Environmental Engineering Laboratory

Department of Chemical Engineering
School of Engineering
Aristotle University of Thessaloniki

Health and Exposome Research: Assessing Contributors to Lifetime Exposure and State of health (HERACLES)

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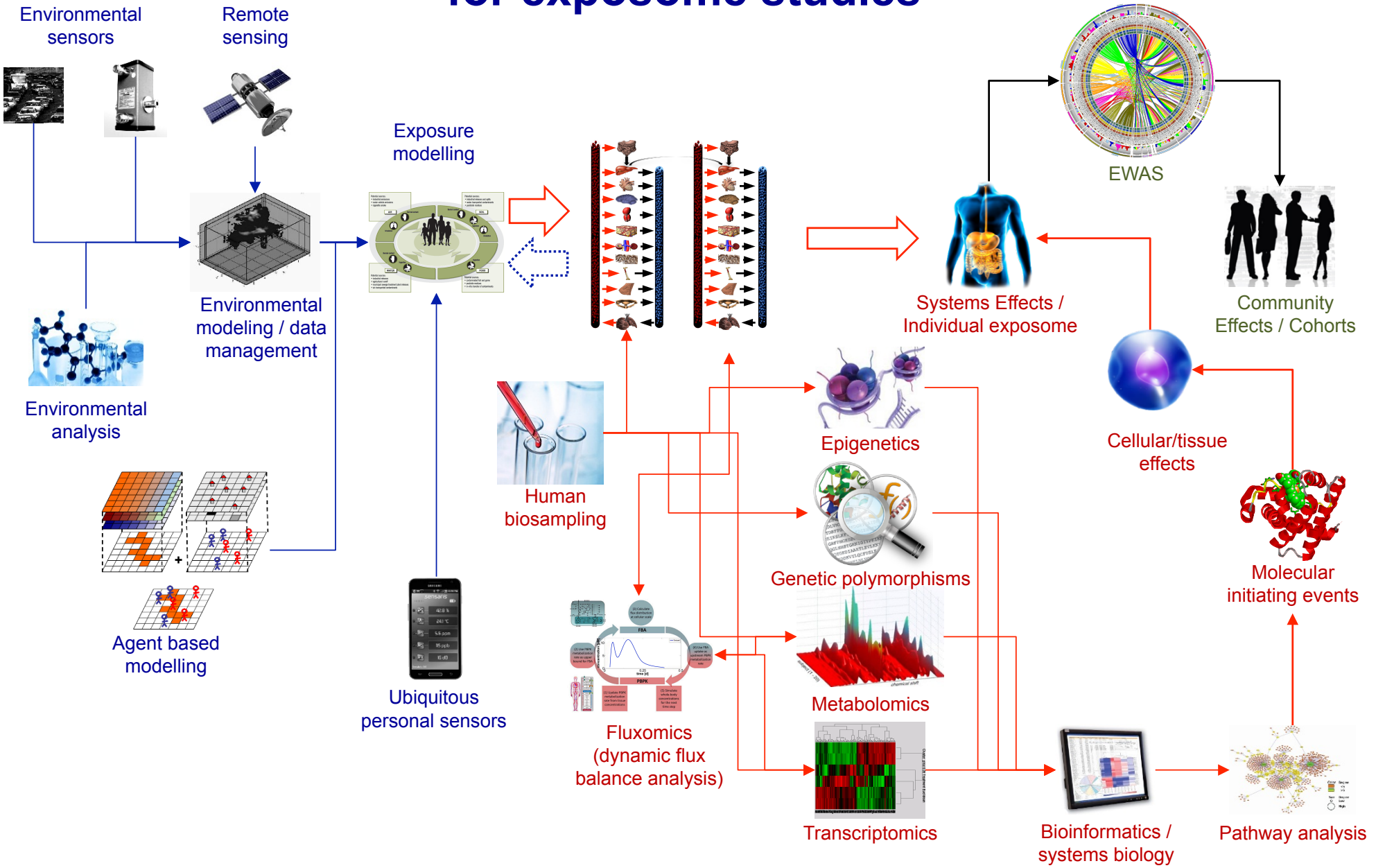
Connectivity-based workflow for exposome studies



