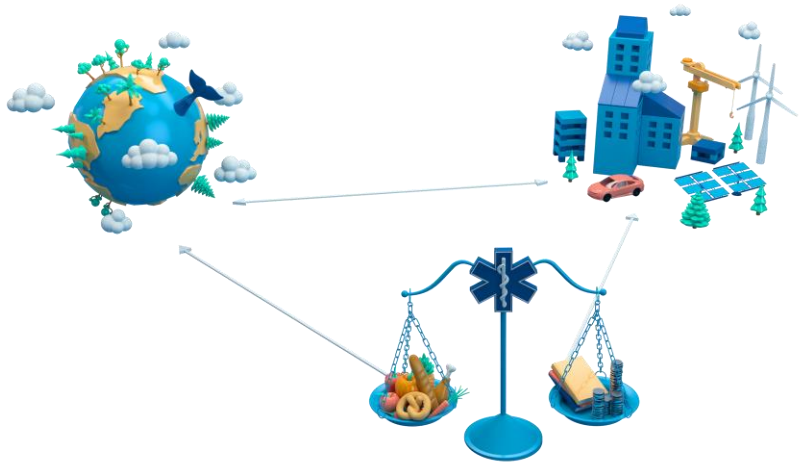
EIRENE RI



SETTING UP AN INFRASTRUCTURAL LANDSCAPE FOR AN ASSESSMENT OF CHEMICAL RISKS

Jana Klánová

on behalf of the EIRENE Consortium

EXPOSOME MOONSHOT FORUM

Did you know that 90% of chronic disease is linked to environmental exposures?

The Human Genome Project revolutionized our understanding of health, but only tells part of the story.

The rest of the story—**how our environment shapes our health**—remains largely unexplored. **Until now.**

We're launching an unprecedented scientific endeavour to map the combined impact of all environmental factors that affect human health from **conception to death.**

This initiative matches the **Human Genome Project** in scope and ambition, promising to revolutionize medicine, public health, and environmental protection.

Why now?

The convergence of advanced technologies makes this the perfect moment for a moonshot:

Artificial Intelligence: Unprecedented ability to analyze complex environmental data

Advanced Sensors: Real-time monitoring of complex environmental factors

Exposomics: Deepened understanding of how exposures affect our biology

Big Data Analytics: Capacity to process and interpret massive datasets

EXPOSOME MOONSHOT FORUM

May 12-15, 2025, Wasington, D.C.

This isn't a traditional conference—it's a strategic forum to launch a **global movement.**

Over four intensive days, participants will:

- Shape the future direction of the Human Exposome Project, creating a strategic roadmap
- Design frameworks and identify benchmarks of success for effective implementation
- Form crucial partnerships across academia, industry, and government to scale impact
- Establish governance structures that ensure low and middle-income nations' participation

Project Impacts:

01

Transform Medicine

- Predict disease risk based on exposure patterns
- Identify environmental triggers for chronic conditions
- Enable early intervention in disease progression

02

Revolutionize Public Health

- Target interventions to communities most at risk
- Reduce healthcare costs through prevention
- Create evidence-based environmental policies

03

Accelerate Innovation

- Design safer chemicals and materials
- Enable precise testing of environmental impacts
- Drive advances in sensor technology

Join this global initiative! Nominate yourself and others at exposomemoonshot.org.

SCAN ME

Washington Declaration on the Establishment of a Global Consortium for the Human Exposome

We, the undersigned participants of the Exposome Moonshot Forum held in Washington, DC in May 2025, representing diverse stakeholders from academia, government, industry, healthcare, media, and civil society, hereby launch the Global Human Exposome Initiative

Adopted in Washington, DC, on the 15th of May, 2025

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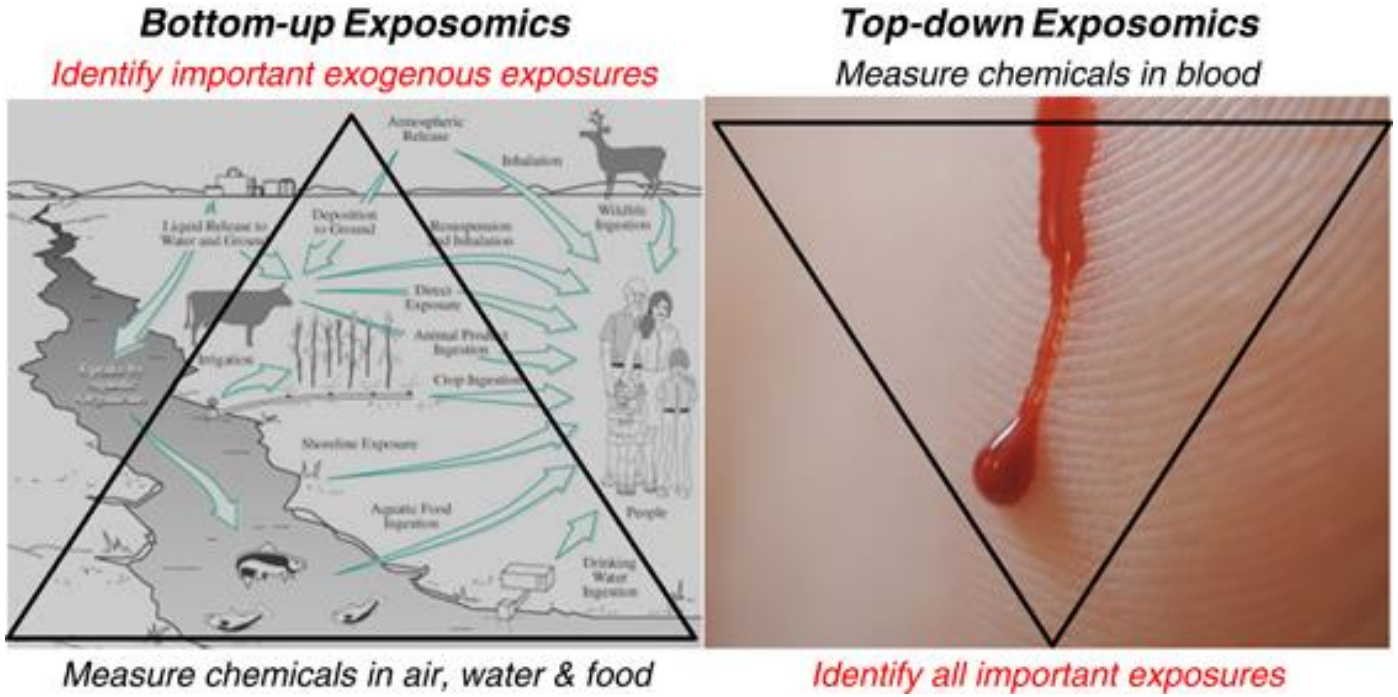
Original definition

- Wild (2005) proposed a **non-genetic complement to the genome** - the exposome - to encompass **all environmental exposures shaping phenotype.**

Monitoring programmes

Earth observations



Exposure markers

Effect markers

Personal samplers, wearables

Mechanistic toxicology

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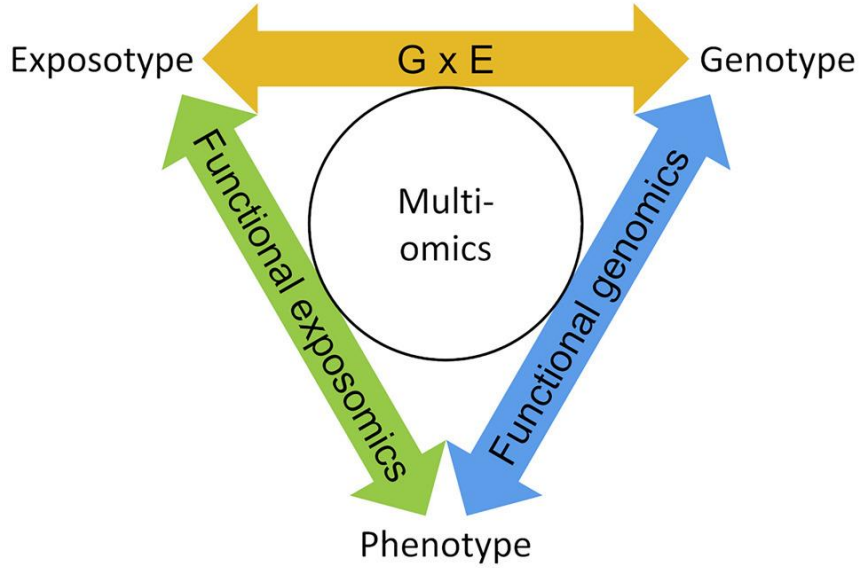
Exposome redefined

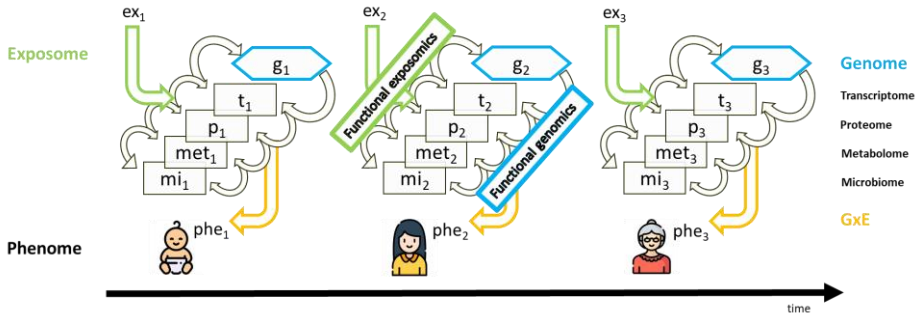
- **Exposome:** the totality of environmental exposures, i.e. the totality of contact between external factors (agents) and a biological entity.

