

Perspectives on
translational research by
a young academy of
science member:
Marrying biophysics with
biomedicine to decipher
disease biomarkers

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Opening Remarks



Role of young
scientists in
translational
research



Biophysics and biomedicine



Applications



Questions



**iThemba
LABS**
Laboratory for Accelerator
Based Sciences



Young Academies



Young academies and translational research



SUSTAINABLE DEVELOPMENT GOALS

17 GOALS TO TRANSFORM OUR WORLD





Voice of YR
Tackle challenges
Policy advice
Capacity building

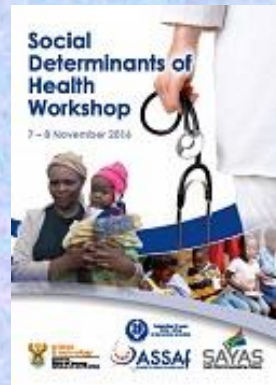
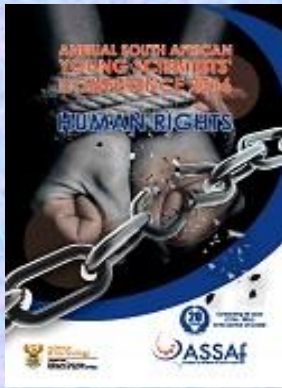


Can We
Trust
Scientists?





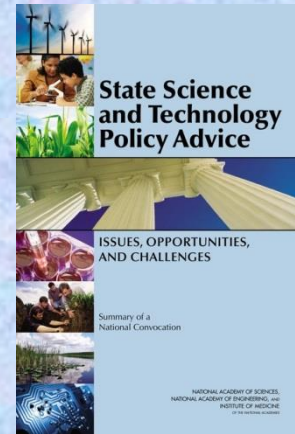
Improving Scholarly Environment



Promoting Science and Society



Policy



Feeding the pipeline





**iThemba
LABS**
Laboratory for Accelerator
Based Sciences



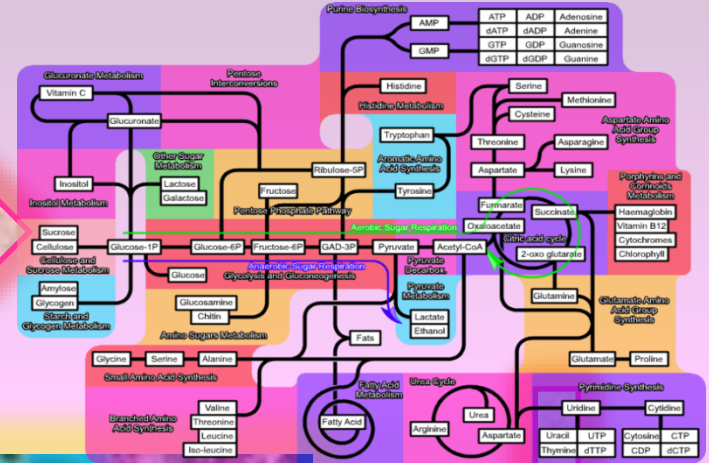
Ion beam analysis in biomedicine related to hair chemical analysis



Elements and health

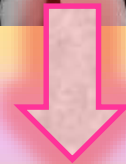


Periodic Table of the Elements





Why study hair?

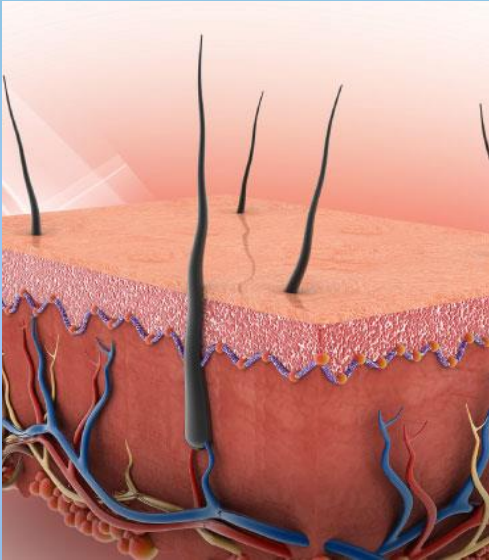


13 Al Aluminium 26.9815385	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.06	17 Cl Chlorine 35.4527	36 Kr Krypton 83.80
31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.921595	34 Se Selenium 78.96	35 Br Bromine 79.904	
49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.757	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.29
81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98037	84 Po Polonium 209	85 At Astatine	86 Rn Radon



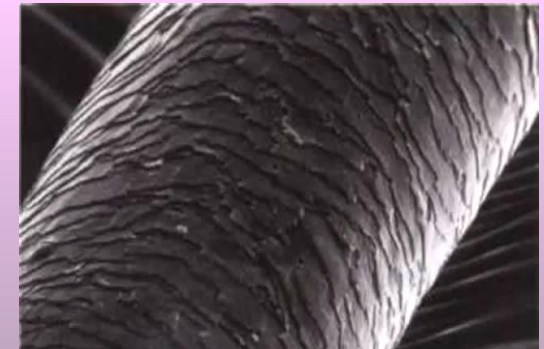


Advantages of using hair as biopsy material





Advantages of using hair as biopsy material



- Higher concentrations
- Longer diagnostic window
- Hair is of premium forensic value due to its high keratin content
- Hair can be collected under close supervision