HERACLES outline

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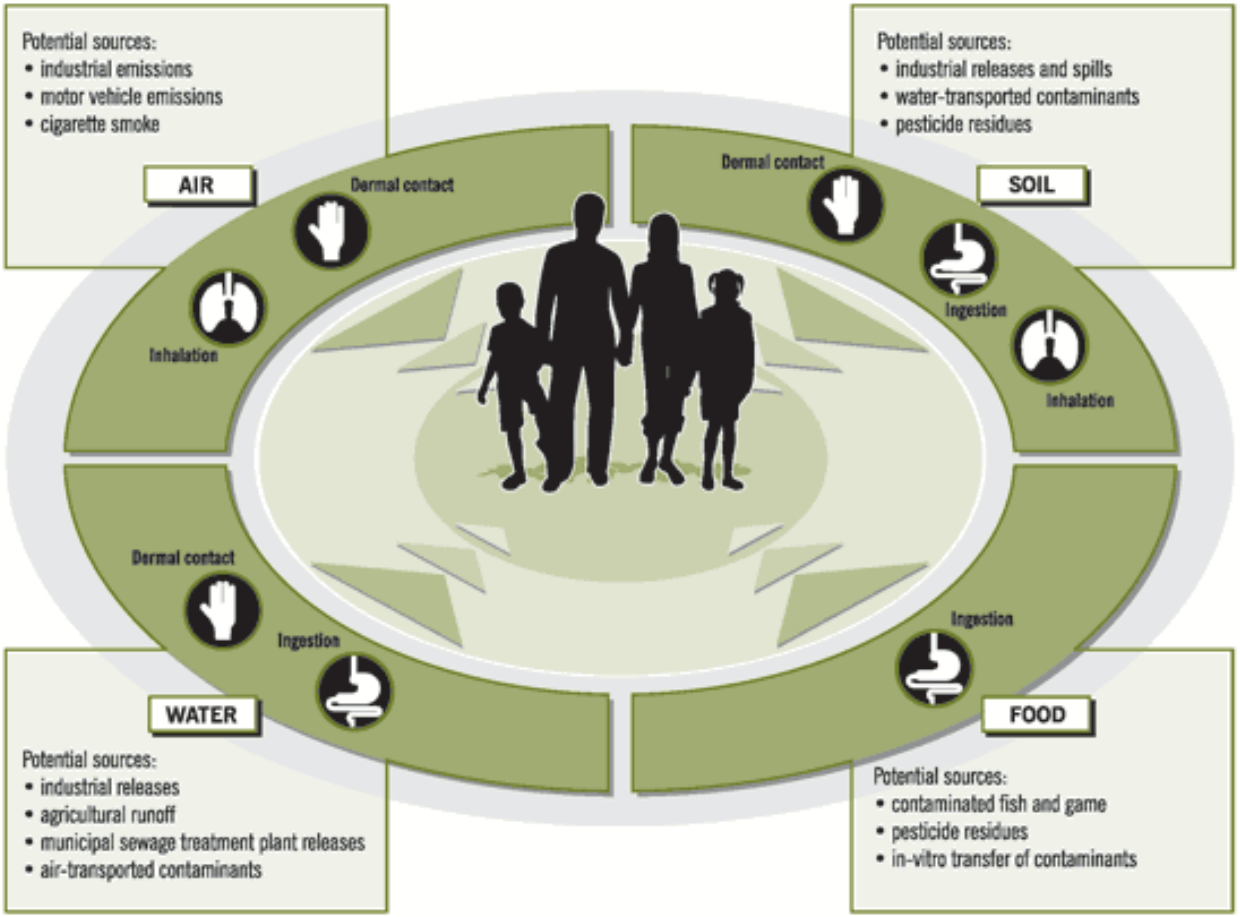
- Integrated use of existing environmental and biomonitoring data
- Improved assessment of the external exposome
  - Environmental data fusion and Agent-Based Models
  - Mobile phone apps
  - Environmental sensor-webs
  - Micro-sensors
  - Satellite remote sensing
- Linking external and internal exposome
  - Integrated use of –omics and chemical biomarker data
  - Take into account the temporal dimension
- Advanced tools for environmental and biological data analysis
  - PBBK modeling for internal dose estimation and exposure reconstruction
  - Coupling PBBK models with gene regulation models
- Novel bioinformatics strategies for biomarker prediction
  - Systems biology meta-modeling for biomarker fusion
- Environment-wide association studies
  - Linkage disequilibrium
  - Use of advanced statistical tools: DAG, Bayesian inference
- Enviromics
  - study of a wide array of environmental factors in relation to health and biology

The external exposome



Pilot Campaign

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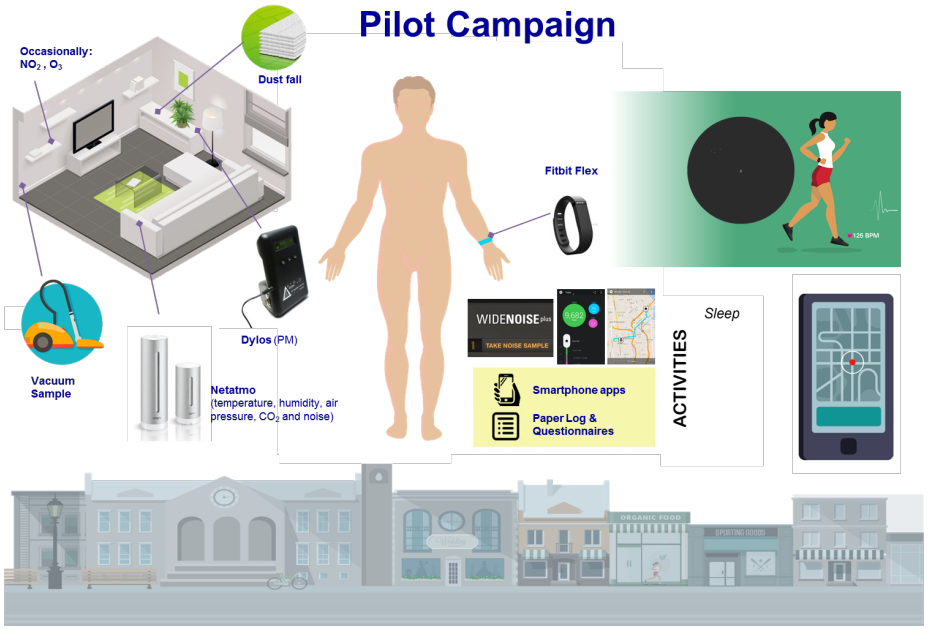

