



**Safety
Quality
Traceability**

ISO-FOOD

ERA Chair for isotope
techniques in food
quality, safety and
traceability

Nives Ogrinc

EFSA meeting



Who is involved?

- **JSI research departments**

- Department of Environmental Sciences (O2)
- Department of Condensed Matter Physics (F5)
- Department for Nanostructured Materials (K7)
- Computer Systems Department (E7)

- **Centres of Excellence**

- Advanced Materials of the Future (NAMASTE)
- Nanoscience and Nanotechnology (NANOCENTER)

- *Jožef Stefan International Post Graduate School*

Pillar themes

- **P1- Food authenticity:** development and application of analytical tools and infrastructure for verification of geographical origin, production origin and species origin of food products using isotope and other techniques
- **P2 – Food traceability:** translation of regional isotopic and elemental signatures from natural environment into local food produce
- **P3 – Food safety:** through detection, identification and characterisation of potentially hazardous substances from the environment and intentionally or unintentionally added to the food products

0.1% of «food literature» refers to food traceability
and 0.05% to food safety

P1 – Food authenticity

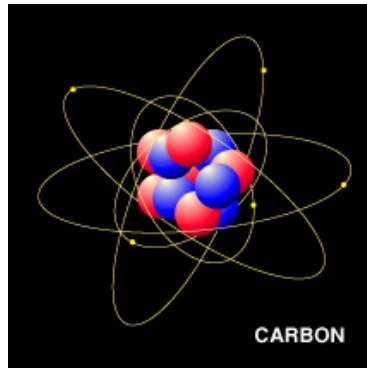
- Stable isotopes: light elements (H, C, N, O, S) heavy elements (Sr, Pb, Hg)
- Molecular markers (sugars, fatty acids, sterols, molecular profiling)
- Elemental composition (major, minor, trace elements)
- Databases - chemometric methods

P2 – Food traceability

- Agricultural practice – organic vs. conventional
- Isotopic and multi-element maps of foods from different geographical locations (GIS maps) – traceability system
- Transport of pollutant from environment to food - the use of biomarkers and stable isotopes for source appointment

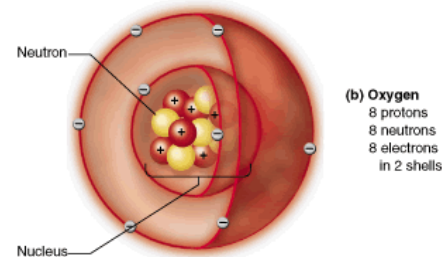
Terminology

Stable isotopes



^{12}C : 98.93 wt%

^{13}C : 1.07 wt%



^{16}O : 99.757 wt%

^{17}O : 0.038 wt%

^{18}O : 0.205 wt%

$$\delta X = \left[\frac{R_{\text{sample}}}{R_{\text{standard}}} - 1 \right] \times 1000 \quad [‰]$$

$X = {}^2\text{H}, {}^{13}\text{C}, {}^{15}\text{N}, {}^{18}\text{O}, {}^{34}\text{S}$

$R = {}^2\text{H}/{}^1\text{H}, {}^{13}\text{C}/{}^{12}\text{C}, {}^{15}\text{N}/{}^{14}\text{N}, {}^{18}\text{O}/{}^{16}\text{O}, {}^{32}\text{S}/{}^{34}\text{S}$

Standard = V-SMOW, V-PDB, V-CDT, V-SMOC, AIR

Isotope ratio	Fractionation	Information
$^2\text{H}/^1\text{H}$ $^{18}\text{O}/^{16}\text{O}$	evaporation condensation precipitation	⇒ geographical origin
$^{13}\text{C}/^{12}\text{C}$	C4, C3 plants marine, terrestrial nutritional status	⇒ diet ⇒ adulteration
$^{15}\text{N}/^{14}\text{N}$	nitrification/denitrification trophic level marine, terrestrial	⇒ agriculture practice ⇒ diet
$^{34}\text{S}/^{32}\text{S}$	bacterial	⇒ geographical origin ⇒ agricultural practice
$^{87}\text{Sr}/^{86}\text{Sr}$	underlyin geology	⇒ geographical origin

These isotopic signatures are translocated through an animal to their product and can be used to trace food origin