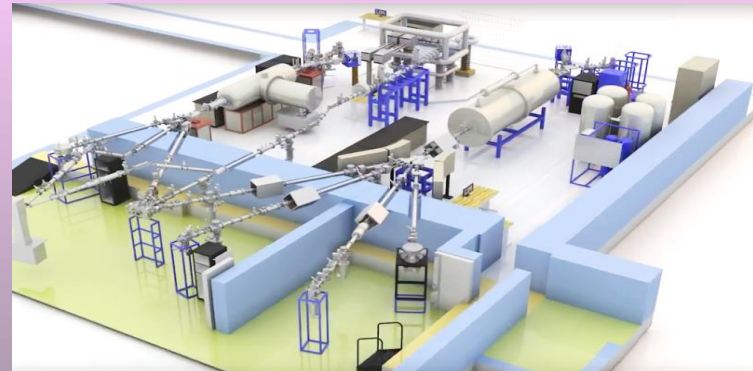




Techniques

When performing hair analysis - **assessment of analytical capabilities + sample preparation methodology** critical:

- Bulk processing destroy spatial information
- Extraction methods may not be optimized



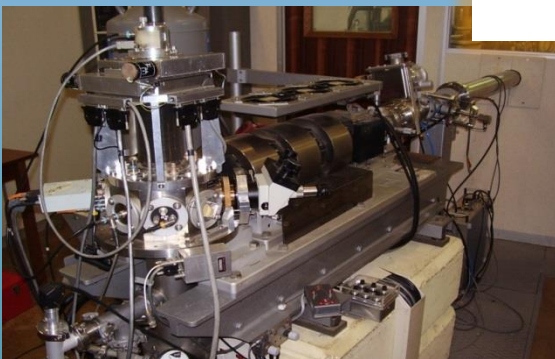
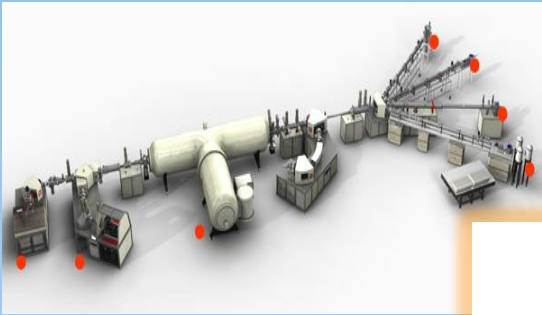
- Versatile techniques: **ion beam techniques**
 - **PIXE**
- Secondary ion mass spectrometry (**MeV-SIMS**)



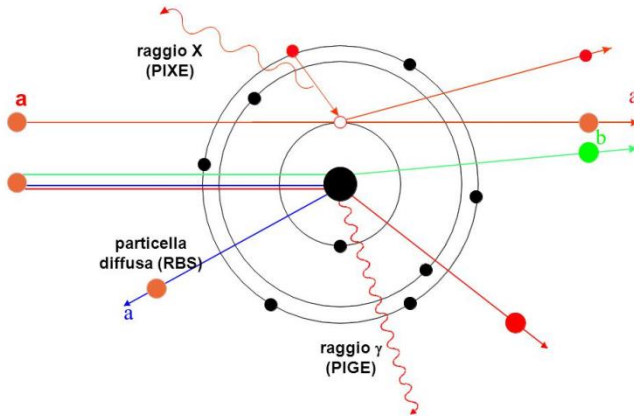
Experimental setup



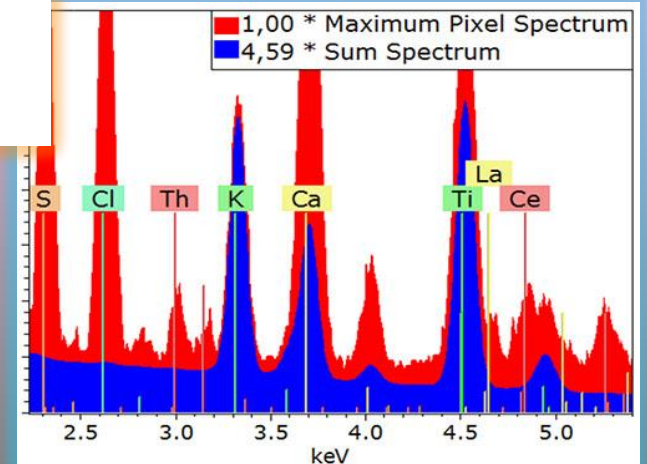
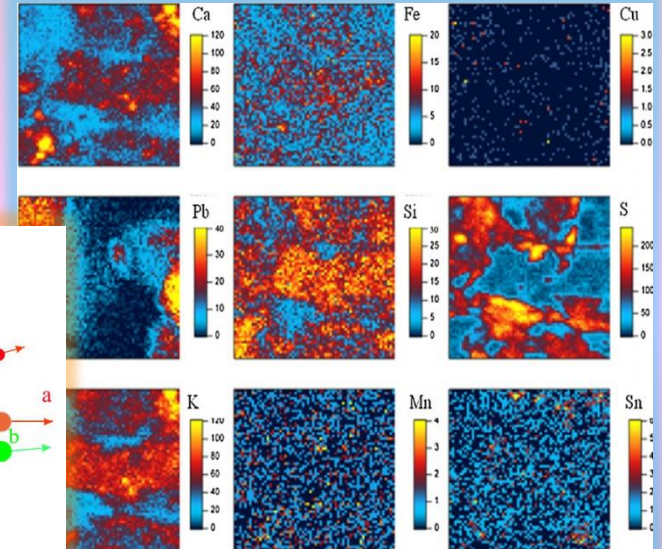
Technical aspects



