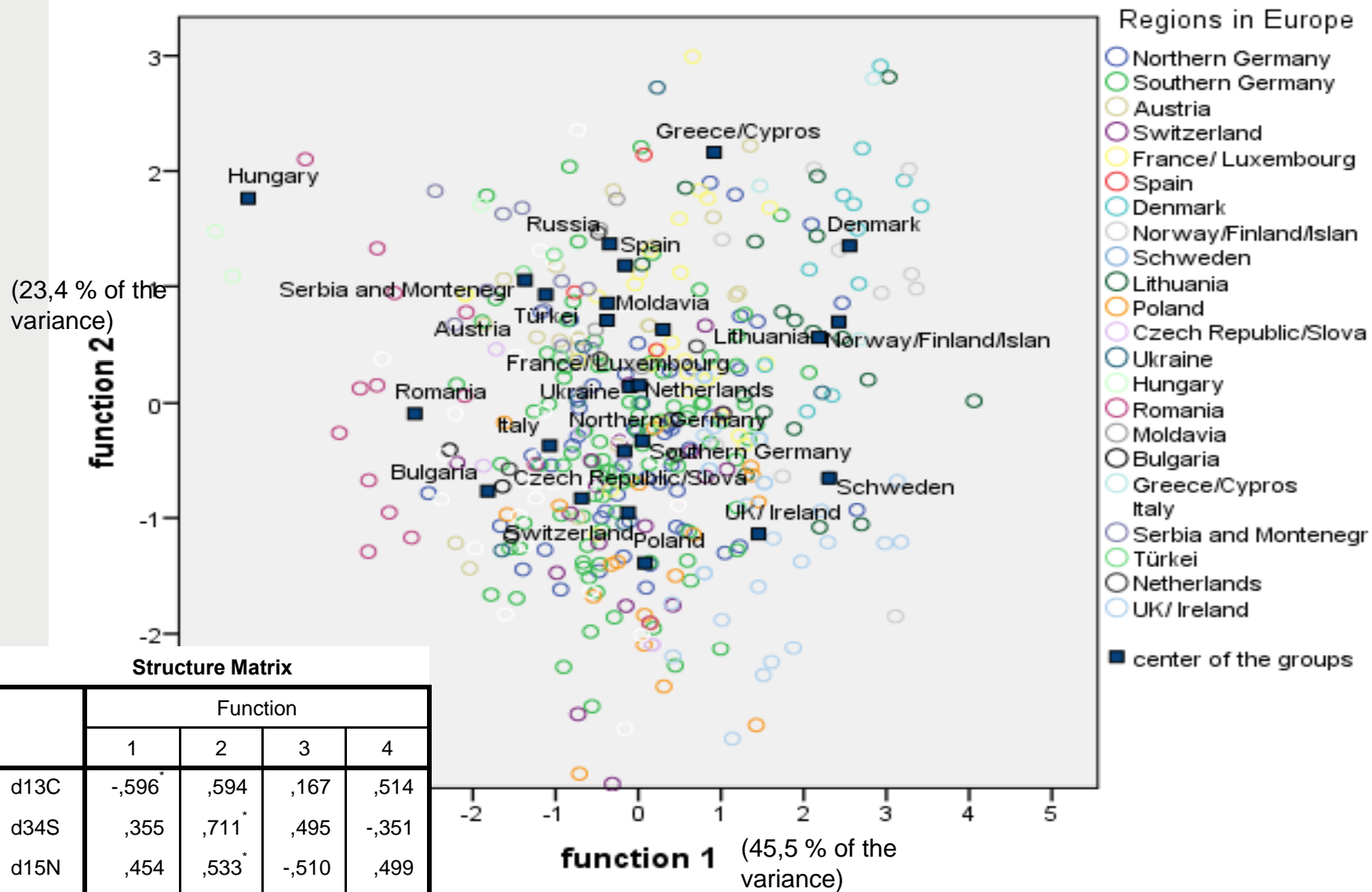
Brasilia	22
Costa Rica	17
Mexico	5
Chile	5
Cuba	4
Bolivia	5
Argentina	1
Peru	10
Martinique	7