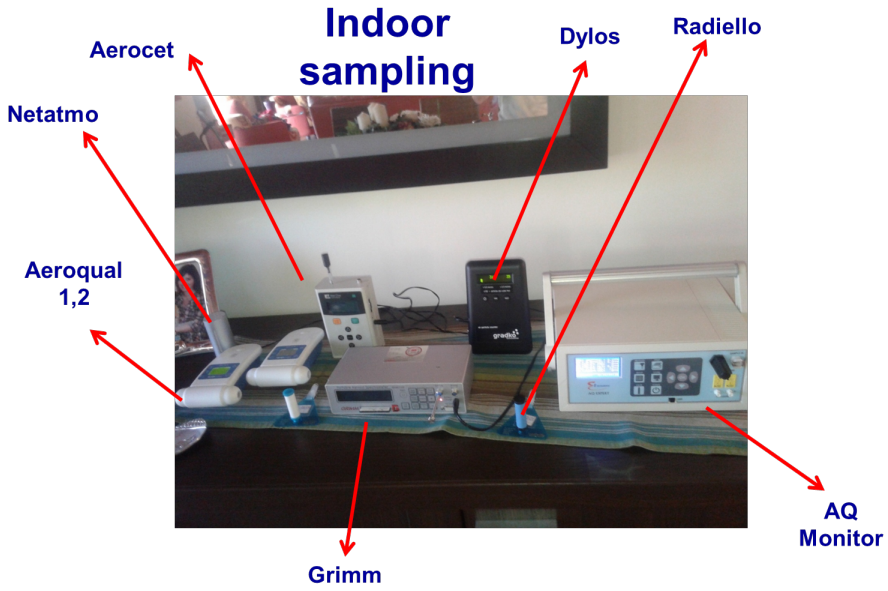

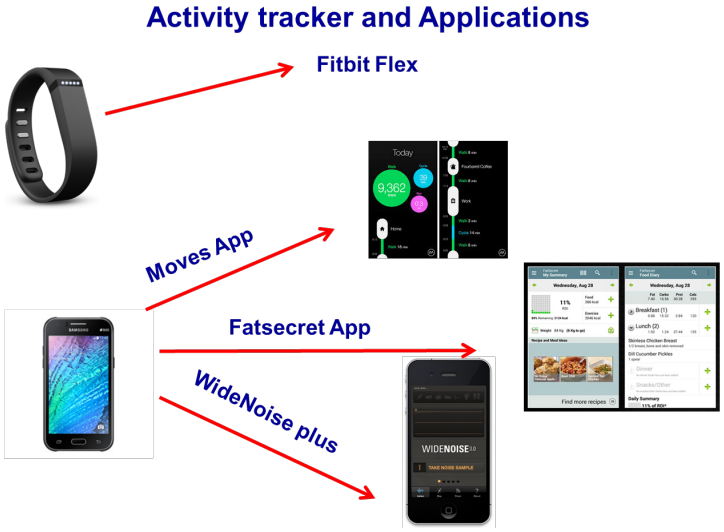

Agent Based Modelling (ABM)

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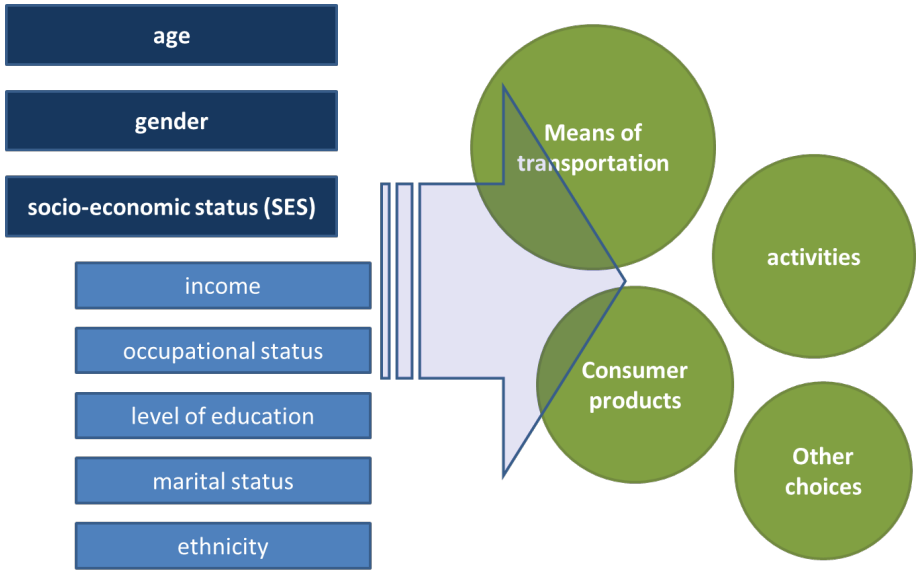
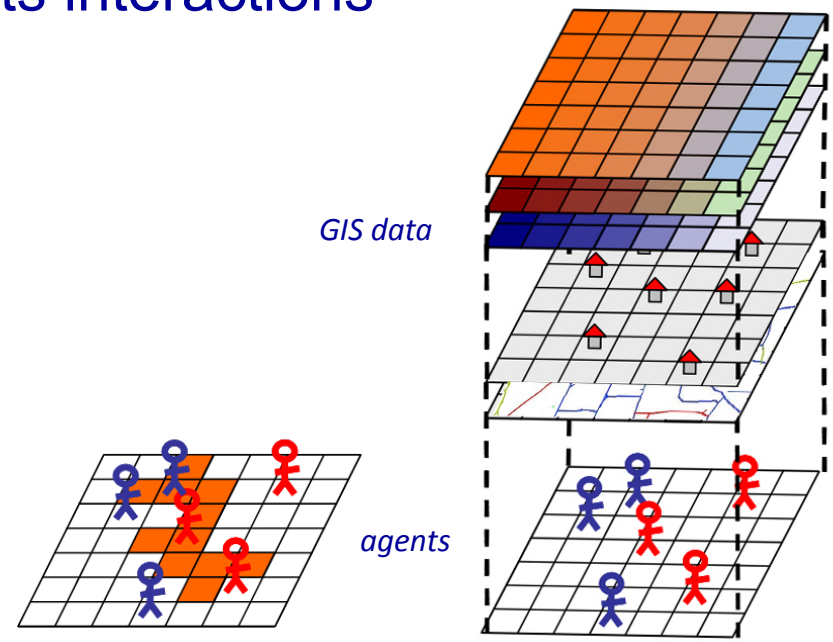
- A system is modeled as a collection of agents and the relationships between them
- The agents, programmed as autonomous decision-makers, react and act in their environment
- Take into account the heterogeneity of the entities composing the system
- Behaviours emerge through the agents interactions