Ion Beam Analysis - Il principio



Results





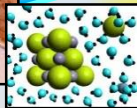
Aims



In-air PIXE: QUANTIFICATION

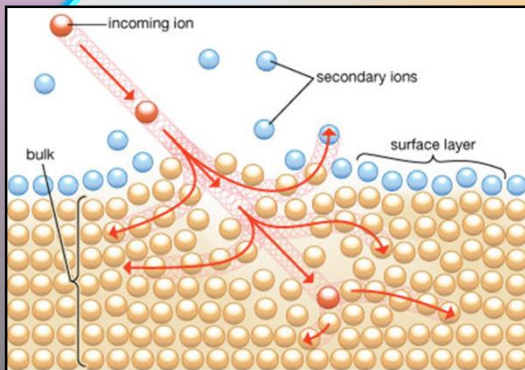
Periodic Table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	H																	
2	Li	Be																
3	Na	Mg																
4	K	Ca																
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rh
7	Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fu	Uup	Lr	Uuq	Uub
8																		
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Elements vs geometry and melanin

Detecting organic and inorganic compounds

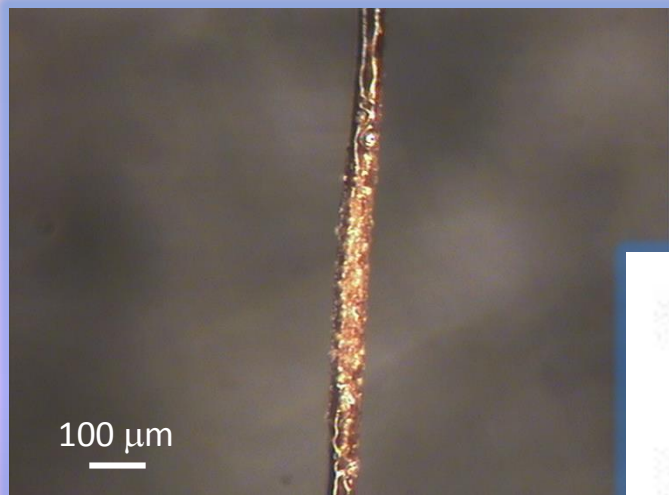


ToF MeV-SIMS: detectable chemical species in the hair samples

DAPNe

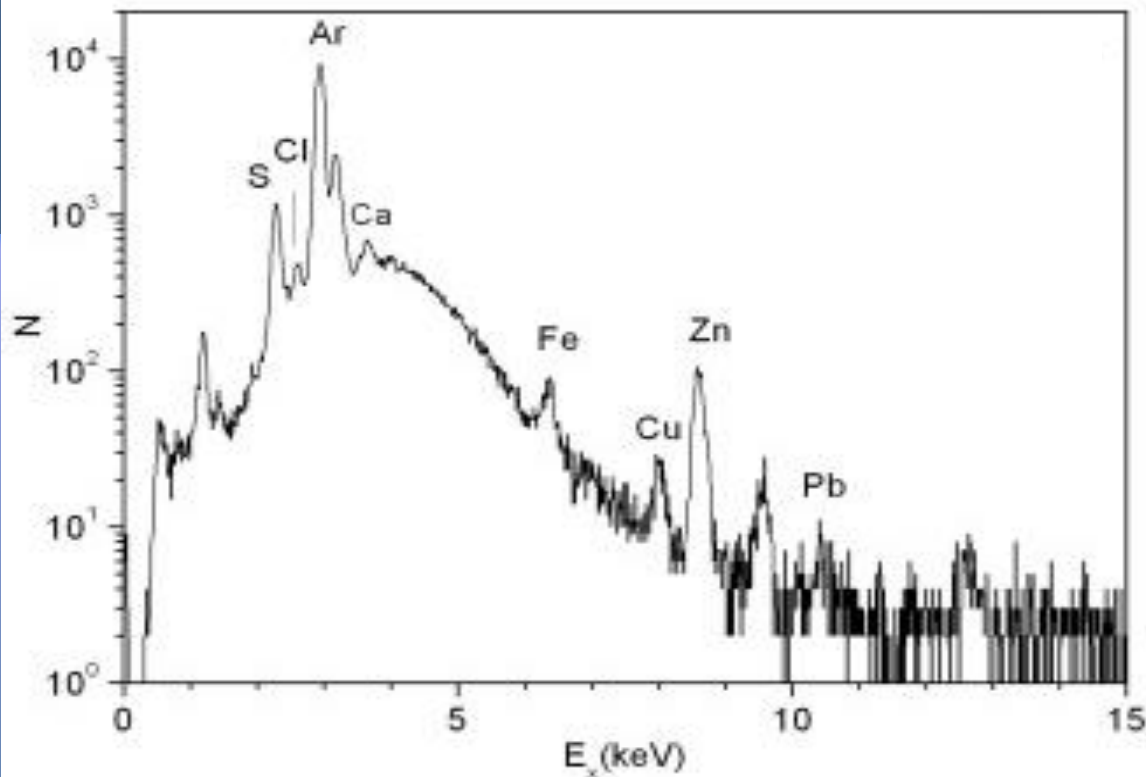


In-air PIXE




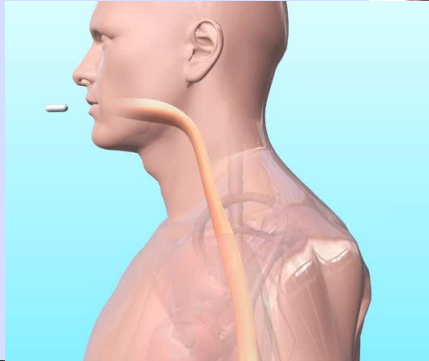





Representative in-air PIXE spectra from a single scalp hair with:

X axis: Characteristic X-ray emission energy (keV)
Y axis: X ray emission intensity (counts)