Elemental and isotopic fingerprinting

Sample

**Multielement
and isotope
analysis**

+

Chemometrics

=

Classification

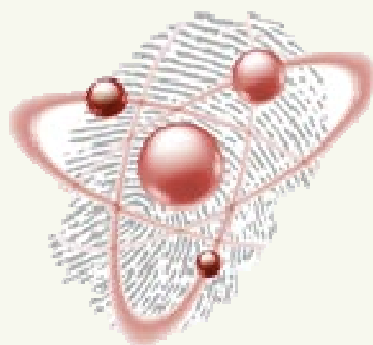
Country
Region
Type



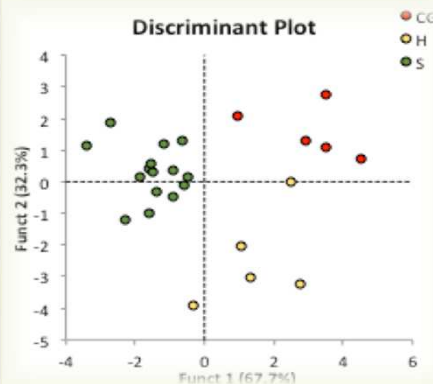
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Elemental and
isotope
fingerprinting



PCA, CA, SIMCA,
LDA, PLS-DA



Database
matching

Country X
Region Y
Type Z

.....

Predicting provenance

Databases

[illegible]

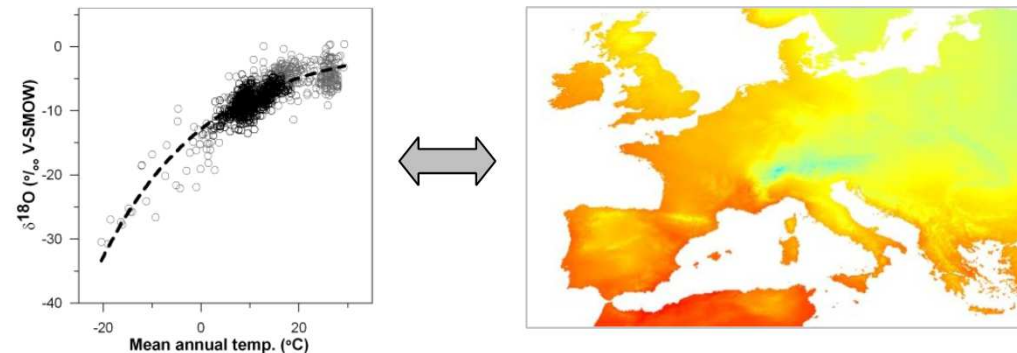
Origin is determined by comparison to data with in a database

- Authentic samples (data from all provenances)
- Large number of data (expensive)
- Regular updates (stability of the data)

Working on a selected number of well defined food

In Slovenia: wine, olive oil, honey

Isoscapes



Origin is determined by comparing the data within a food to interpolated geo- climatic factors depicted in an isotopic map

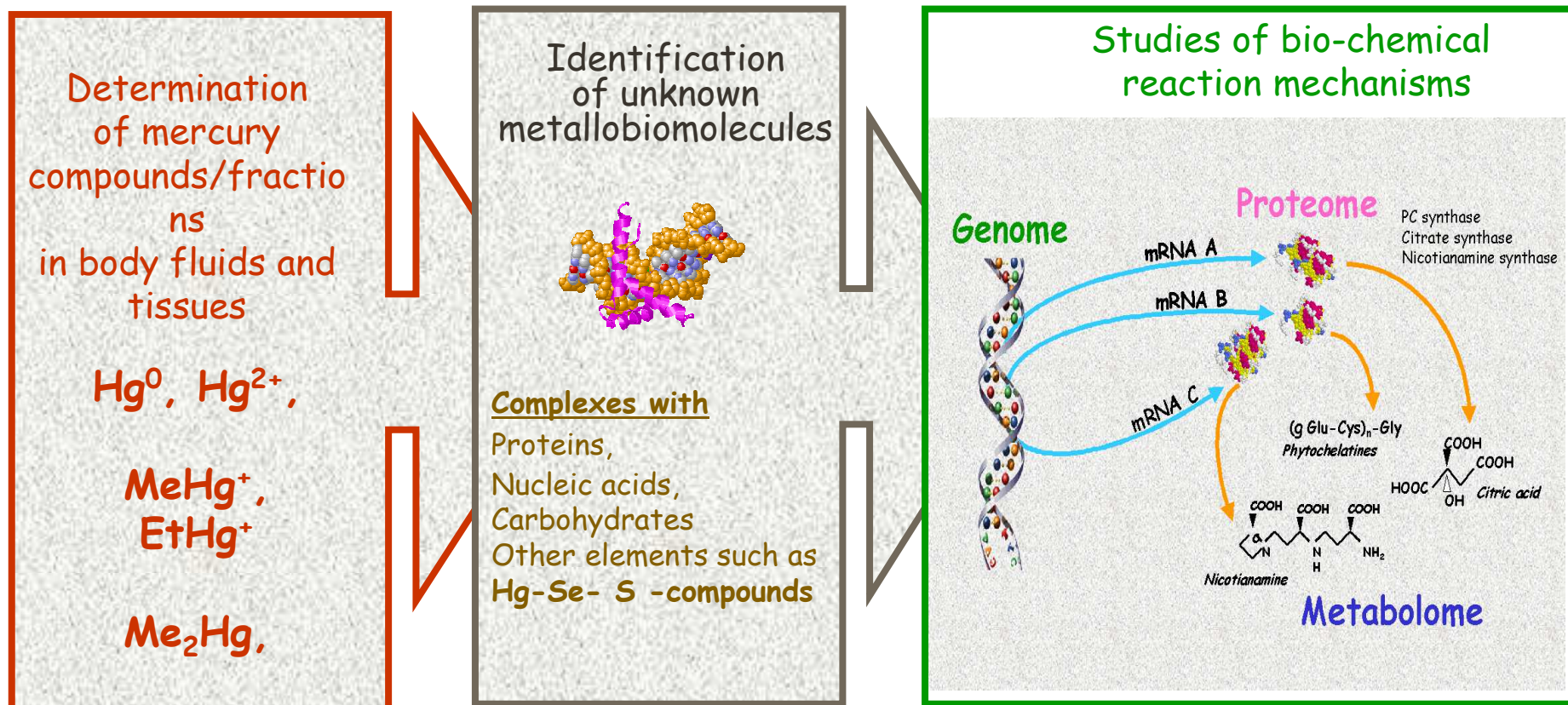
- Prediction of the data where no stable isotope data are available
- Large scale data might overlook regionality
- Annual/seasonal stability has to be proven