Entire 679



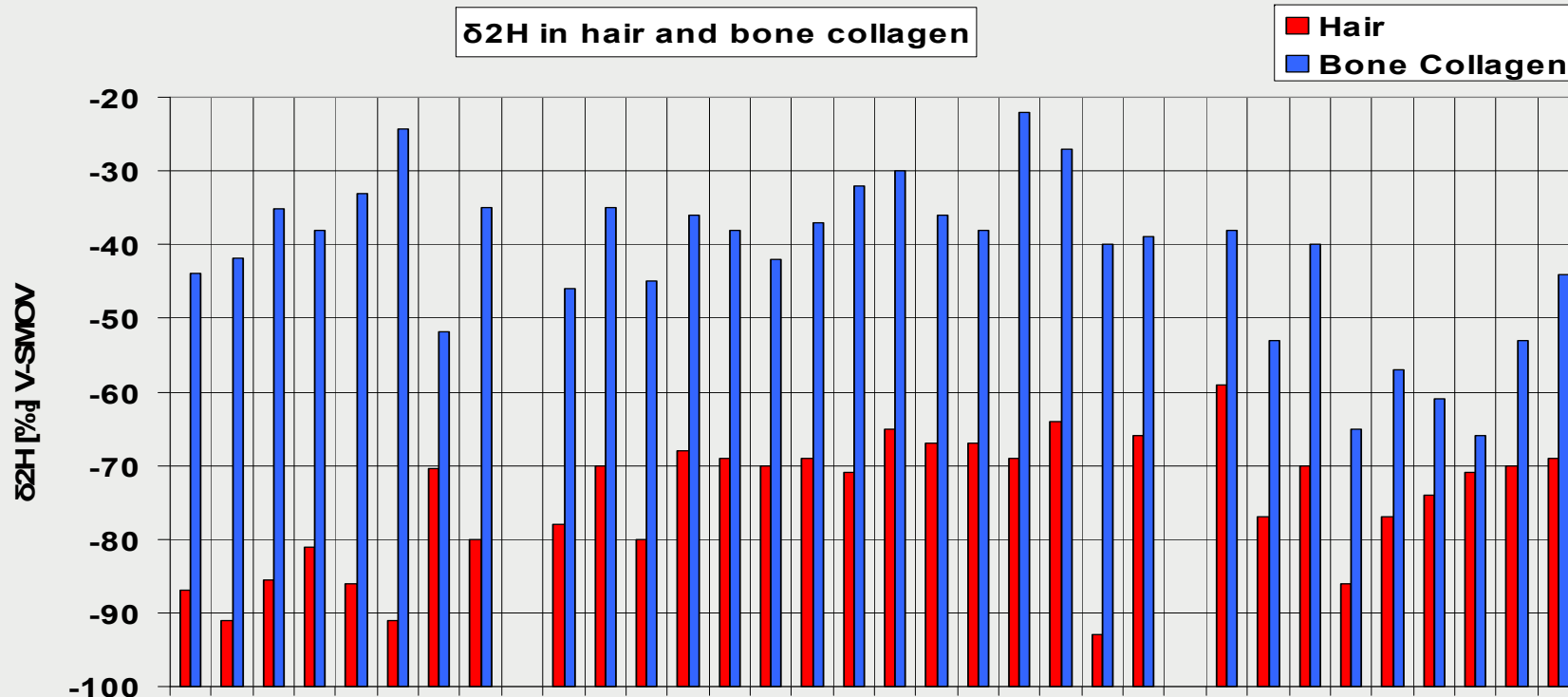
Canonical Discriminant Function (HCNS)

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Structure Matrix

	Function			
	1	2	3	4
d13C	-,596*	,594	,167	,514
d34S	,355	,711*	,495	-,351
d15N	,454	,533*	-,510	,499
d2H	,099	-,015	,489	,866*



Correction factors for comparison of collagen and keratin ($\Delta_{\text{Hair-Collagen}}$):