Compound	m/z	Description
Amino acids		
NH ₄ ⁺	18	<div style="border: 2px solid blue; padding: 5px; text-align: center; font-weight: bold; font-size: 1.2em;">MeV-SIMS</div> <p>The list of amino acid fragments may originate from hair keratin.</p> <div style="text-align: center;"> </div>
Glycine (CH ₄ N ⁺)	30	
Alanine (C ₂ H ₆ N ⁺)	44	
C ₃ H ₈ N ⁺	58	
Methionine (C ₂ H ₅ S ⁺)	61	
Asparagine, proline (C ₃ H ₄ NO ⁺ ; C ₄ H ₈ N ⁺)	70	
Threonine (C ₃ H ₈ NO ⁺)	74	
Glutamine, glutamic acid, lysine (C ₄ H ₆ NO ⁺ ; C ₅ H ₁₀ N ⁺)	84	
Isoleucine, leucine (C ₅ H ₁₂ N ⁺)	86	
Asparagine (C ₄ H ₄ NO ₂ ⁺)	98	
Inorganic biogenic elements		
Sodium	22.99	<div style="text-align: center;"> </div>
Phosphorus	30.97	
Potassium	39.10	
Calcium	40.08	
Volatile organic compounds		
Nitric oxide	30.01	<div style="text-align: center;"> </div> <div style="text-align: center;"> </div>
Pyrrole	67.09	
Putrescine	88.10	
Pyruvic acid	88.02	

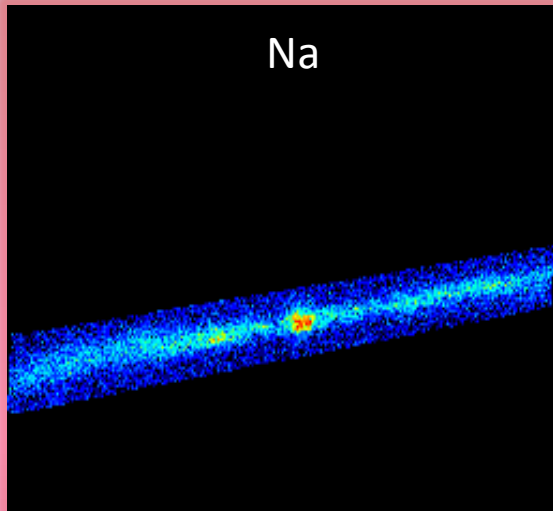
Pharmaceutical compound	<i>m/z</i>	Description*
Betazole	111.15	<div style="border: 2px solid blue; padding: 5px; text-align: center; background-color: #e0f0ff;"> <h1>MeV-SIMS</h1> </div> <div style="display: inline-block; vertical-align: top;">  </div> <div style="display: inline-block; vertical-align: top;">  </div> <div style="display: inline-block; vertical-align: top;">  </div> <div style="display: inline-block; vertical-align: top;">  </div> <div style="display: inline-block; vertical-align: top;">  </div> <div style="display: inline-block; vertical-align: top;">  </div> <div style="display: inline-block; vertical-align: top;">  </div>
Phensuximide	189.21	
Carglumic acid	190.15	
Phendimetrazine	191.27	
Ibuprofen	206.28	
Pilocarpine	208.26	
Medrogestone	340.51	
Methantheline	340.44	
Mepenzolate	340.44	
Propafenone	341.44	
Bromopride	344.25	
Bambuterol	367.44	
Sodium aurothiomalate	367.09	
Ketazolam	368.81	
Perindopril	368.47	
Gentian Violet	372.53	
Nabilone	372.54	
Prasugrel	373.44	
Hydroxyzine	374.90	
Trimebutine	387.48	
Flurazepam	387.88	
Cyclothiazid	389.88	