- **Functional exposomics:** the systematic and comprehensive study of environmental exposure-phenotype interaction over a defined time-period.

- Operational definition for studies **considers the environmental exposures** (contacts with external factors) that **influence phenotype and health.**



https://doi.org/10.1016/j.isci.2022.103976



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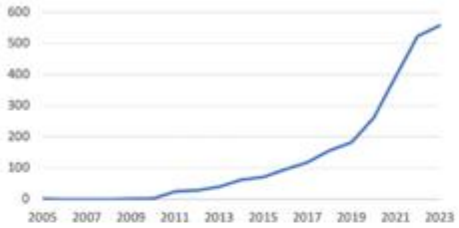
A brief history of the exposome and exposomics

The Exposome
à la Chris Wild



2005

EU Exposome
3 projects

Japan study

NATIONAL ACADEMY OF Sciences
Exposome
Workshop

2010

The Exposome
Rappaport + Smith

Patel…Butte
1st EWAS

Human exposome
Project website

HERCULES Exposome Research Center
1st NIH center

1st book

@exposome
on social media

EU Human
Exposome Network
9 projects

NIH CHEAR
HHEAR

2015

Institute and
NYC symposium

Icahn School of Medicine at Mount Sinai

Vermeulen et al.
Science

NIH
NIEHS workshop
exposome series

DECODING THE MOLECULAR UNIVERSE
m/q INITIATIVE

EIRENE RI

NIH
MOHD

THE BANBURY CENTER
Cold Spring Harbor Laboratory
Banbury-CSHL

IHEN

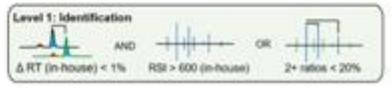
CANCER GRAND CHALLENGES

2020

Miller
2nd Edition

1st journal
founded

Columbia
Center for
Innovative
Exposomics



GC-orbitrap exposomics user group

2024

NEXUS

?

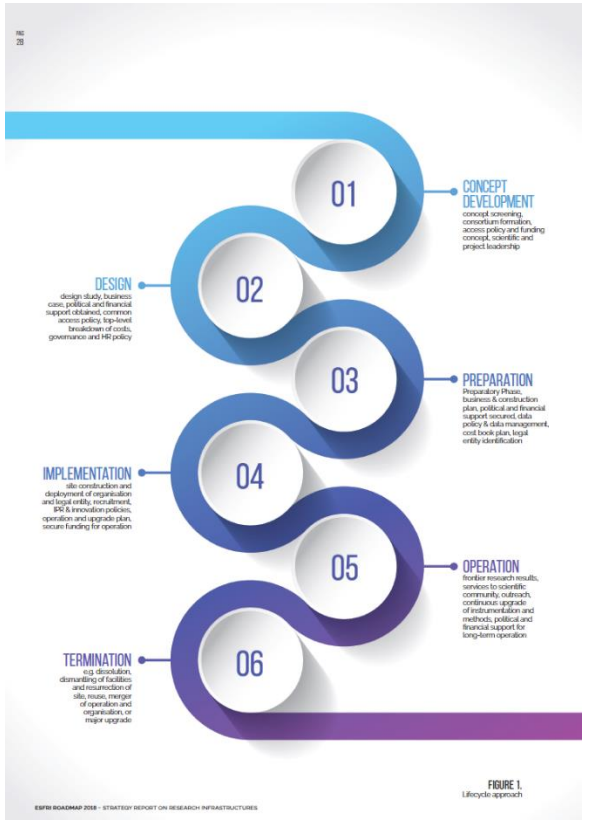
EXPOSOME THERAPEUTICS INC.

RI

Gap in the 2018 ESFRI Roadmap

„There is a need to enable a research infrastructure that will facilitate research on the human health and wellbeing at all stages in development, including ageing, nutrition and behavioural studies, and their connections to the social sciences and humanities. There are ***geographic, economic and environmental drivers affecting human health and wellbeing. Climate change, extreme weather, dramatic changes in ecosystem services, environmental pollution and exposure to harmful chemicals*** *represent a new combination of issues that* ***require an integrated approach at pan-European level.***

At the heart of this approach is the ***EXPOSOME****, taking* ***a holistic view throughout the human lifetime on the effect of exposures to diet, lifestyle, and the environment on human health and disease****. The EXPOSOME coupled with advanced genetic and medical approaches represents an opportunity to tackle this complex issue by connecting to the landscape of Health & Food RIs and other domains. Ongoing EU projects and networks on human biomonitoring (HBM4EU and EMEP) are important steps to bring together relevant parties."*



https://www.eirene-ri.eu

EIRENE RI

EIRENE RI: Prioritised in the 2021 ESFRI Roadmap

EIRENE RI

Research Infrastructure for EnvIRonmental Exposure assessmeNt in Europe

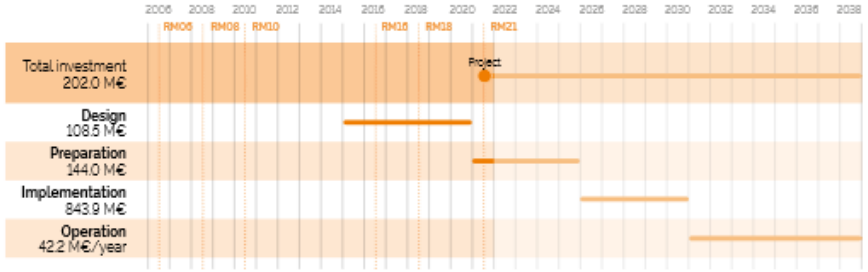
Website	Headquarters	Legal status	Type
pending	Masaryk University Brno, Czech Republic	pending	distributed

DESCRIPTION

The Research Infrastructure for EnvIRonmental Exposure assessmeNt in Europe (EIRENE RI) pioneers the first European Research Infrastructure on environmental determinants of human health, the Human Exposome. EIRENE RI intends to support large-scale research for the interdisciplinary assessment of environmental determinants of health, including indoor and outdoor environment factors, lifestyle, socioeconomics, and the individual's ability to cope with various stressors such as infection or disease. EIRENE RI will provide harmonised workflows and integrated services for data and sample collection, as well as knowledge and tools that will be made accessible to academic researchers, private companies, public authorities and citizens through the EIRENE open-access system and the EIRENE knowledge hub.

The concept of a pan-European Infrastructure supporting research on the effects of long-term exposures to various types of stressors on population health and the roles these exposures play in the development of chronic diseases is based on ten-year experience of Czech national RECETOX RI. Entered in the ESFRI Roadmap 2021, EIRENE RI already connects 50 research institutions from 17 countries. It builds on the legacy of the European environmental monitoring networks and their databases (EMEP, GMP, GMOS), GEO Initiatives (GOS4POP and GOS4M) and related H2020 projects (ERA PLANET, e-SHAPE), EU biomonitoring initiatives (DEMOCOPHES, HBM4EU), UNEP/WHO global biomonitoring efforts, EU exposome (HELIX, EXPOSOMICS, HEALS and EHEN cluster) and other related projects (HERA, EURION cluster).