Working in the areas with no isotopic data

P3 - Food safety

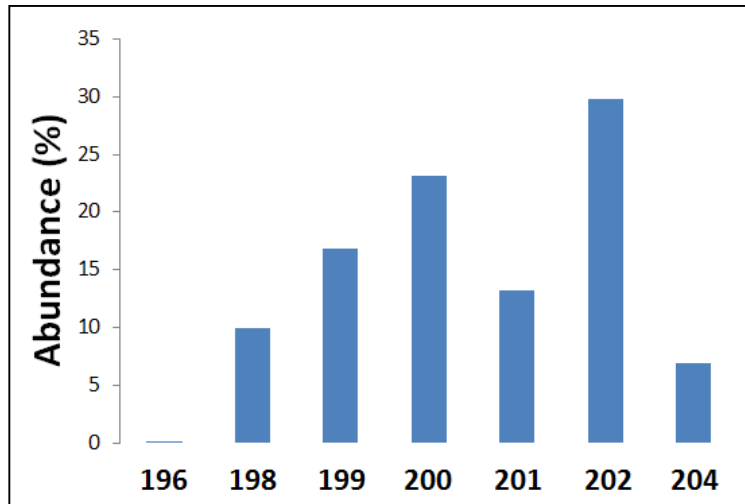
- Organic pollutants (pharmaceutical residues; hormones and other endocrine disruptive compounds (BPA and its alternatives, pesticide residues, organo-Br compounds, ..)
- Food additives and packaging
- Potentially toxic elements and essential elements and their species (Zn, As, Hg, Cr, Al, Se, I, Fe, etc.....)
- Radionuclides
- Nano-sized particles

Evolution of speciation analysis in biological systems



Lobinski, pers. comm.

MDF vs. MIF fractionation



- Photochemical processes generate strong MIF on odd isotopes (^{199}Hg , ^{201}Hg)
- Biological processes generate only MDF