Typical daily indoor PM profile

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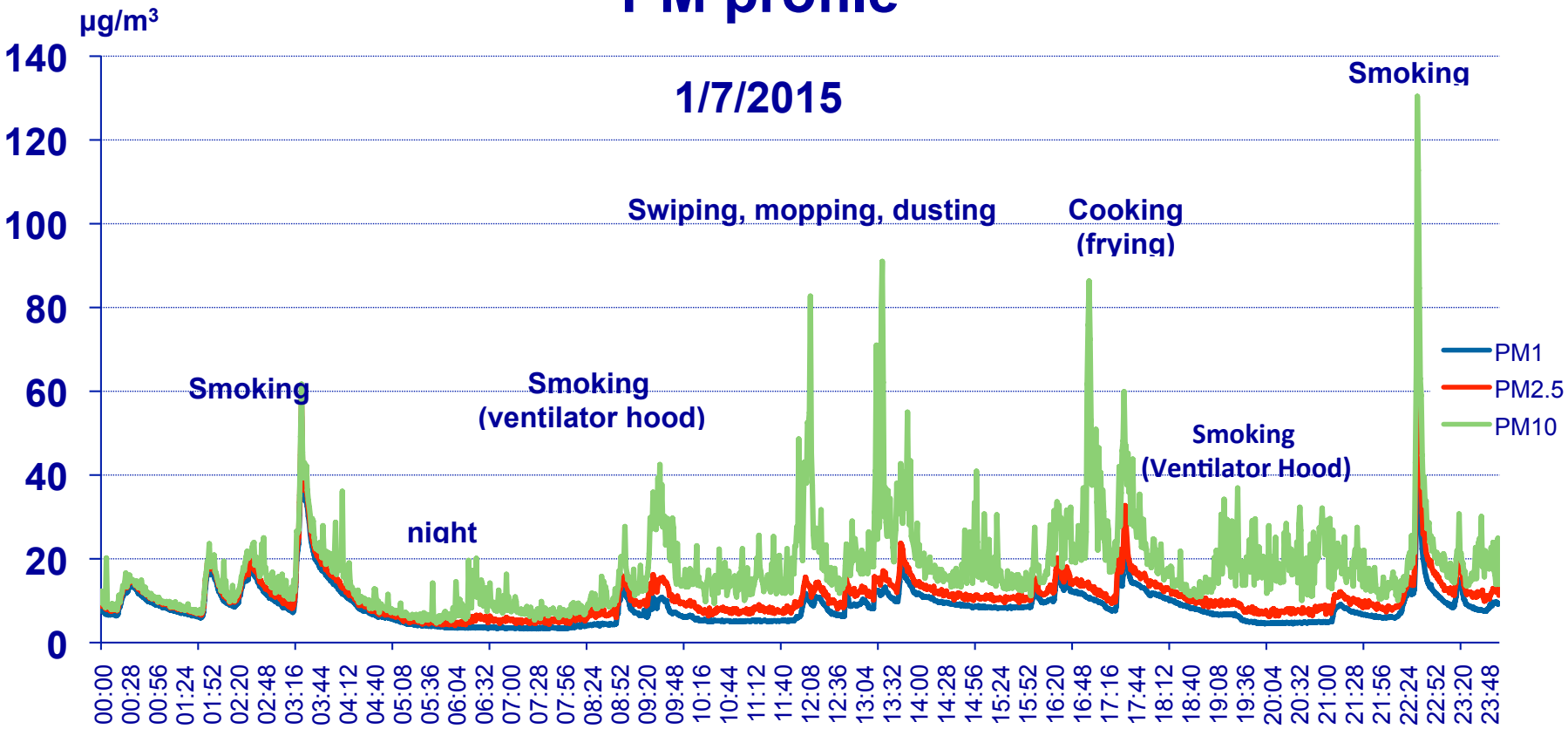

- At night the number of particles is significantly reduced (since no activities are carried out).
- In the morning, when activities such as walking-particles resuspension and preparation of breakfast are carried out, the number of particles increases.
- Smoking is a major source of PM, even when it is carried out under the ventilator hood.
- Cleaning activities (sweeping, vacuuming, mopping) and cooking activities (especially frying) are important contributors of PM in a house.

Personal Exposure Assessment

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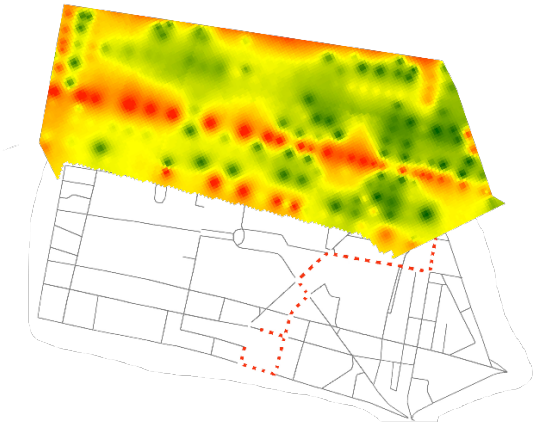
INPUT — SIMULATION — OUTPUT