TIMELINE & ESTIMATED COSTS



INTERCONNECTIONS

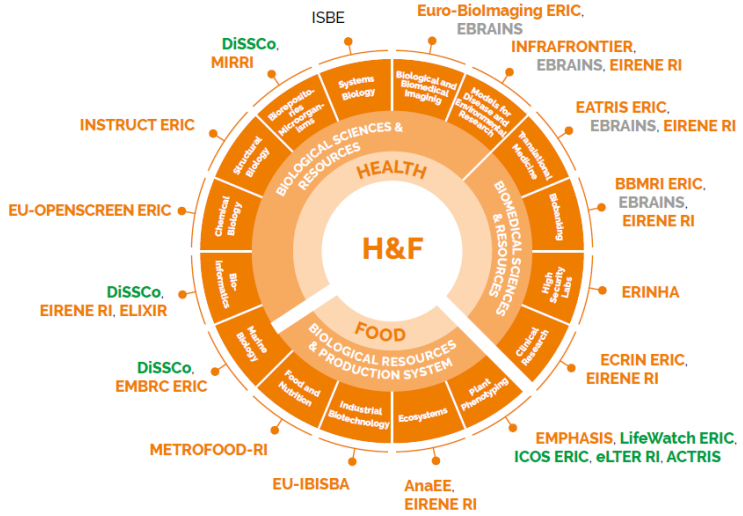
POLITICAL SUPPORT

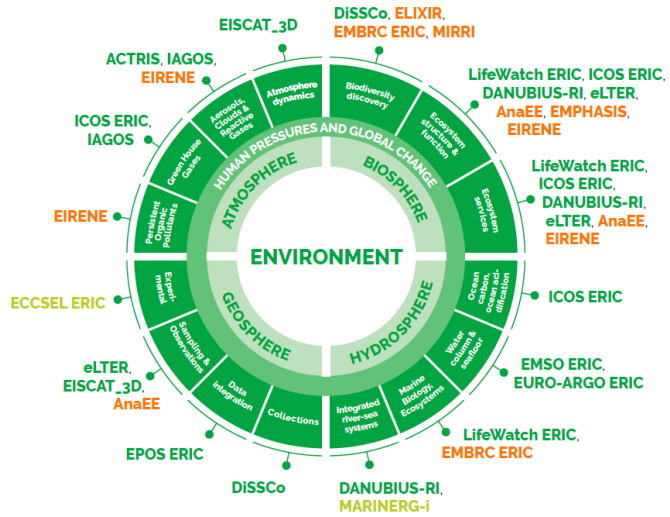
Lead
CZ

Prospective member
AT, BE, DE, EL, ES, IS, IT, NL, SK

Members

- **Austria, Belgium, Czechia, Italy, Netherlands**
- Germany, Greece, Island, Slovakia
- France, Norway, Sweden
- Finland, Slovenia, Spain, UK, US
- Cyprus, Denmark, LX, Portugal
- Australia
- EMBL/EBI



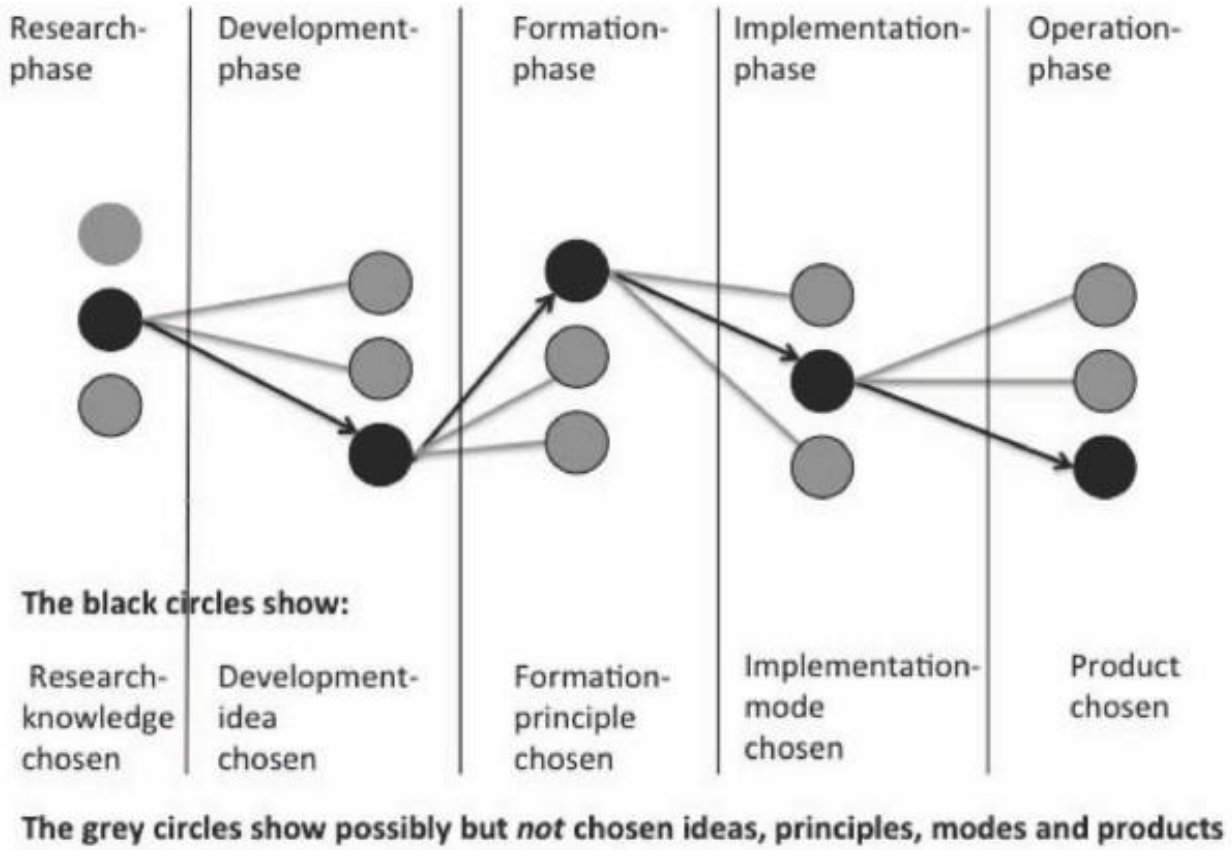


EIRENE RI

Steps forward

During a series of meetings ‘Accelerating Precision Environmental Health: Demonstrating the Value of the Exposome’, organised by the US NIEHS in 2022, several obstacles to progress in this field were identified:

- The need to establish **standardized and robust approaches for biomonitoring of the human exposome**;
- **Data sharing** in exposome research: databases, metadata, encouraging data sharing, and reporting responsibility;
- Creating and sustaining interoperable **data repositories** for environmental health data;
- **Harmonizing exposome data** across studies;
- **Merging data** from existing longitudinal studies;
- Making the exposome relevant to **public health interventions** and policy & addressing disparities by intervening on the social and physical environments;
- Establishing a **community-of-practice**.