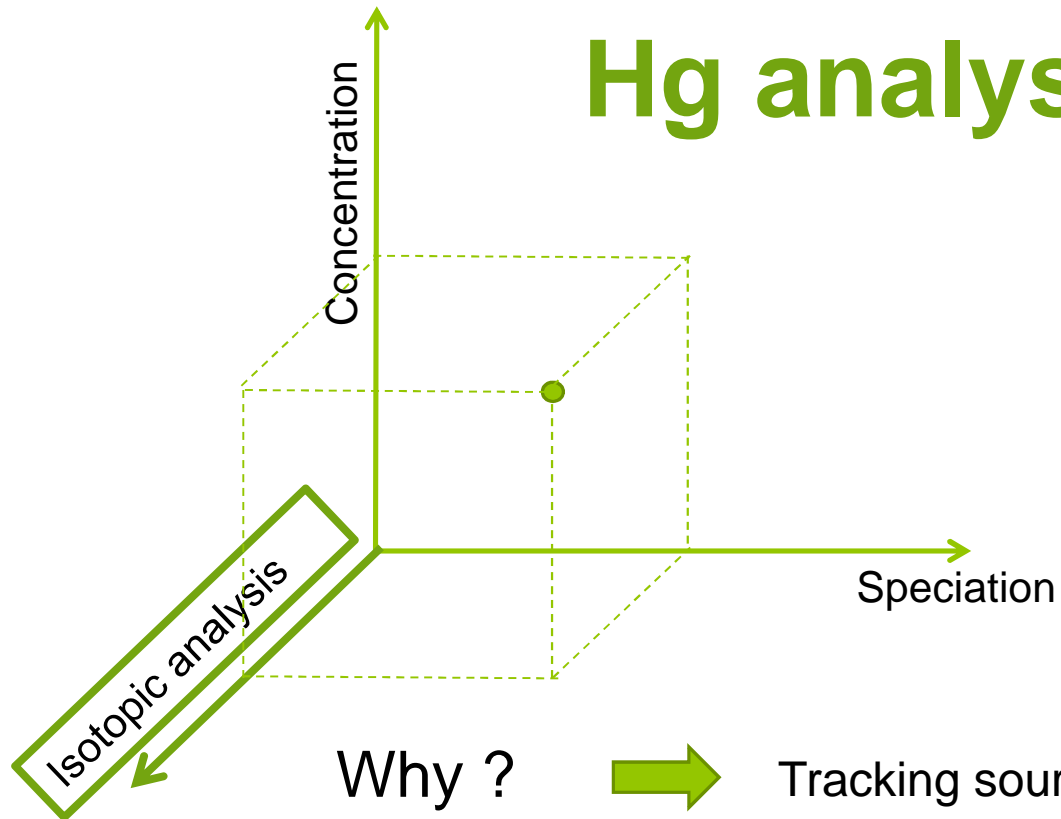
PRECISION

Single collector ICP MS:
0,1%



Multicollector-ICP/MS:
0,001%

Hg analysis



=



Why ?



Tracking sources and fate of Hg in the environment

Where ? :

- Soil and sediments
- Air
- Water
- **Food**
- Biological tissues
- Lichens



Iso-food speciation topics

- Speciation of Zn, Ni, organo-Sn, As, Hg, Se in foodstuffs of plant and animal origin
- Br - polybrominated diphenylethers
- Pesticide residues (organo-P compounds)

„Pharmaceuticals, steroids, pesticides that are yet to be regulated“

Nanoparticles in food

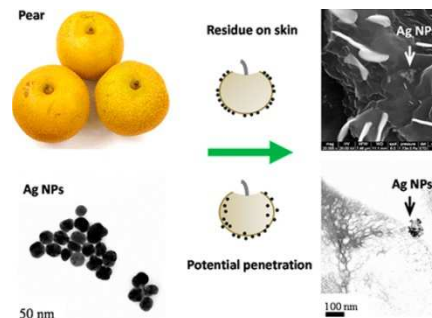
- **Natural NPs**

- **Intentionally added engineered NPs:** metal-based NPs (Ag-NP, TiO₂-NP, ZnO-NP, Fe-NP)
 - materials with new functionality (anti-caking, thickening and colouring agents)
 - for antimicrobial activity
 - for food conservation
 - to help deliver nutrients (nanoencapsulation of food ingredients and additives)