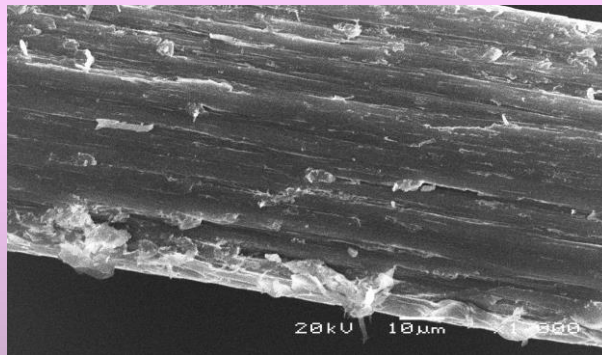
MeV-SIMS



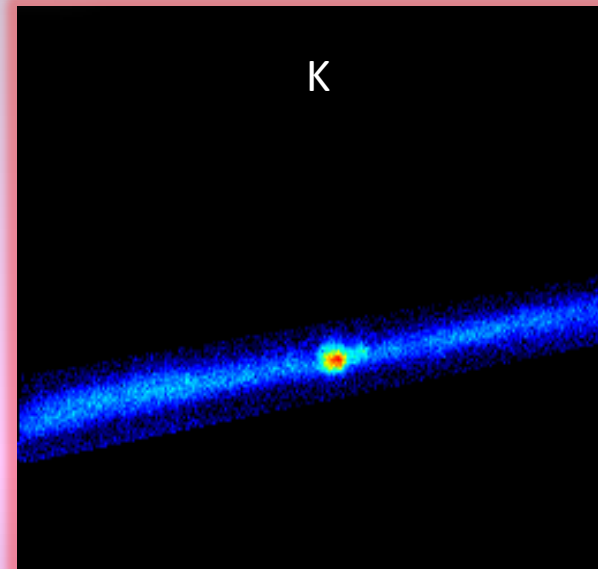
Na



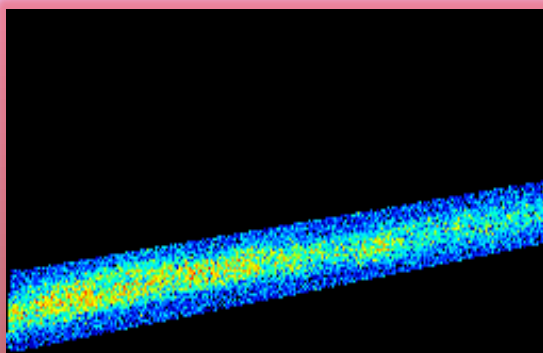
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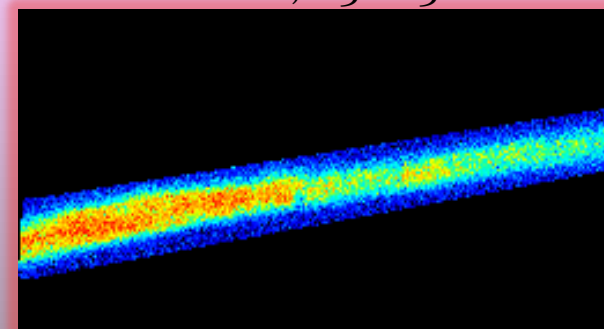
K



scan size, 2.3 x 1.3 mm



Pharmaceutical compound A



Pharmaceutical compound B



Analytical Methods

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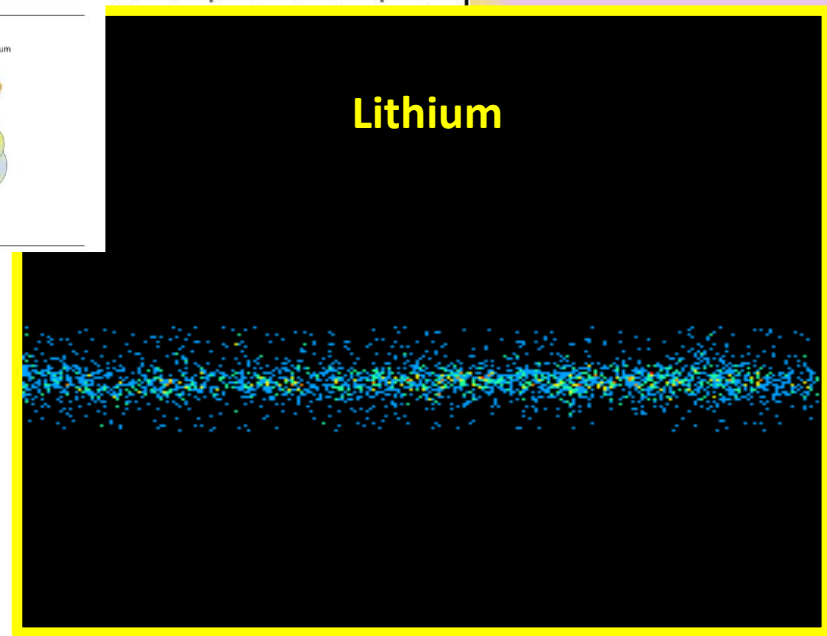
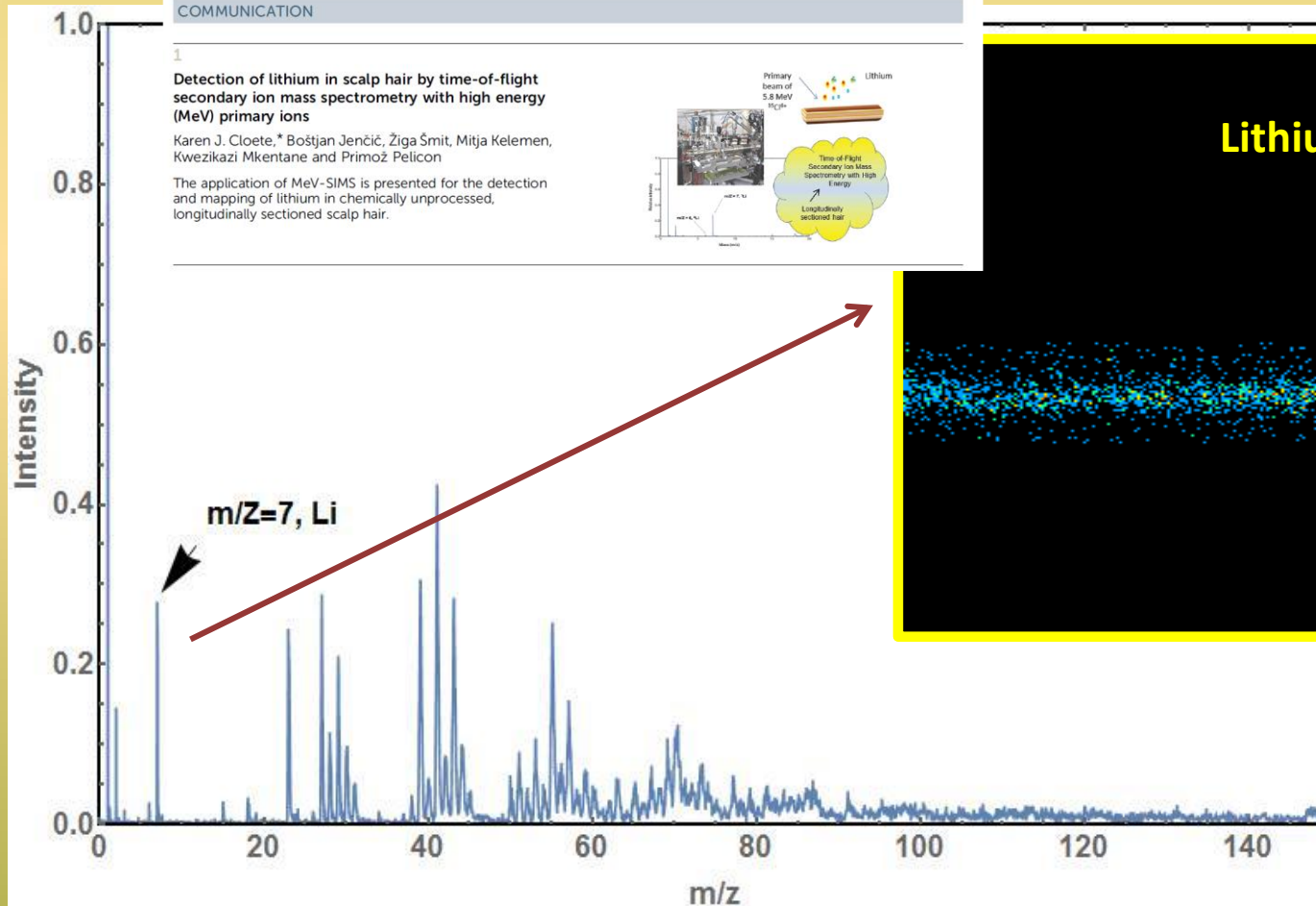
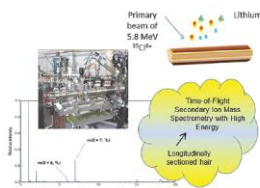
We have presented the Graphical Abstract text and image for your article below. This brief summary of your work will appear in the contents pages of the issue in which your article appears.