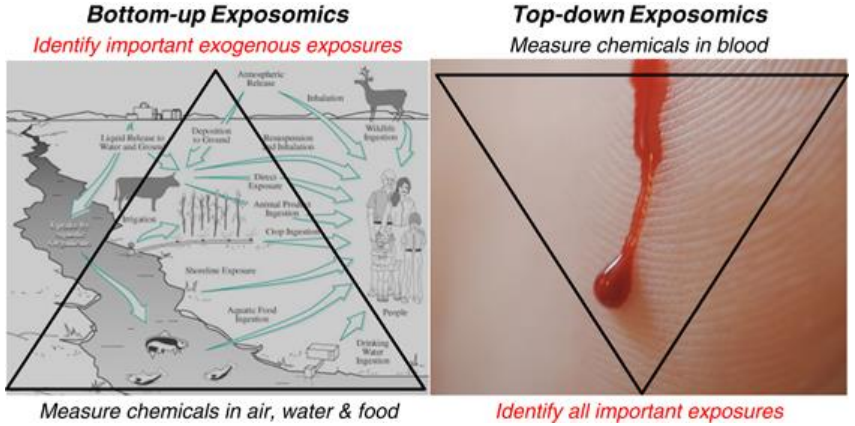


Hostgaard et al. 2011

EIRENE RI

Exposomics challenge

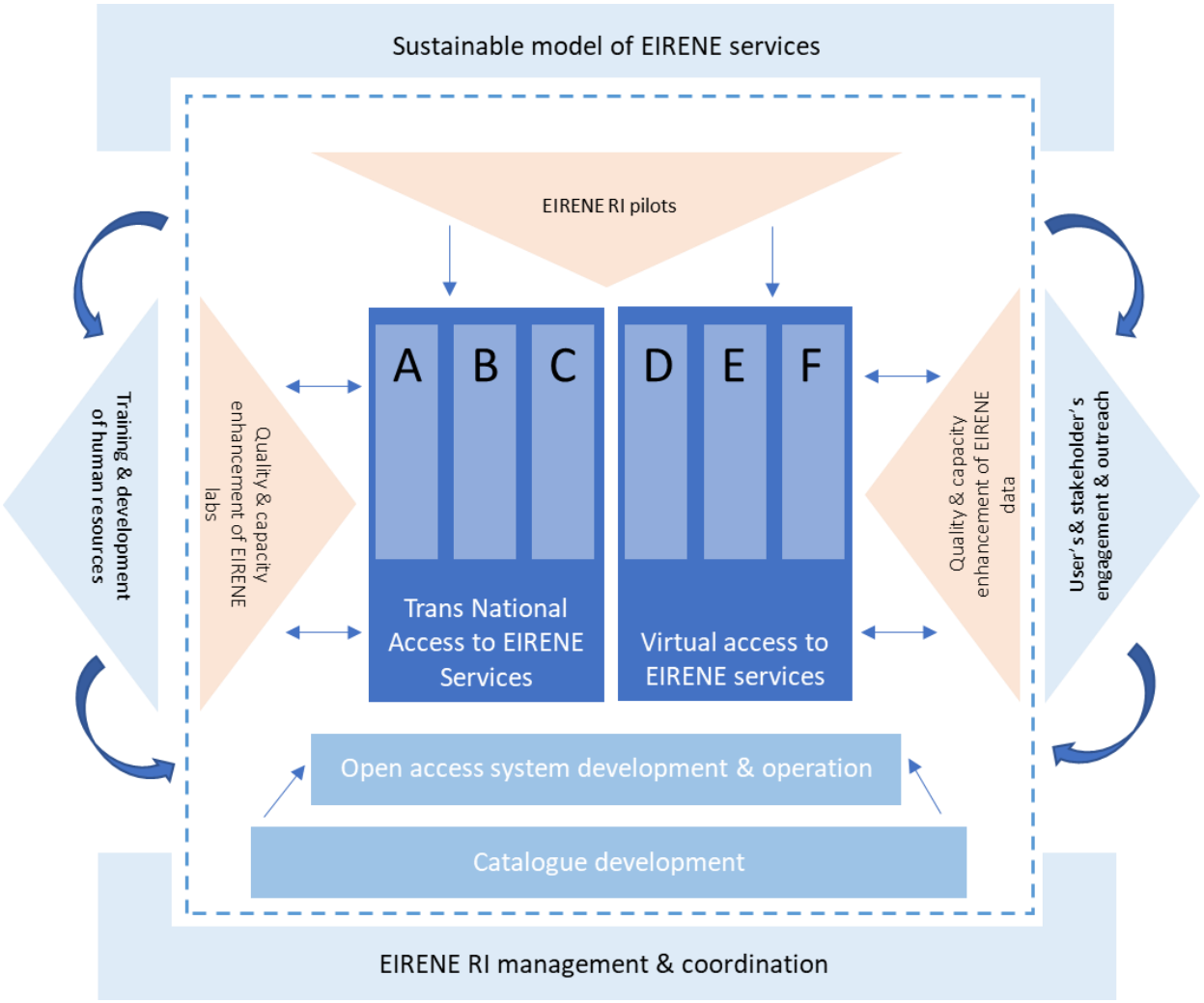
- To support integration into the biomedical sciences, exposomics should provide **a readily deployable toolbox** including methods of **high-resolution mass spectrometry for detection of environmental chemicals and metabolic perturbations**, **epigenomics** to measure environmentally mediated alterations to DNA, or **geospatial techniques** for mapping proximity to exposure sources.



- Such a toolkit should be **accessible to researchers** from multiple fields demanding the analyses of tens of thousands (and potentially millions) of samples **through the open-access services** of the harmonized network of (laboratory and data) research infrastructures.

EIRENE RI

EIRENE RI services



Open-access services

A – chemical (exposure) profiling

B – biological (response) profiling

C – hazard (risk) assessment

D – environmental data

E – human data and samples

F – data processing tools & platforms

Central services

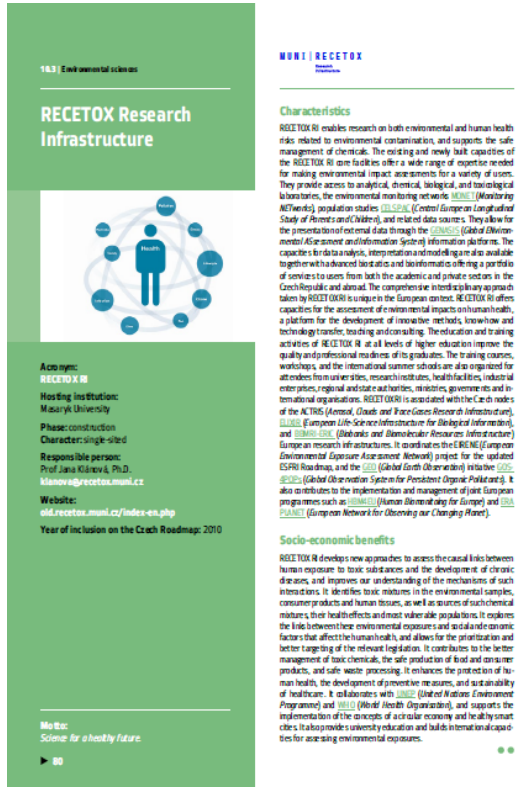
Quality and capacity enhancement in labs

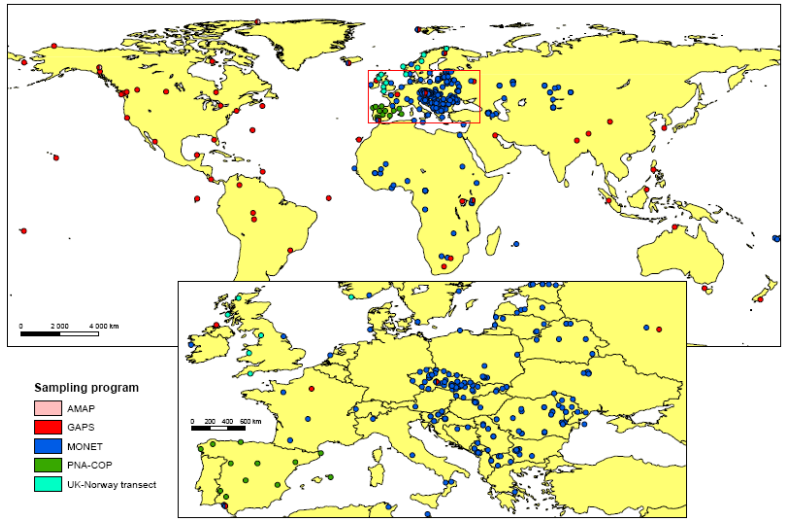
Quality and capacity enhancement in data

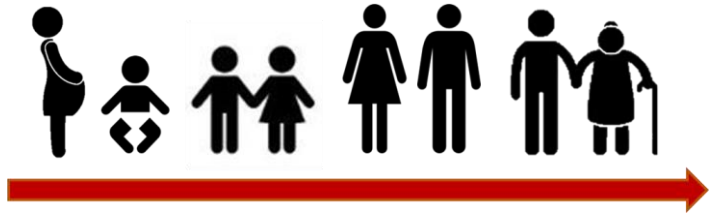
HR development and training

EIRENE RI

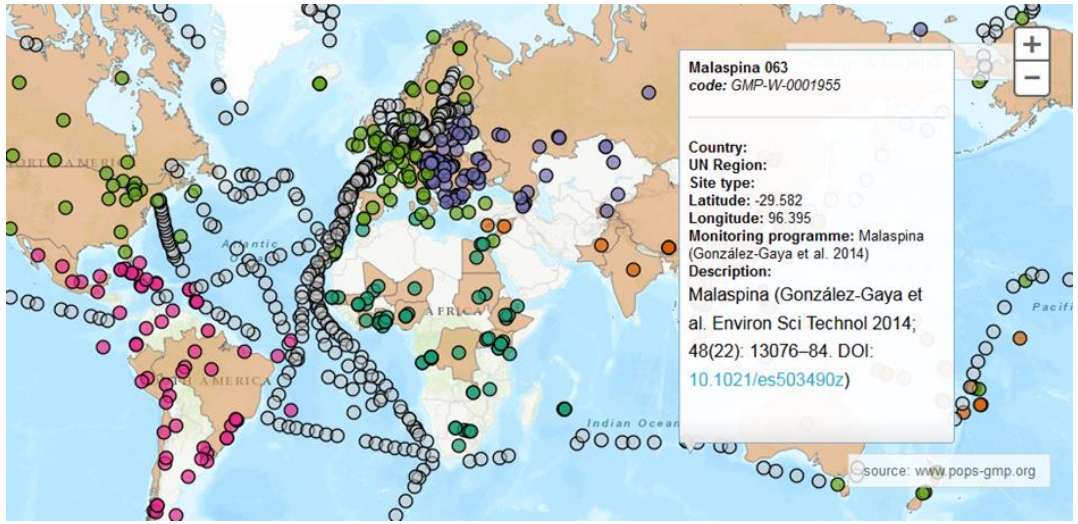
RECETOX RI at the roadmap since 2011







RECETOX accredited trace laboratories
CELSPAC population studies
MONET air and water monitoring networks
GENASIS/GMP information platforms