Air Quality Data



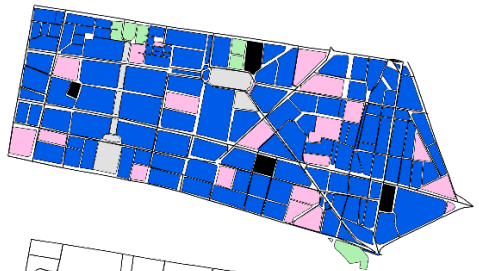
Personal Exposure

Human Agent Trajectories

Population Data

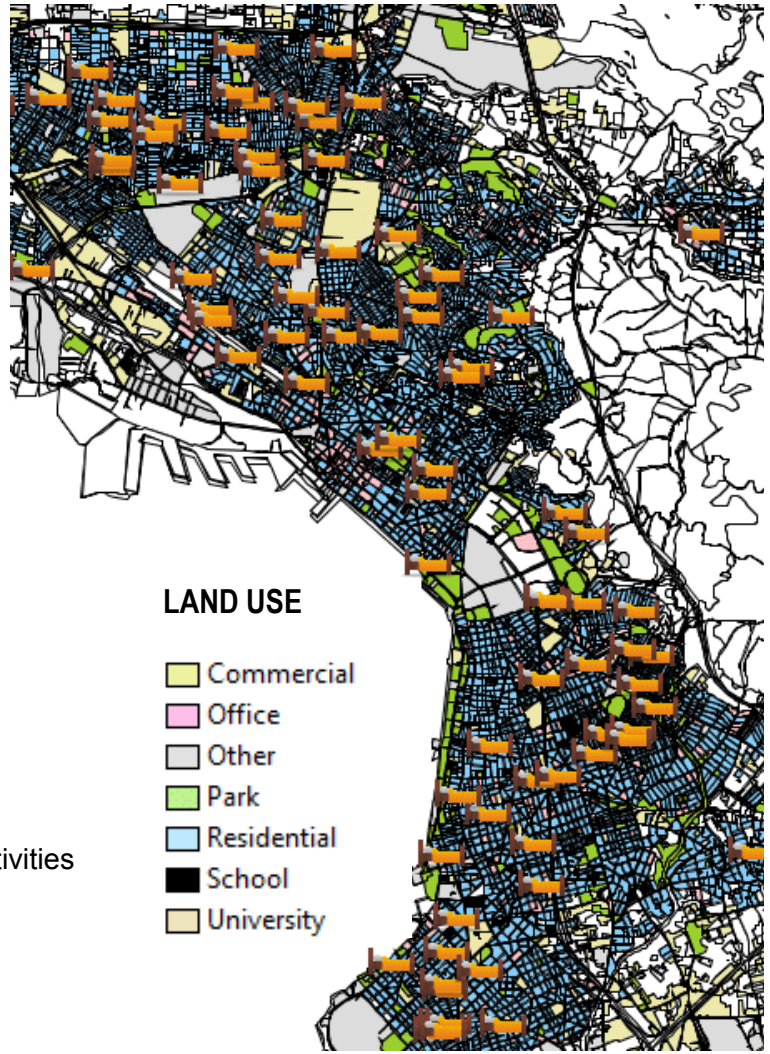
Agent Based Modelling

Buildings, Land Use



Road Network

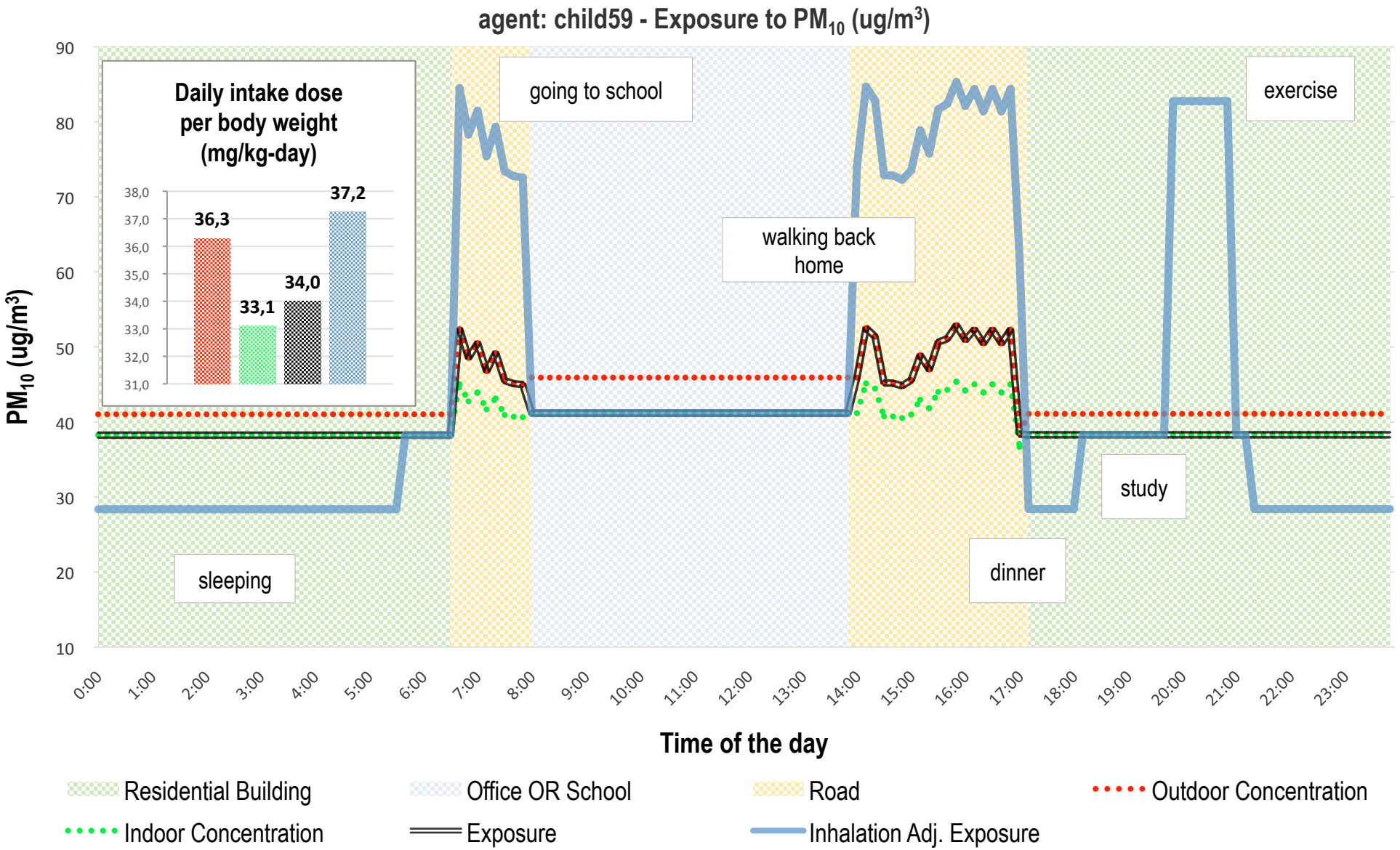
ABM simulation preview



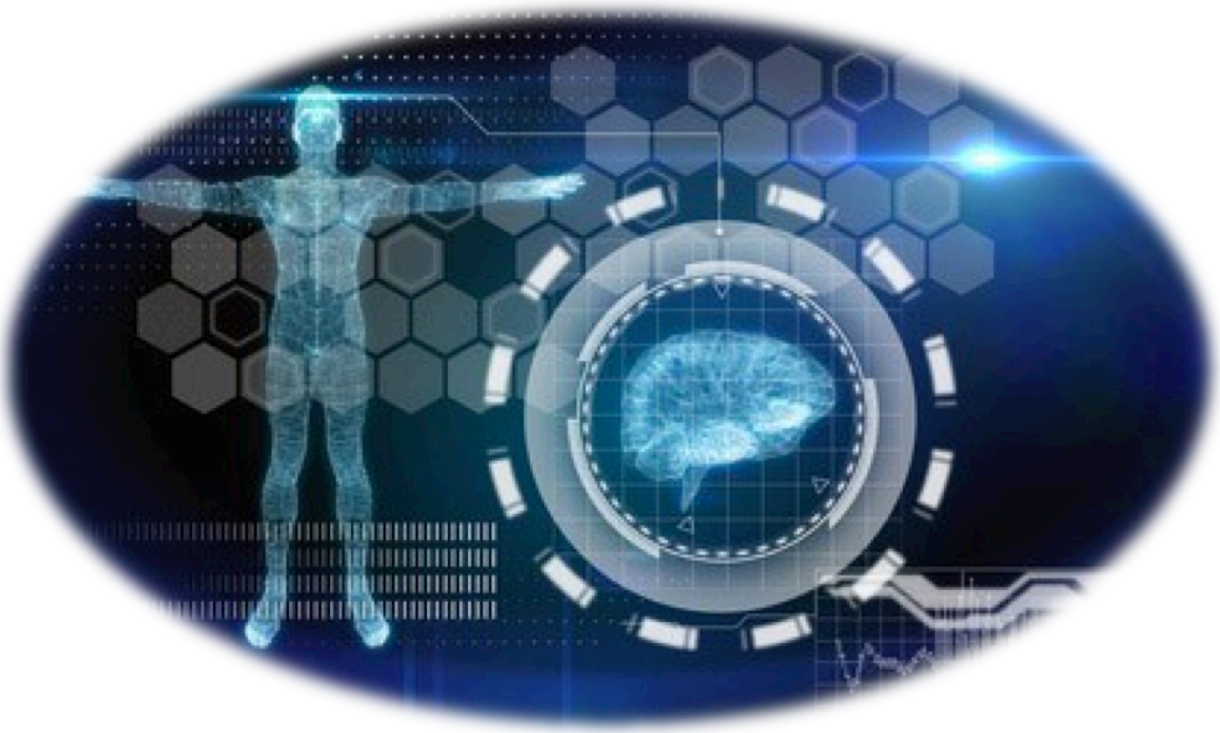
Thessaloniki, Greece

Results

Personal Intake Dose of agent

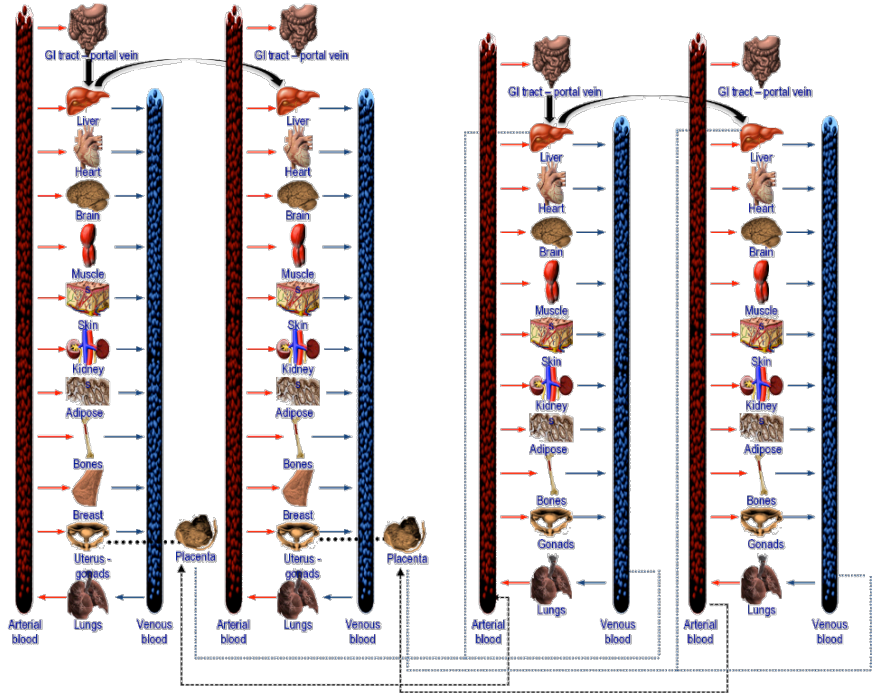


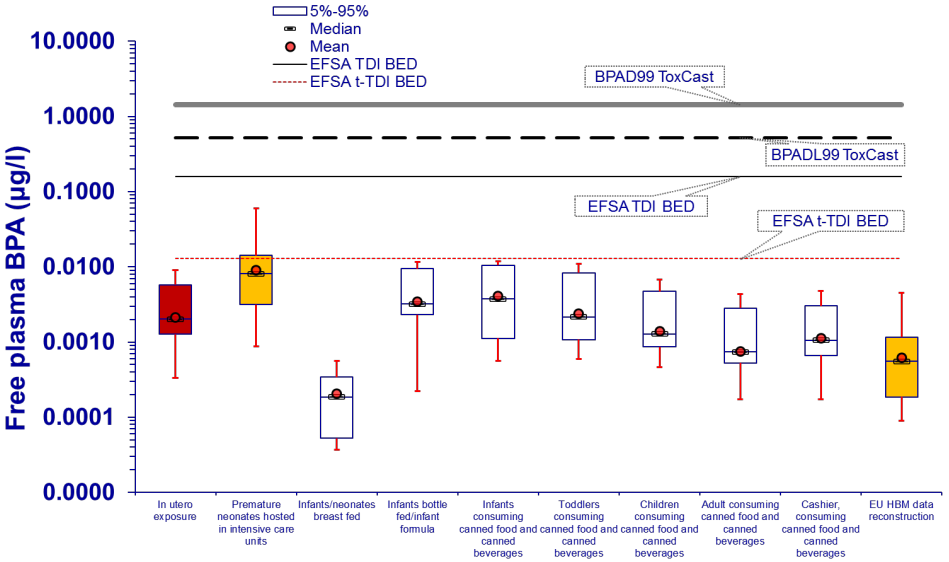