COMMUNICATION

1 Detection of lithium in scalp hair by time-of-flight secondary ion mass spectrometry with high energy (MeV) primary ions

Karen J. Cloete,* Boštjan Jenčič, Žiga Šmit, Mitja Kelemen, Kwezikazi Mkentane and Primož Pelicon

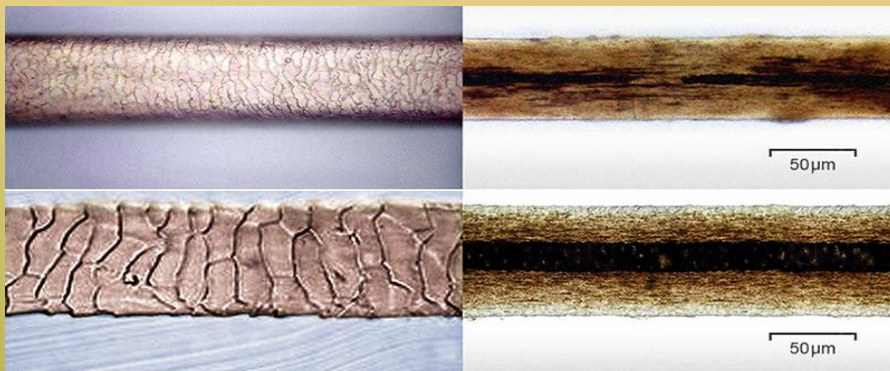
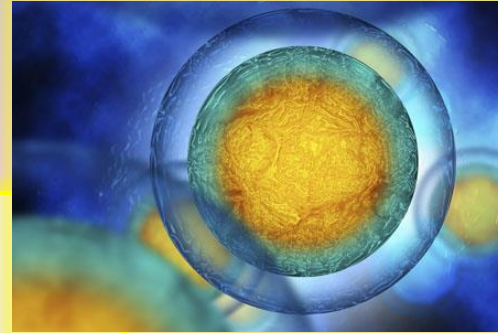
The application of MeV-SIMS is presented for the detection and mapping of lithium in chemically unprocessed, longitudinally sectioned scalp hair.





MeV-SIMS

- **Detection sensitivity and speed**
- **Conventional analysis methods traditionally used**
- **Chemical processing**
- **Destroys historical and spatial information**
- **Low recoveries trace elements**



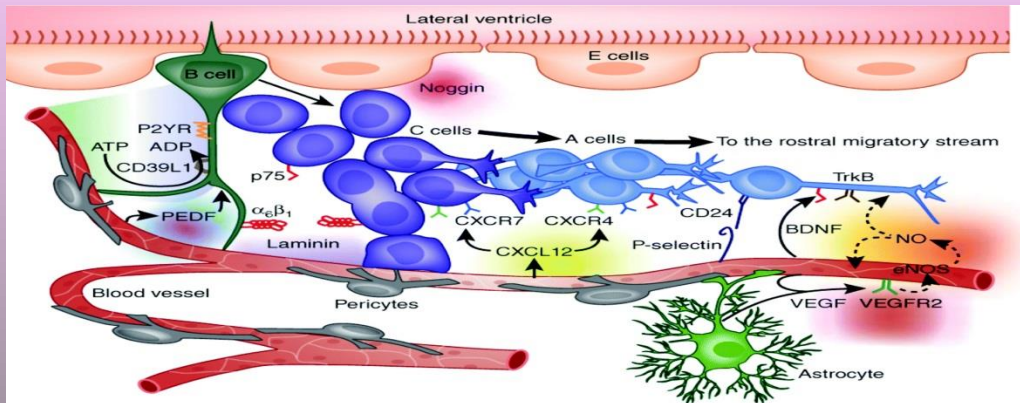


Lithium

- Li may enter biological tissues via food



- No apparent vital physiological function, nutritional trace element multifactorial biochemistry in body