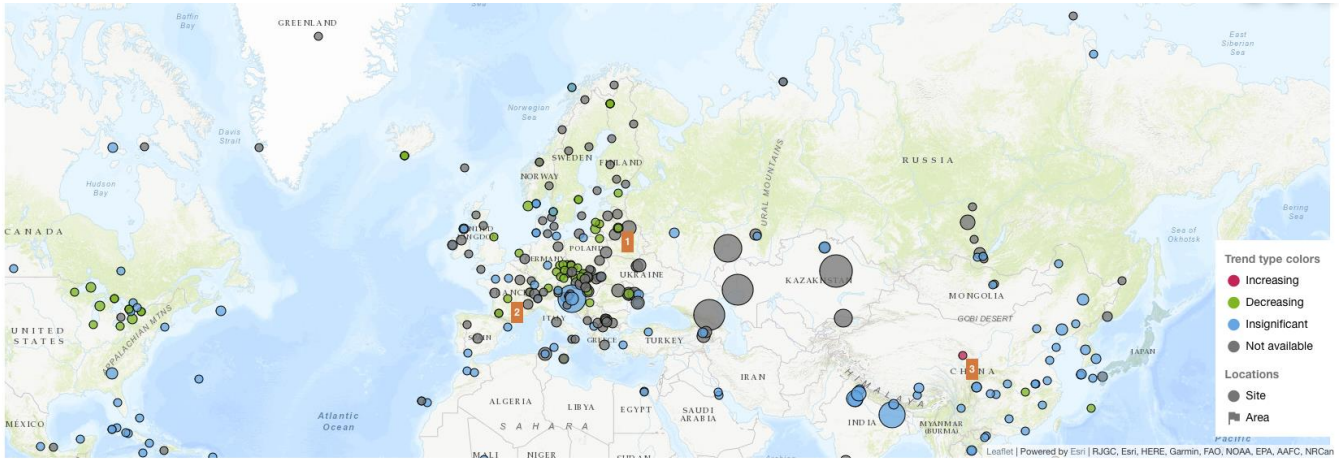


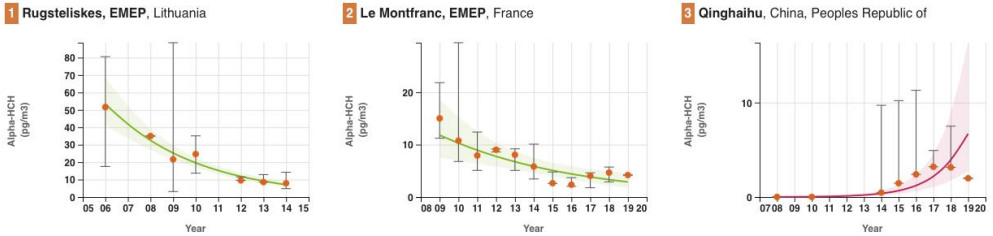
EIRENE RI

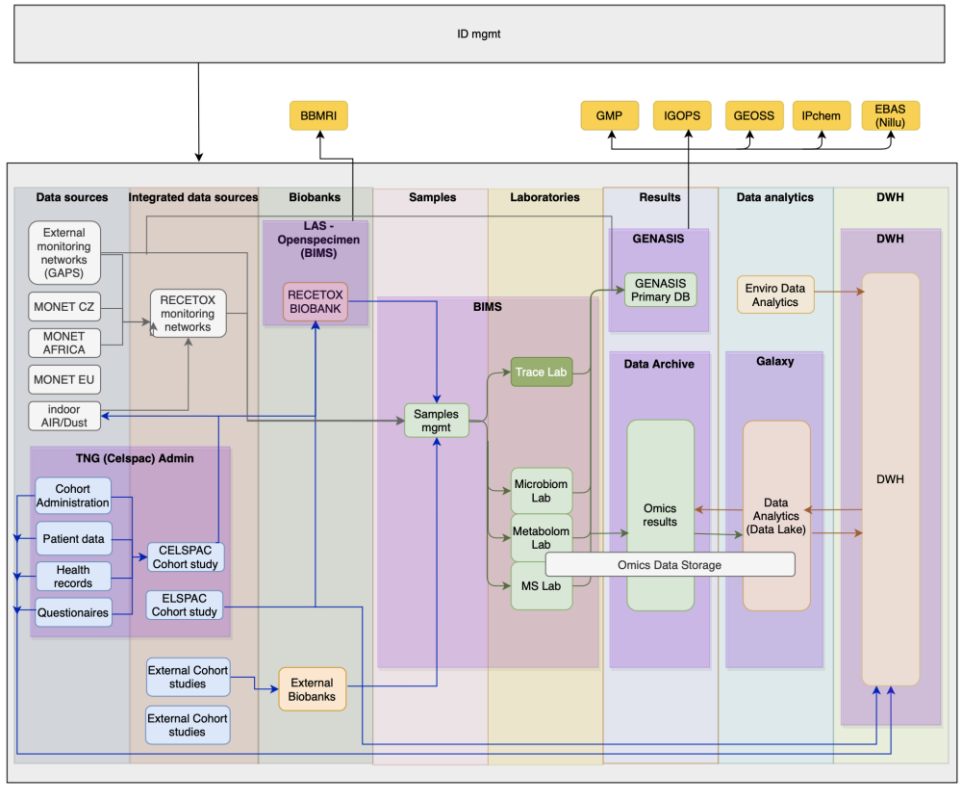
Data integration and visualization

Development, customization and operation of information and database systems

To support: Data integrations across systems and scientific domains







UNEP Regional Centre since 2008

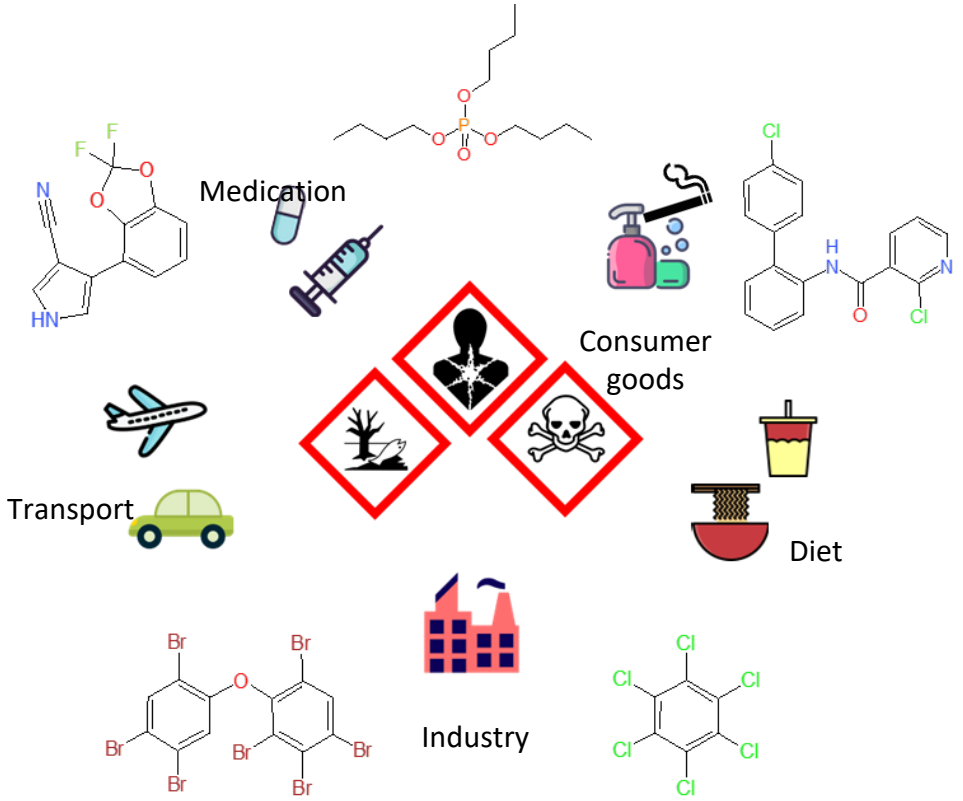
EIRENE RI

Chemical exposures

- **Molecular characterisation of exposures focuses on chemicals** (and their biochemical responses)
  - Many environmental exposures do not elicit observable biochemical responses
  - Cumulative nature of burden means association of exposure – effect is challenging