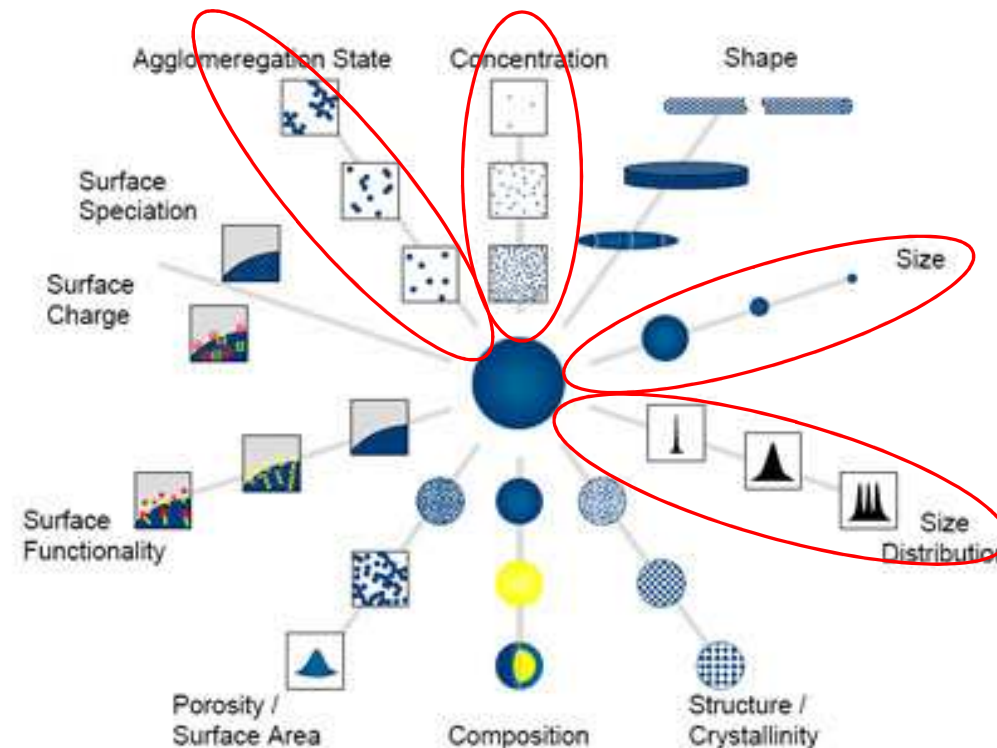
- **NPs from contamination**

- during food preparation and processing
- potential migration of NPs from food packaging containing nanomaterials
- during agriculture production (nano-based pesticides)



What do we want to measure?

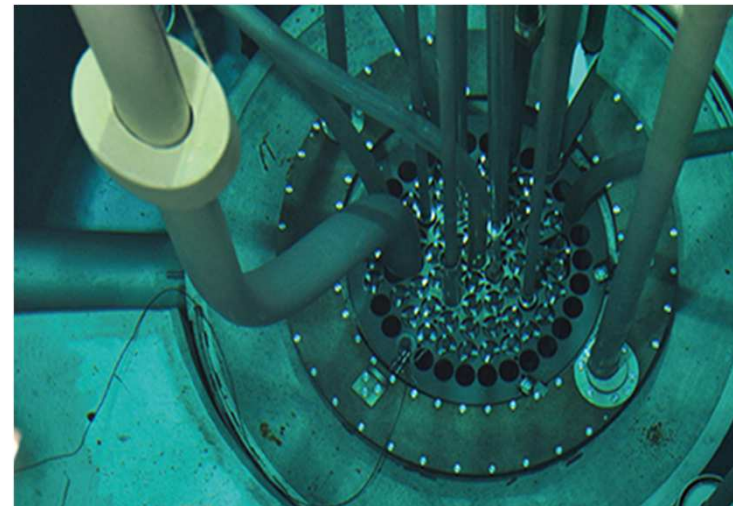
- Chemical composition
- Particle size and size distribution
- Mass/particle number concentration
- State of agglomeration/aggregation



Natural and man-made radionuclides

- natural:
 - uranium and thorium and their decay products

- man-made:
 - fission products:
Sr-90, Sr-89, Cs-137, I-131, ...
 - activation products:
H-3, Cs-134, Pu-238, Pu-239,
Pu-240, Pu-241, Am-241, ...



Horizontal themes

- H1 – providing validation and standardization of methods where many analytical methods and approaches are not yet standardized and certified reference materials are not available
- H2 – management and exploitation of food composition data and region, species- and practice-specific fingerprints



- Research throughout training:
 - PhD studies (3 PhD candidates already started)
 - Post-doctoral positions (6 positions for 1 or 2 yrs) with the following subjects:
 - Radionuclides in food
 - Nanoparticles in food (2x)
 - Compound specific stable isotopes in food
 - Organic contaminants in food
 - Metrology support in food analysis
- Workshops:
 - Food traceability methodologies (2nd year)
 - Nanoparticles in food (3rd year)
 - Isotopic techniques in food characterisation (4th year)
 - Metrology in food analyses (5th year)
- Summer schools:
 - Radioisotopes in food (1st year)
 - Authentication of food products by isotope and elemental fingerprinting (2nd year)
 - Element speciation in food analysis (3rd year)
 - Nanoparticles in foodstuffs (4th year)
- Interlaboratory exercises:
 - Speciation of selected metals in environmental samples (4th year)
 - Stable isotope analyses of light elements in foodstuffs (5th year)



www.isofood.eu

Thanks for your attention!