- Psychopharmacuetical

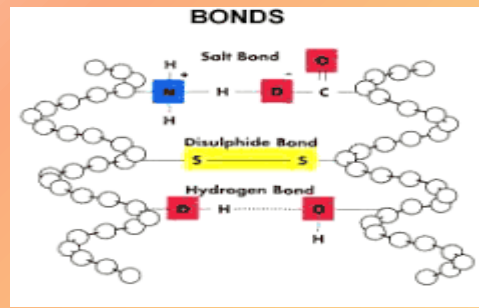
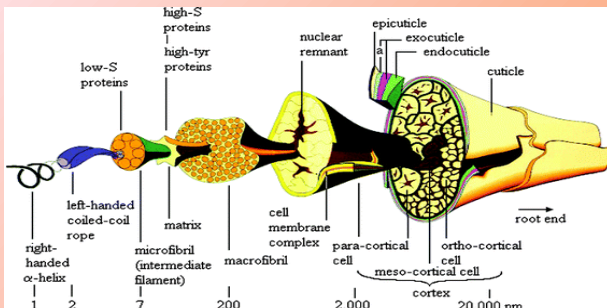


Lithium

- Alkaline hair straightener or no-lye relaxer emulsions



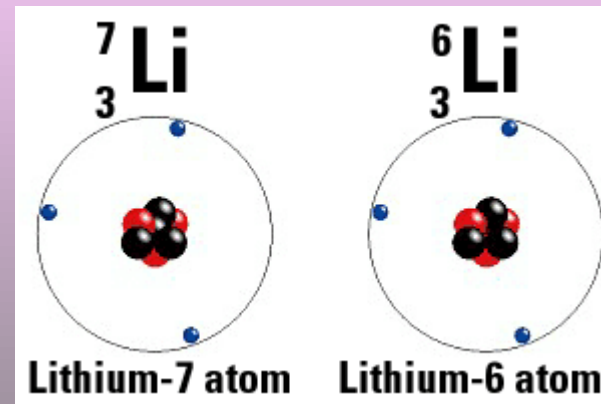
- Use of hair relaxers popular in certain cultures
- Damage hair





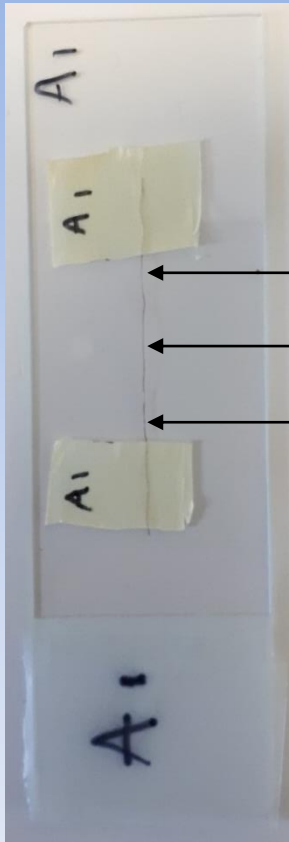
Lithium

- External vs internal origin
- Binding to hair chemical components
- Li isotopes?
- Transfer to new growth