– **What distinguishes a response and an effect**

https://doi.org/10.1136/jech-2011-200643



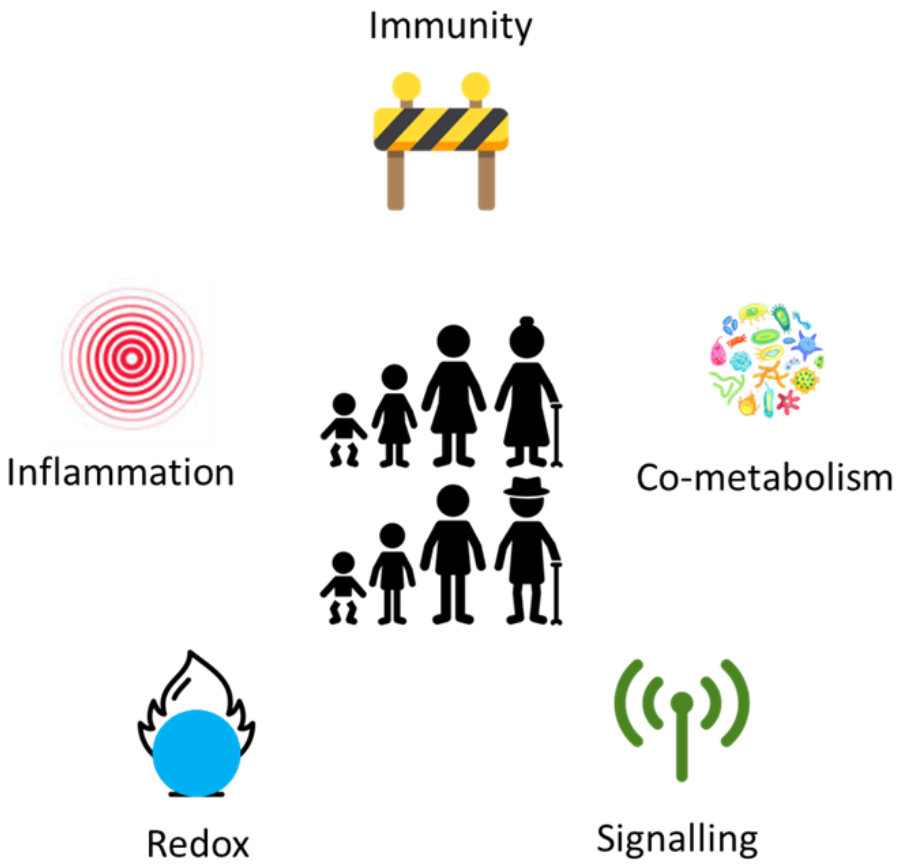
EIRENE RI

Biochemical response

- **Molecular characterisation of biochemical responses focuses of endogenous metabolites**

- Molecular-level (biochemical) **responses are not the same as higher-order phenotypic effect** i.e. not necessarily biomarkers of clinical effect

- Molecular hallmarks of health are generalised and non-specific



https://doi.org/10.1016/j.cell.2020.11.034

https://doi.org/10.1016/j.cell.2021.01.043

https://doi.org/10.1016/j.isci.2022.103976

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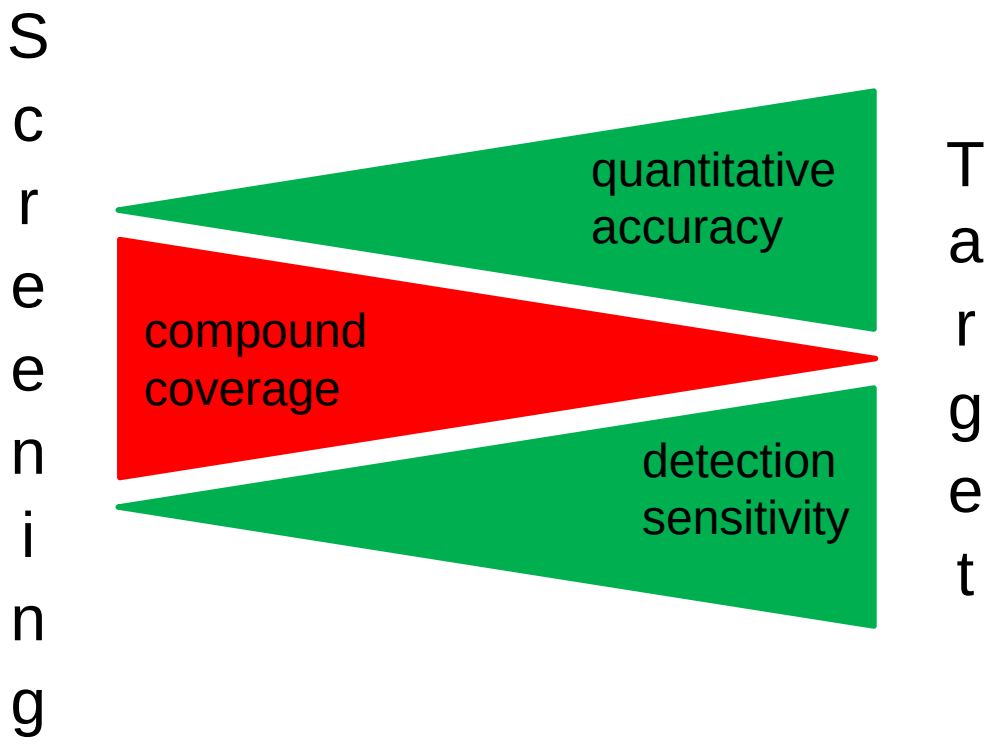
HRMS profiling

- Exploratory analysis of sample composition
- Detection and discovery of novel chemicals
- Broader chemical coverage but reduced accuracy:
  - qualitative i.e. analyte identity
  - quantitative i.e. analyte concentration
- **QA/QC standards in the metabolomics field have largely not progressed since ~2000**

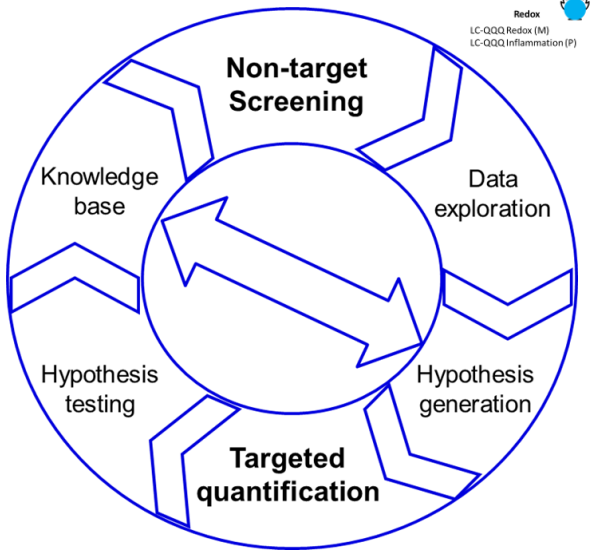


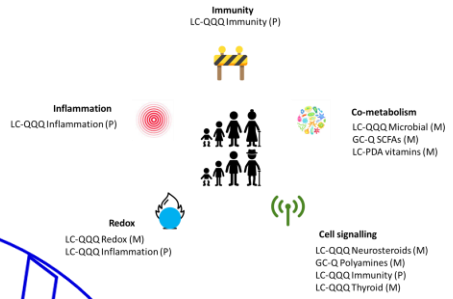
EIRENE RI

EIRENE chemical exposomics

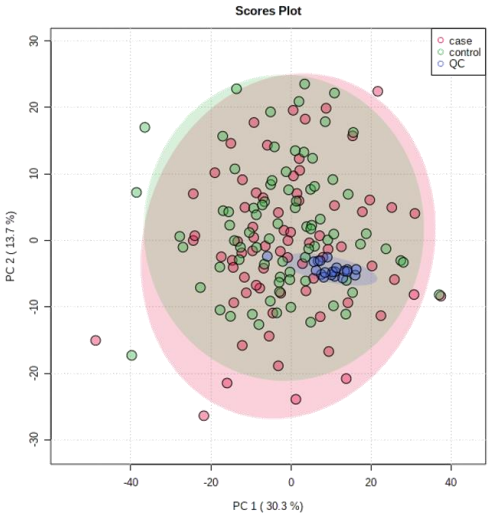
- Integrate target & screening
- Harmonized QA/QC approaches