Group	$\delta^2\text{H}$ [‰] Mean (\pm SD)	$\delta^{13}\text{C}$ [‰] Mean (\pm SD)	$\delta^{15}\text{N}$ [‰] Mean (\pm SD)	$\delta^{34}\text{S}$ [‰] Mean (\pm SD)
Adults (N=15)	-35 (7)	-0.7 (0.6)	-1.4 (0.6)	+1.8 (0.8)
Newborns (N=9)	-20 (7)	-0.4 (0.2)	-1.3 (0.3)	+2.0 (0.4)



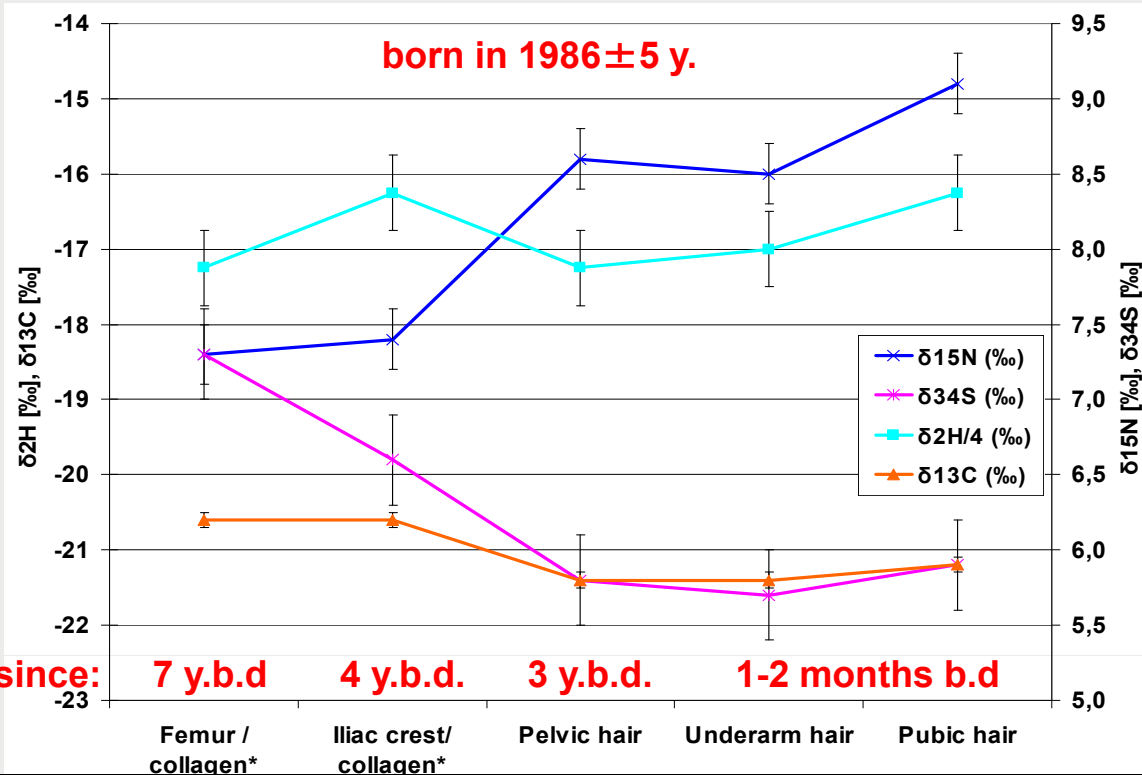
Case 1: Parts of a male body found in a flood basin in Eastern Germany

- November 2011: Both arms, torso, part of a pelvis, femur were found, – but no scalp!