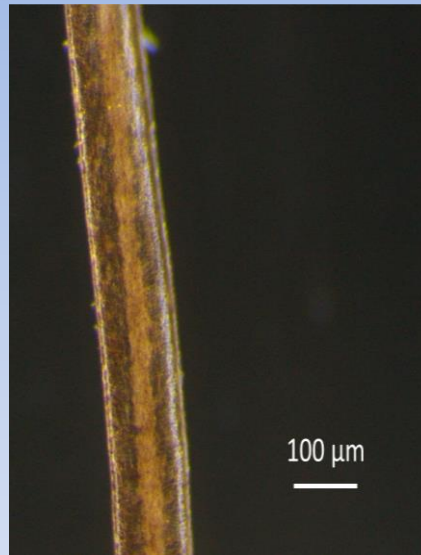
Sample preparation



Top

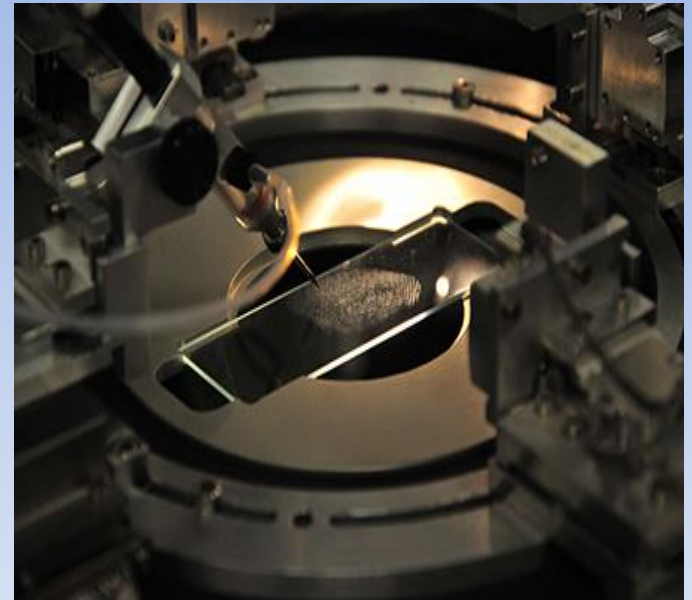
Middle

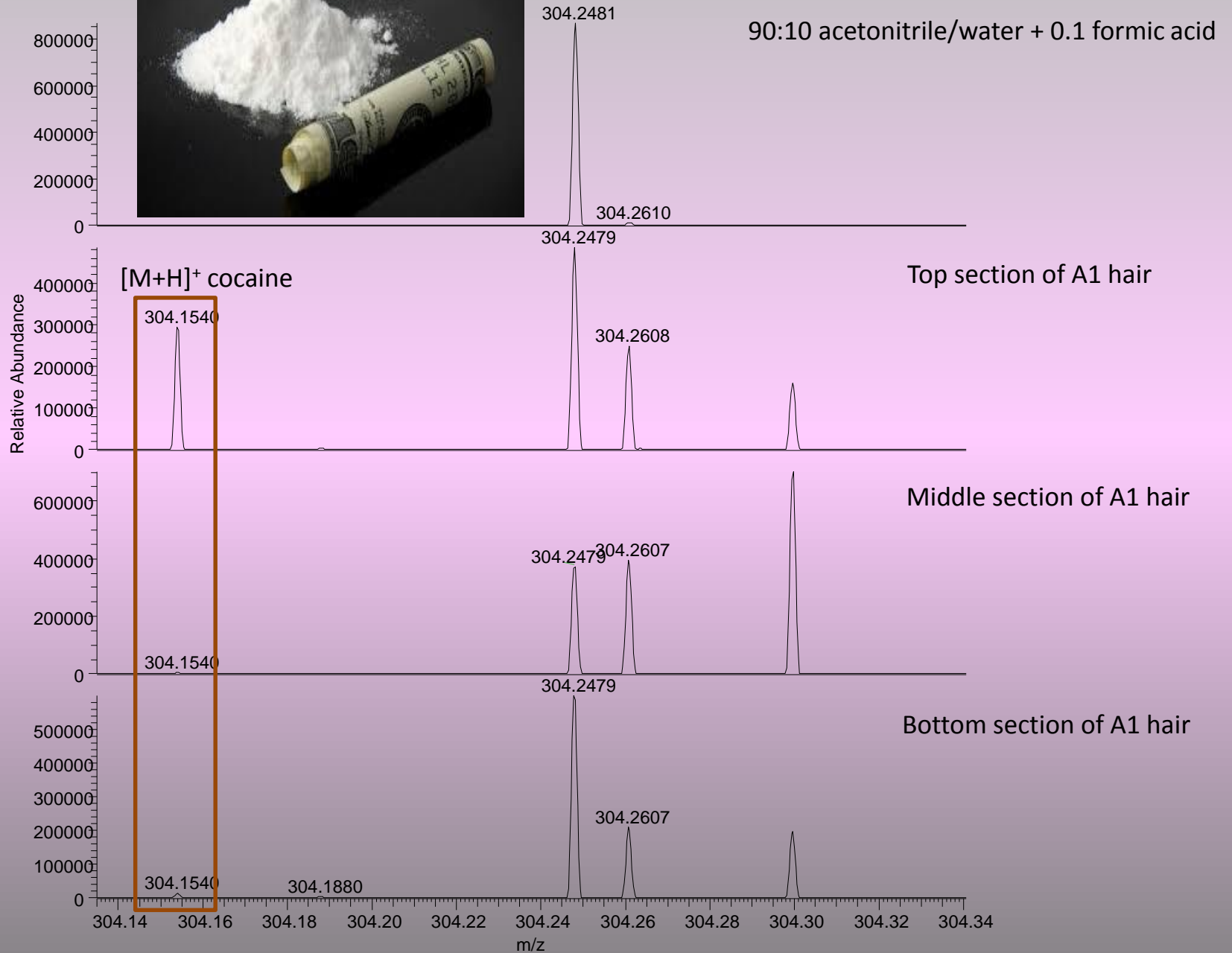
Bottom



100 μm

Analysis

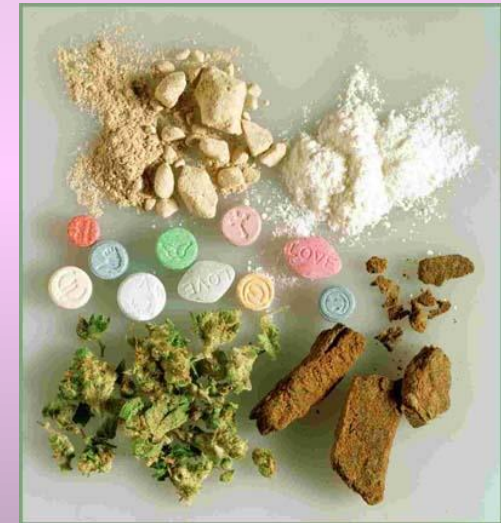
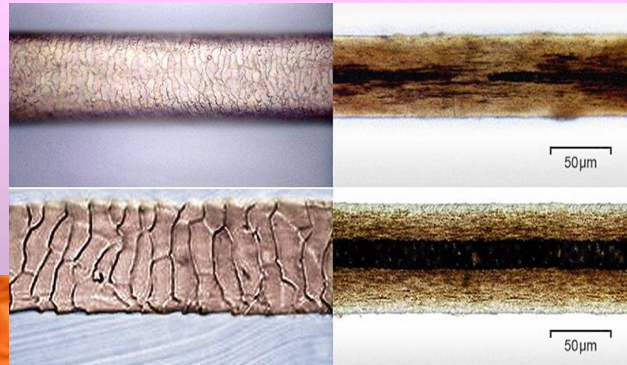






Applications of hair screening

Hair analysis
exploited in
**clinical
medicine**



Hair analysis in **forensic science**



R: Relevance
E: Excellence
S: Society
E: Expertise
A: Applied
R: Reasoning
C: Creative
H: Honourable



Acknowledgements

Collaborations

International

- Jožef Stefan Institute, Slovenia: Prof Žiga Šmit, Prof. Primož Pelicon, Boštjan Jenčič, Mitja Kelemen
- University of Surrey, United Kingdom: Dr Melanie Bailey, Janella de Jesus
- University of Rome, Italy: Prof Francesco Romolo



National

- University of Cape Town: Drs. Kwezikazi Mkentane and Jennifer van Wyk; Prof. Nonhlanhla Khumalo



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