The internal exposome

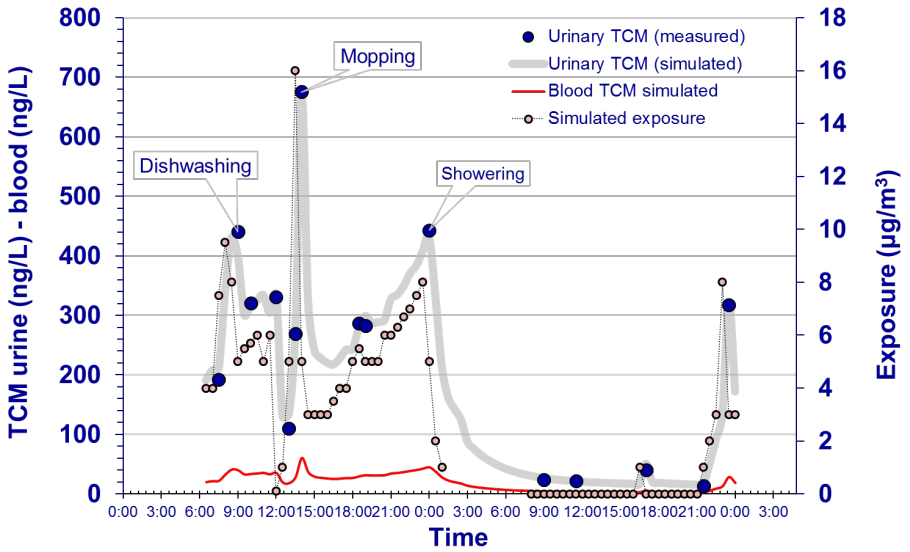


Internal exposure

Development of generic lifecourse PBBK computational platform

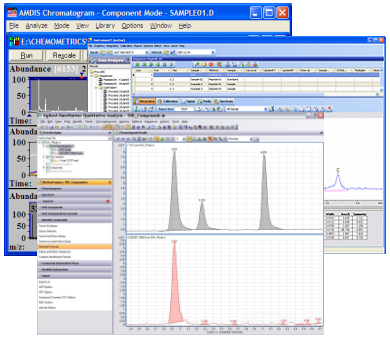






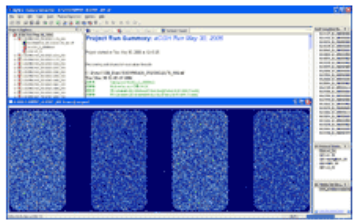
Exposure biology workflow

LC-MS/MS
GC-MS/MS



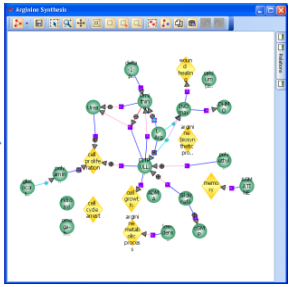
MassHunter Qual/Quant
ChemStation AMDIS

Microarrays



Feature Extraction

GeneSpring Platform



Biological
Pathways

NGS

Alignment to Reference Genome

Application of exposome based studies

- **EXHES study**
- **Discovering disease mechanisms through multi-omics pathway analysis coupling *in vitro*, *in vivo* and human data**

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EXHES Campaign

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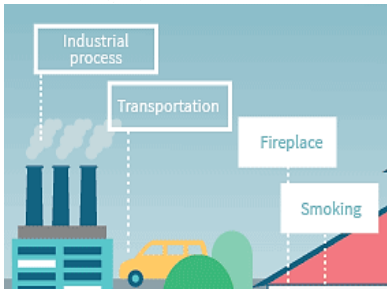
ENVIRONMENTAL ASSESSMENT

- *living room*
- *child's bedroom*

Chemical Compounds

Particulate Matter (PM)