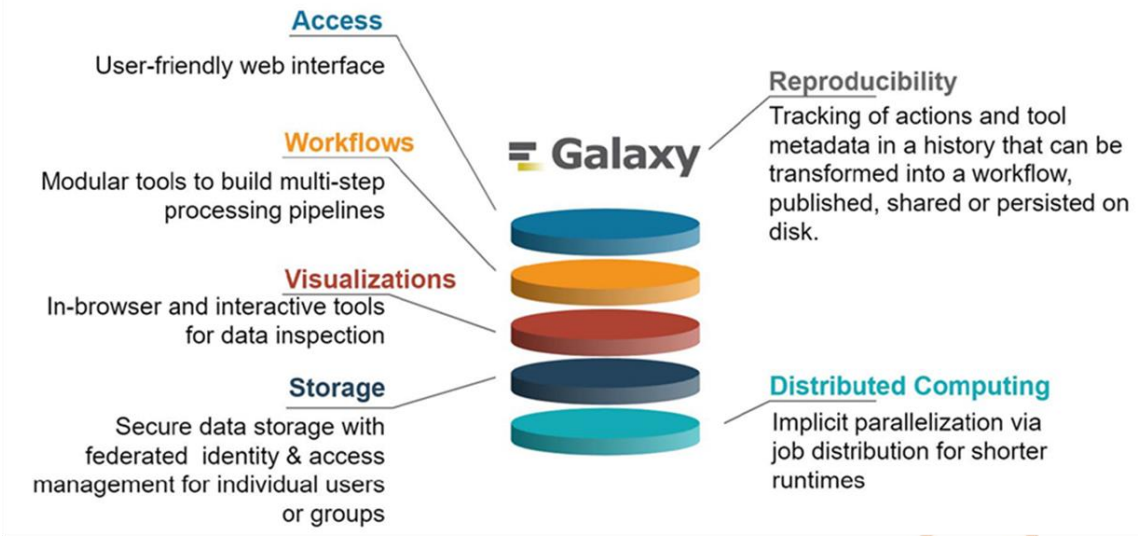
- **Public SOPs & setup**
- **Public spectral libraries**
- **Public processing pipelines**
- **FAIR data & reporting**





Instrumental blank 1
Alkane mix 1 (retention-index lock)
PCB mix 1 (system sensitivity check)
Instrumental blanks 2 & 3
QC dilution series 1 (2-64x dilution)
Procedural blank 1
External pooled long-term QC 1
Samples 1-10
Procedural blank 2
External pooled long-term QC 2
Samples 11-20
Procedural blank X
QC dilution series 2 (2-64x dilution)
Alkane mix 2 (retention-index lock)
PCB mix 2 (system sensitivity check)
Instrumental blanks x, x+1, x+2





- First step = full transparency for reproducible, standardised single-site analysis
- Second steps = multi-site harmonisations

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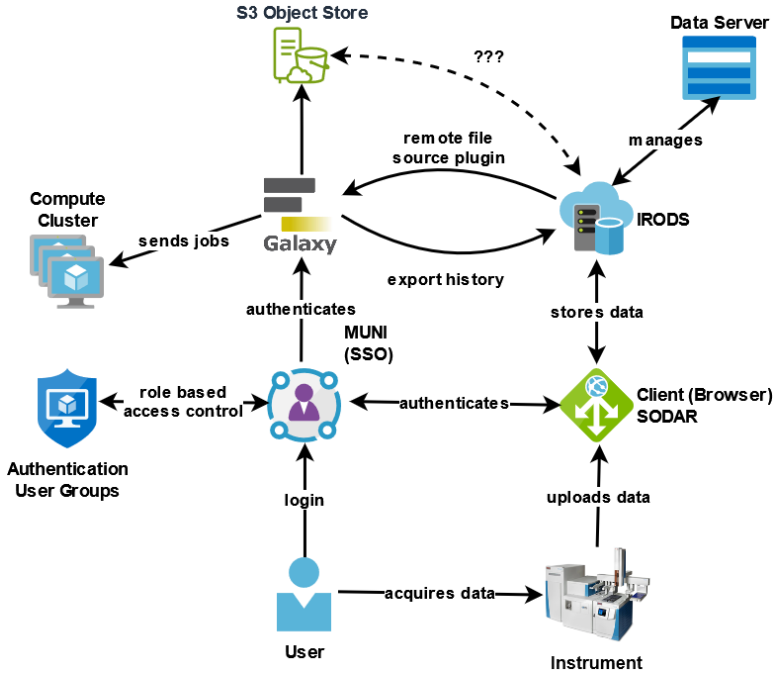
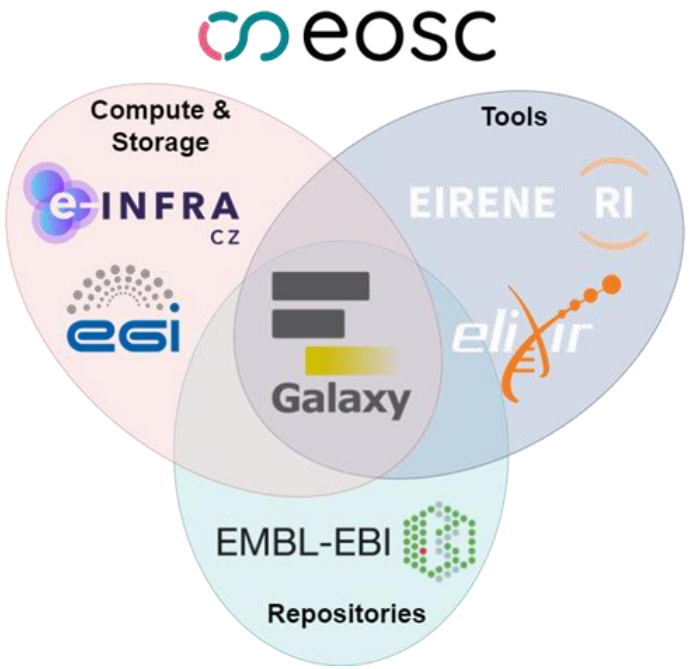
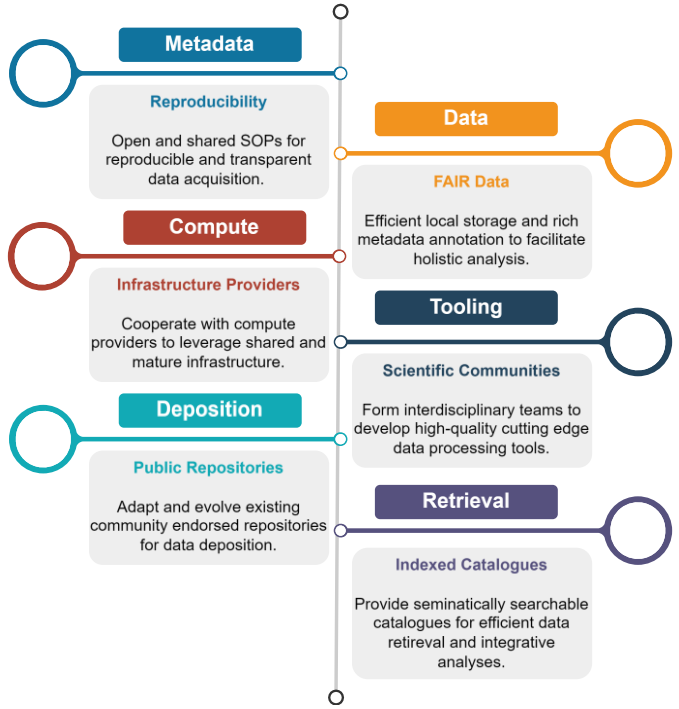
SpecDatRI (EIRENE-CZ) Data Infrastructure (upcoming)







- Robust open-source research data management software (i.e. iRODS)
- Integrating ELIXIR authentication mechanisms (LifeScienceRI)
- Interoperable framework of distributed data storage (SODAR) and processing solutions (Galaxy)
- Ontology based metadata annotations, standardized data formats and procedures

MUNI | RECETOX

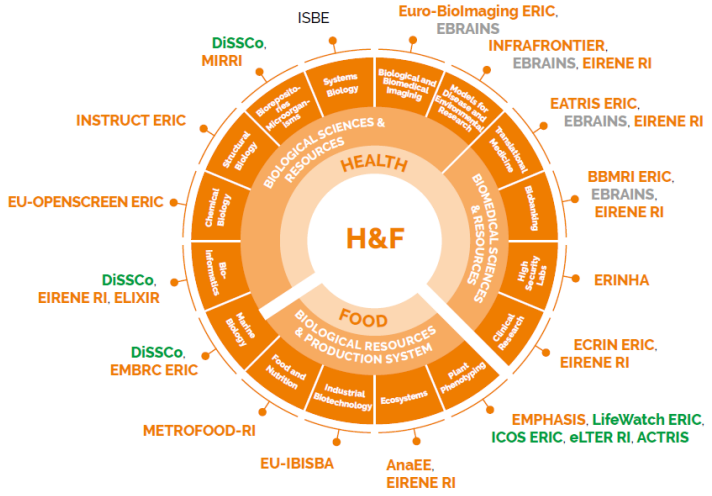
Repositories for data on chemical exposures and their effects