Results of autopsy:

- Male person, aged between 21 and 30 years
- Slender, athletic, well-conditioned frame, body height between 167 and 177 cm
- Time of death max. 1-2 days before bringing into water
- Laytime in water several days until two weeks

Tissue	Incorporation time for the chemical elements	Stable isotope analyses
Femur	from 2004 – 2011	Collagen: HCNS Apatite: Pb, Sr
Iliac crest	from 2007 – 2011	Collagen: HCNS Apatite: Pb, Sr
Pelvic hair (10 cm)	Oct. 2008 – Oct. 2011	Hair: HCNS
Pubic/ underarm hair (1 cm)	Sept. – Oct. 2011	Hair: HCNS
Muscle	Some weeks before death in Nov. 2011	Pb



Incorporation time since:

Femur / collagen* Iliac crest/ collagen* Pelvic hair Underarm hair Pubic hair

Tissue/ Segment	Continent		Region	
	1. Priority (P)	2. Priority (P)	1. Priority (P)	2. Priority (P)
Femur/ Coll.*	Asia (0.77)	Europe (0.23)	North.Germany (0.24)	West-China (0.21)
Iliac crest/ Coll.*	Asia (0.69)	Europe (0.31)	South.Germany (0.28)	North.Germany (0.24)
Pelvic hair (max. 10 cm)	Europe (0.89)	Asia (0.11)	South.Germany (0.37)	England (0.33)
Underarm hair (shaved, 1cm)	Europe (0.87)	Asia (0.13)	South.Germany (0.38)	England (0.31)
Pubic hair (shaved, 1 cm)	Europe (0.92)	Asia (0.09)	England (0.47)	South.Germany (0.28)

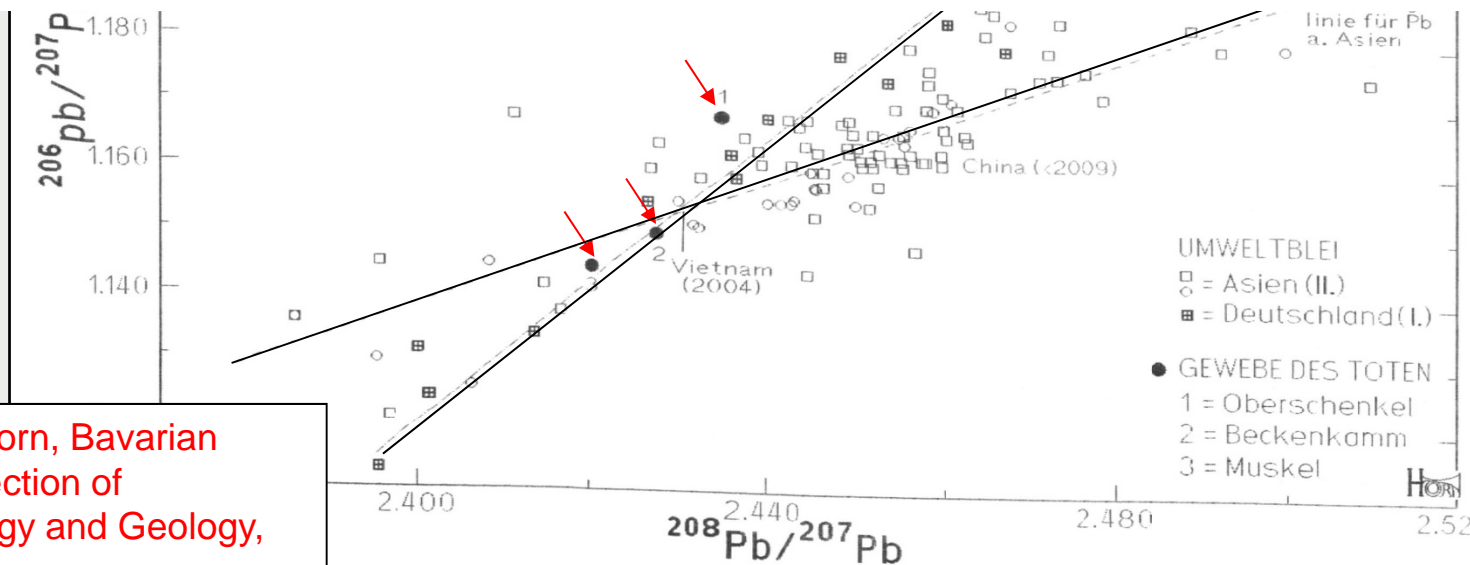


Isotope values
of the geo-
elements:

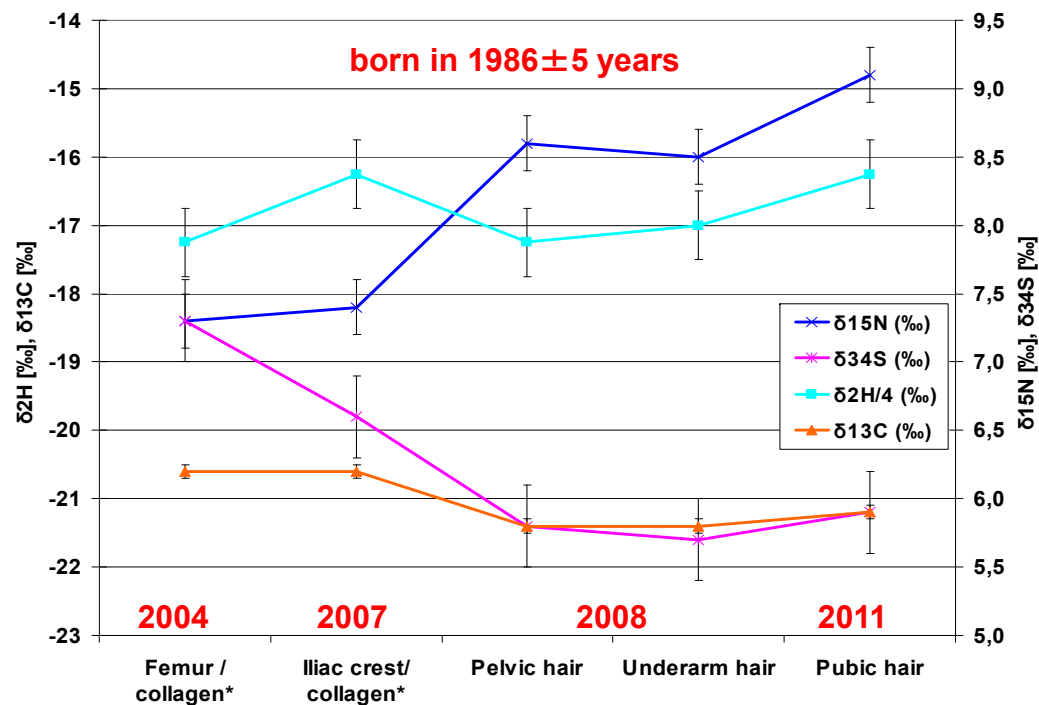
Tissue	$^{87}\text{Sr}/^{86}\text{Sr}$	$^{206}\text{Pb}/^{207}\text{Pb}$	$^{208}\text{Pb}/^{207}\text{Pb}$
1 Femur	0.70901 ± 0.00010	1.1682 ± 0.0007	2.4346 ± 0.0014
2 Iliac crest	0.70917 ± 0.00001	1.1499 ± 0.0006	2.4275 ± 0.0012
3 Muscle	0.71001 ± 0.00002	1.1447 ± 0.0006	2.4201 ± 0.0013

Interpretation of Pb-Isotopes/ Conclusion (P. Horn):

- Pb-isotope values of the man's tissue lay along the German Pb mixture line.
- The dead man most probably was born in Germany and predominantly lived there or in bordering countries.
- About two or three years before death he changed his residence from a rural area to a place with more traffic and stayed there until at least two weeks before death.
- Sr-isotope values are not specific for special worldwide regions. But the values support the possibility, that the man could have lived in the region where the human remains were found.