allergens

Temperature | Humidity

Ventilation | Noise

HEALTH & BIOLOGICAL DATA

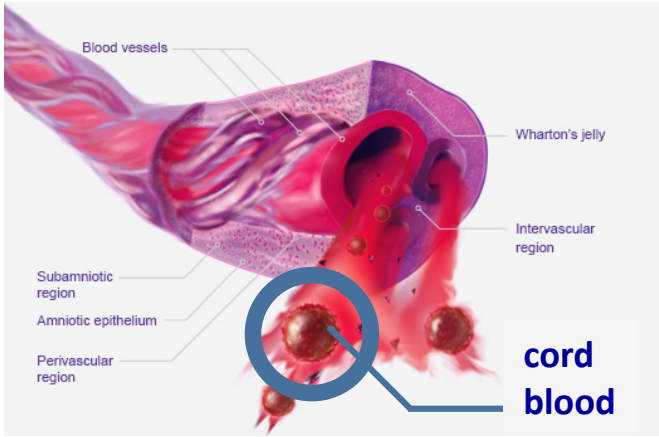
- *mother*
- *father*
- *children*

urine

blood

hair

saliva



cord blood

maternal milk

QUESTIONNAIRES

pregnancy → at delivery → post-partum → 1 year → 3 years → XX years

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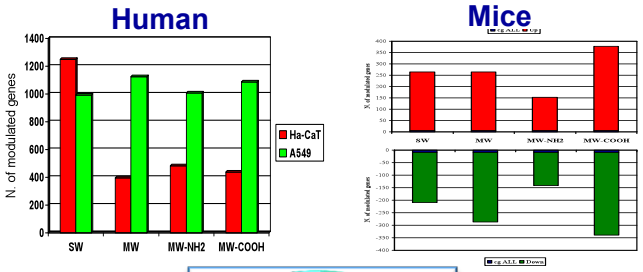
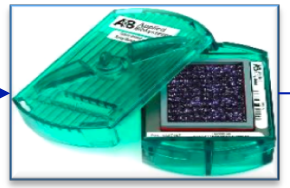
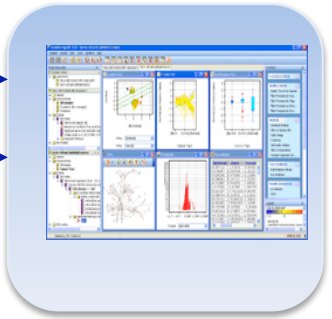
Vitkina, T. I., et al., 2016. Food and Chemical Toxicology. 87, 138-147
Golokhvast, K. S., et al., 2016. Environmental Research. 142, 479-485



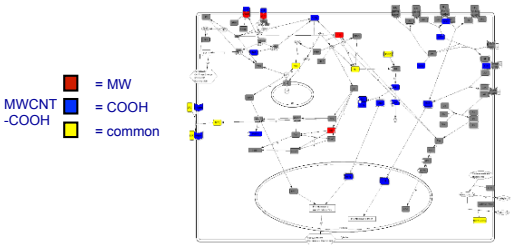
In vitro

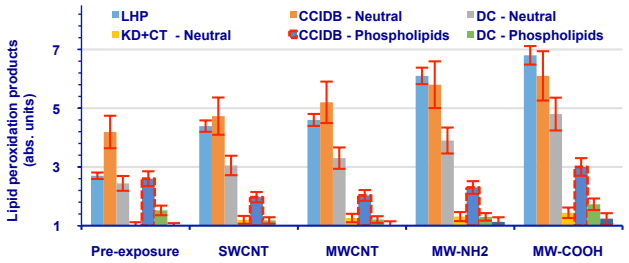


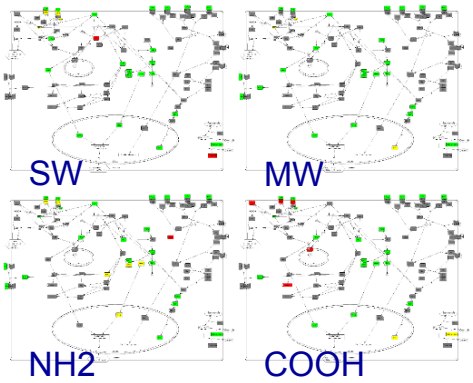
Transcriptomics



GeneSpring Platform

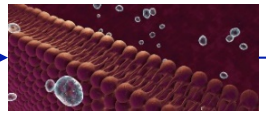




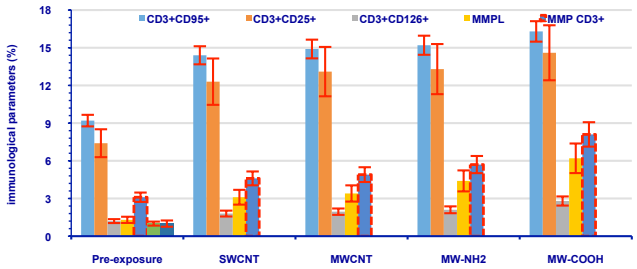


Pathway Architect

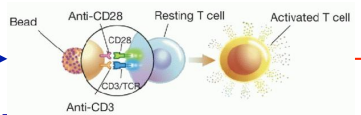
In vivo
(animal model)



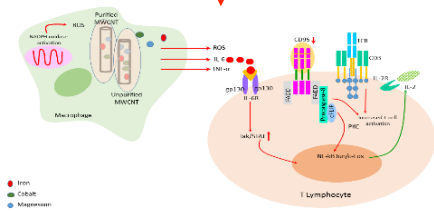
Lipidomics



In vivo
(human volunteers)



Immunologic response



Mechanism identification

Future steps (activities)

DG Research

- **CROME** - Common (med) case study / Hg repro-toxicity
- **HEALS**
  - EXHES study
  - Multi-omics Repro-PL
- **HBM4EU** / ~ 2M € / ~ 1.3M € EU income for the next 5 years
- **BlueHealth** / ~ 470K € EU income for the next 4 years
- **ICARUS** / ~ 900K € EU income for the next 4 years

DG ECHO

- **PEC –** Chemical disasters ~ 120K € EU for the next 1.5 years
- **GRIN –** Green infrastructure/Urban health ~ 100K € EU for the next 2 years

DG JRC

- **ERNCIP** – Chemical and Biological risks (terrorism)

The exposome / a Big science endeavor

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- Big Data
- Transdisciplinary science and education
- Multi-technology – high dimension biology and environmental engineering
- Open collaboration paradigm
  - USA, Russia, all EU countries
- International ethics Control / Approval
- Leads to precision prevention – going beyond precision medicine
- Worldwide recognition
  - Summer school in Exposome at Emory Univ. in Atlanta, GA, USA
  - Next year in Thessaloniki

Bertold Brecht's *Life of Galileo*:
"*The main objective of science is not to open the door to infinite wisdom but to roll back the boundaries of infinite error*.

Thank you for your attention

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A connectivity perspective to environmental health