by Peter Horn, Bavarian
State Collection of
Paleontology and Geology,
Munich

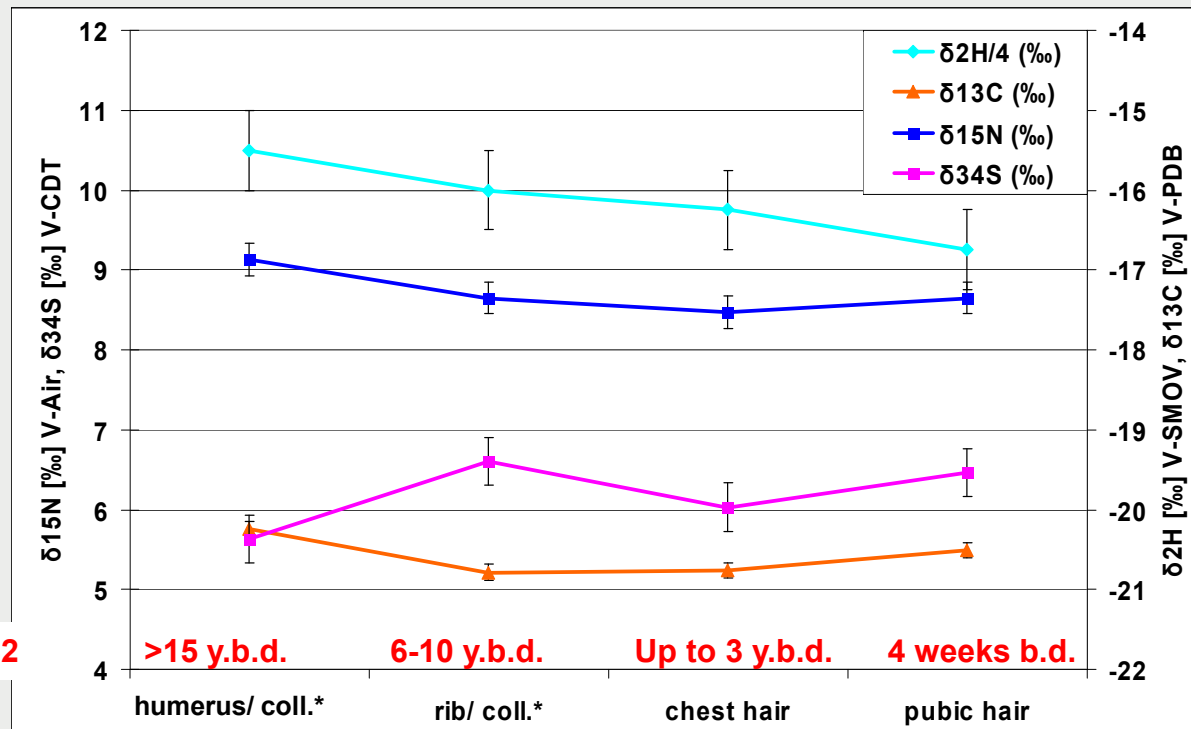


Identity:

- 23-years old man from Leipzig (born in 1988).
- Father came from Eastern Asia, mother from Germany.
- At the age of 18 (2006) the young man came into a boarding school near Leipzig.
- Two years later (2008) he lived in his own apartment in Leipzig, he stayed there until his death in November 2011.

Case 2: Male torso, found in a forest area (Sept. 2012)

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Born before 1982

Tissue/ Segment	Continent (P) I	Continent (P) II	Region (P) I	Region (P) II
Humerus/ Coll.*	Europe (0.73)	Asia (0.27)	South.Germany (0.37)	England (0.14)
Rib/ Coll.*	Europe (0.67)	Asia (0.33)	South.Germany (0.38)	England (0.16)
Chest hair (4 cm)	Europe (0.68)	Asia (0.32)	South.Germany (0.42)	England (0.14)
Pubic hair (1 cm)	Europe (0.64)	Asia (0.36)	South.Germany (0.41)	North.Germany (0.12)

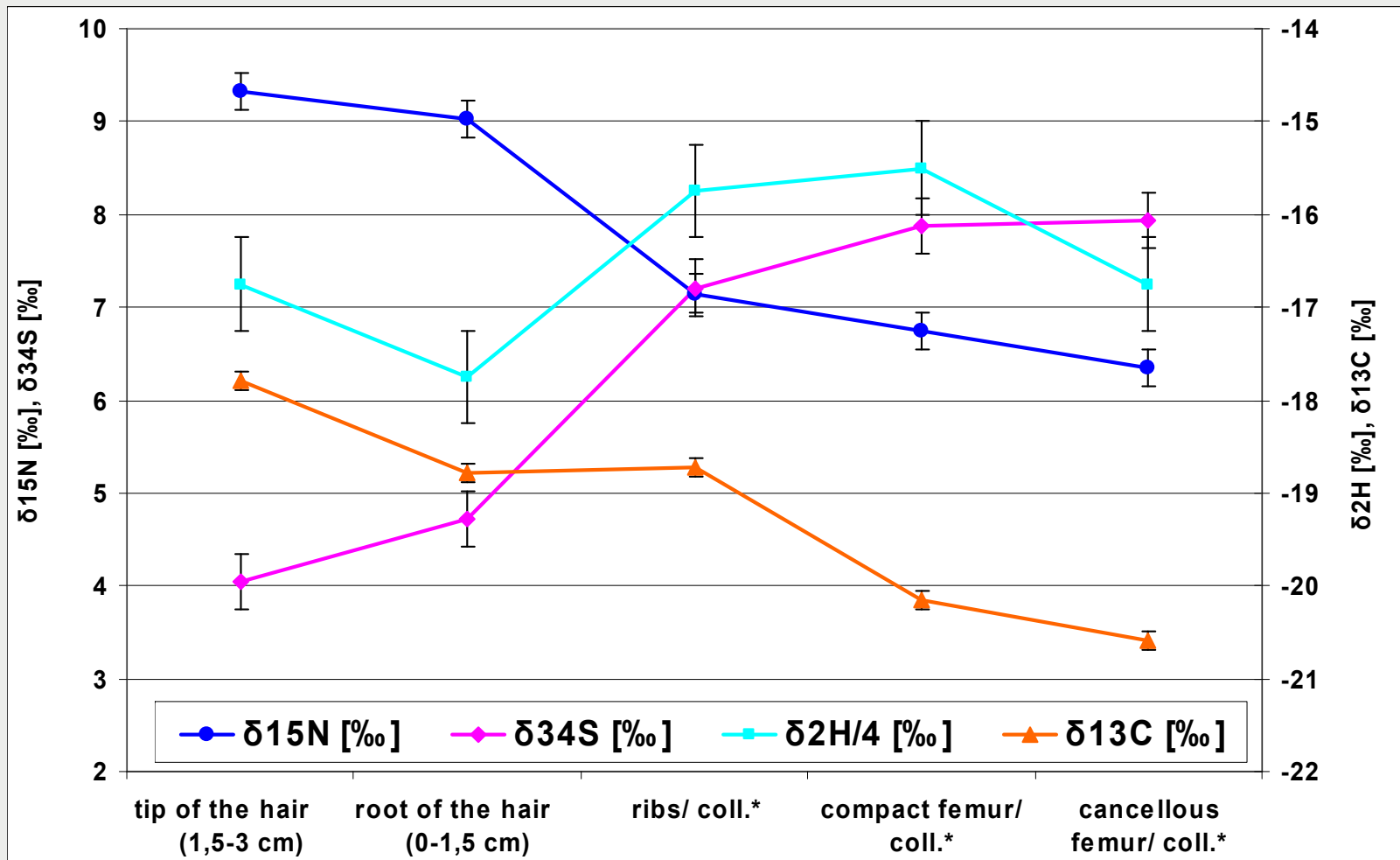
Identity and living circumstances:

- Statement of the police: Hints from the prison in Frankfurt show that the man was a 48-years old drinker, who permanently lived in a geographically small region (between Frankfurt and Darmstadt)

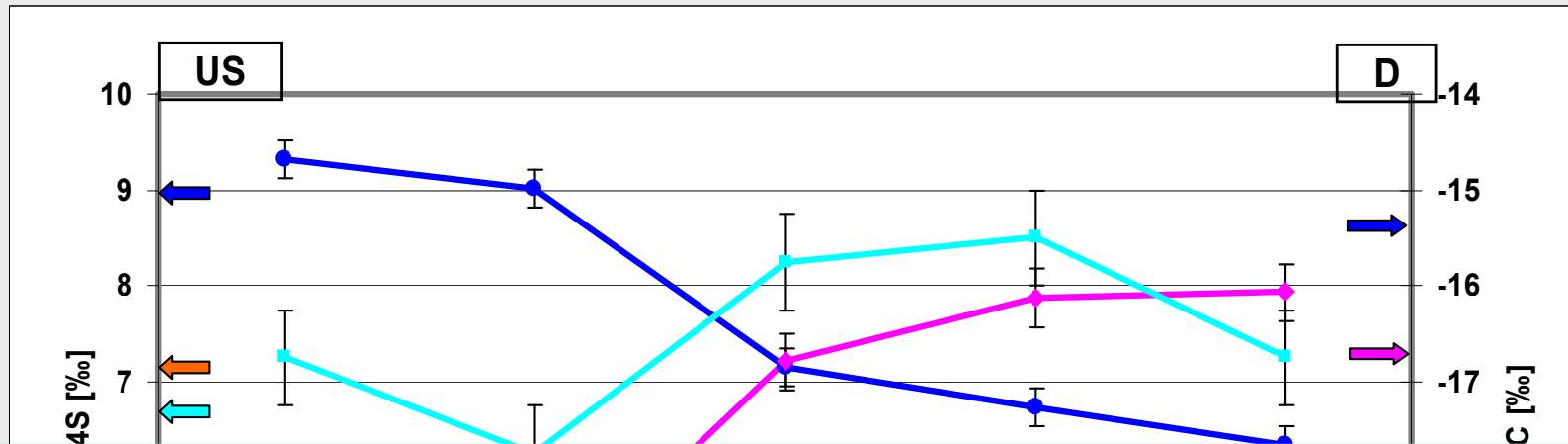


- A female newborn was found dead in a city of Western Germany (March 2010)
- Body was partly skeletonized
- No advice to the child mother
- Tissues for isotope analysis: hair, rib bones, femur bone

Body tissue	Incorporation time of the elements	Stable isotope analyses
Tip of the hair (1,5-3 cm)	7 th month of pregnancy	Hair: HCNS
Root of the hair (0-1,5 cm)	8 th -9 th month of pregnancy	Hair: HCNS
Rib collagen	Up to delivery	Collagen: HCNS
Compact femur bone	Up to delivery	Collagen: HCNS
Cancellous femur bone	Up to delivery	Collagen: HCNS



7th month of pregnancy: Michigan/ Illinois	8th/9th month of pregnancy: Canada/ Michigan	up to delivery: Hungary/ Romania	up to delivery: Spain/ Turkey	up to delivery: Northern Germany
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Identity and living circumstances of the child's mother:

- The child mother was a 18-ye-rars-old exchange pupil from New Mexico.
- She went to Germany during the 7th month of pregnancy and lived at a German family during the following months.
- Geographical assignment e.g. to Hungary and Spain occurred because of mixed isotope values of the elements, these are transitional values due to different diets between the US and Germany.

tip of the hair (1,5-3 cm)	root of the hair (0-1,5 cm)	ribs/ coll.*	compact femur/ coll.*	cancellous femur/ coll.*
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7th month of pregnancy: Michigan/ Illinois	8th/9th month of pregnancy: Canada/ Michigan	up to delivery: Hungary/ Romania	up to delivery: Spain/ Turkey	up to delivery: Northern Germany
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- Isotope expert reports give **important advices** to the police (geographical origin and whereabouts, time of changing residences, special circumstances).
- Isotope analysis of **different body tissues** are necessary – information about defined periods of life from birth until death, resp. during pregnancy.
- **Correction factors** for the bio-elements must be considered for comparison collagen with keratin - have proved to be successful for practical use.
- **Canonical discriminant analysis** of the isotope signature of the four bio-elements can be used for origin assignment.
- Reference hair database is still incomplete – **need for more reference hair samples** from different regions, mainly from Eastern Europe and Asia.
- Special nutritional habits conditioned by **cultural identities can influence regional character** of the isotope signatures.
- Common **considerations of bio- and geo-elements** (different isotope systems) in most cases are necessary for a more precise provenancing of an unknown individual.
- Basic **research is necessary**, e.g. about definite incorporation times of the elements into body tissues.