Masaryk University, Faculty of Science

Communities

GENASIS chemical exposure repositorry (soil, water, sediment, air, indoor, consumer products, human tissues)	Metabolomics data reporitory	Toxicology data repository	Geo-coded data repository
Metadata scheme	Metadata scheme	Metadata scheme	Metadata scheme
	Advanced tools		
	ÚOCHB AV ČR		

Institutional data policy
Data curator



Data and Metadata Collections

https://www.eirene-ri.eu

EIRENE RI

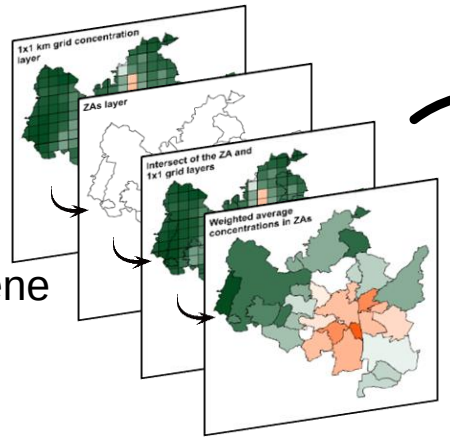
Urban Exposome Tool

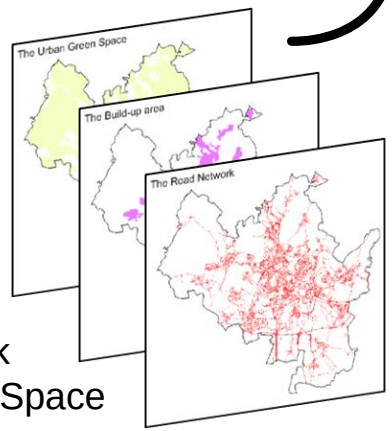
Very High Spatial Data Resolution

CVD and respiratory health conditions

Air Quality

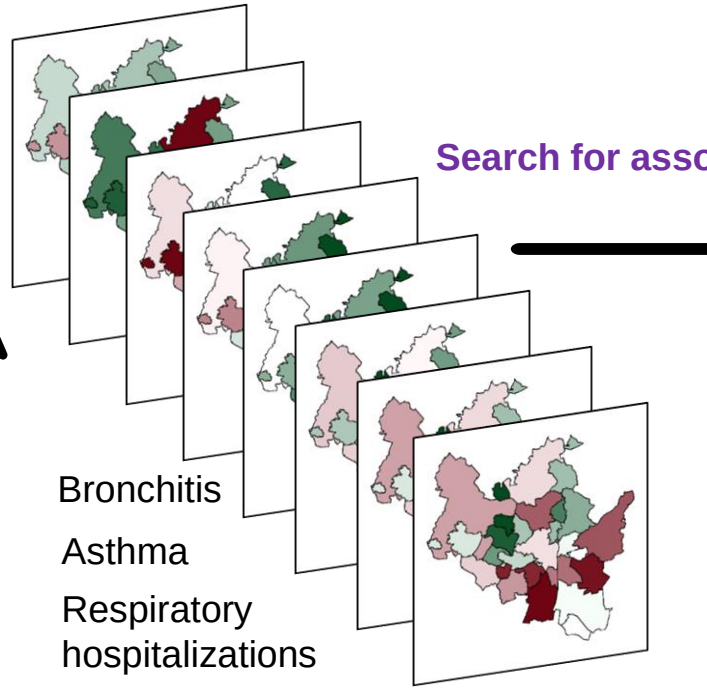
AQ:
$PM_{2.5}$
PM_{10}
NO_2
Benzene
B[a]P
SO_2





Other Exposome parameters:
Build-up Area
Road Network
Urban Green Space

Search for associations



Bronchitis
Asthma
Respiratory hospitalizations
Cardiovascular-related hospitalizations

Long-term observation (2010-2024)

A new approach to urban health risk management as a long-term sustainable **tool for Smart Cities**

For policy decision making.

<u>New tool, annual updated</u> = *on-line live data linking and automatic recalculation.*

Brno Living Lab

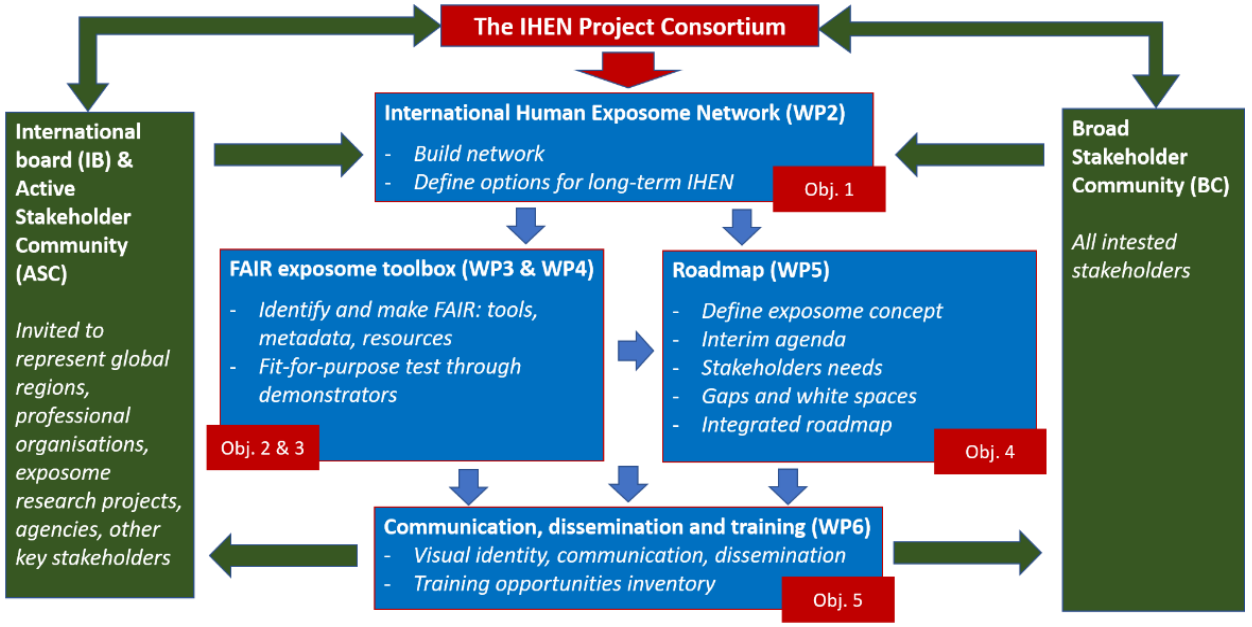
INTERNATIONAL HUMAN EXPOSOME NETWORK PROJECT (IHEN)

Vision

To establish an international network that will improve global research and cooperation on the exposome

Maturation of the field requires coordination of worldwide efforts to

- facilitate rapid exchange,
- increase harmonization,
- align future research efforts, and
- translate scientific findings into effective policies.



EIRENE RI

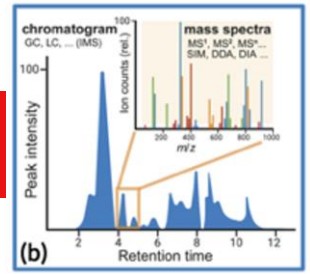
NEXUS Hubs

NEXUS
Network of Exposomics in the US

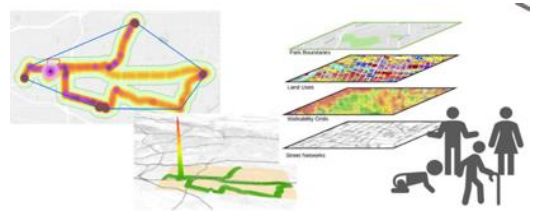
1. Administrative/Stakeholder Engagement Hub (Miller, Singh, Wu, Thualt-Restituito).

2. Analytical Sciences Hub (Metz, Pollitt). Yale, PNNL/DOE

ThermoFisher SCIENTIFIC



3. Geospatial Sciences Hub (Habre, Rajasekar). USC, UNC



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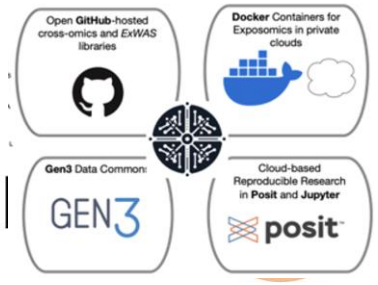
4. Data Sciences Hub (Patel, Sirota). Harvard, UCSF



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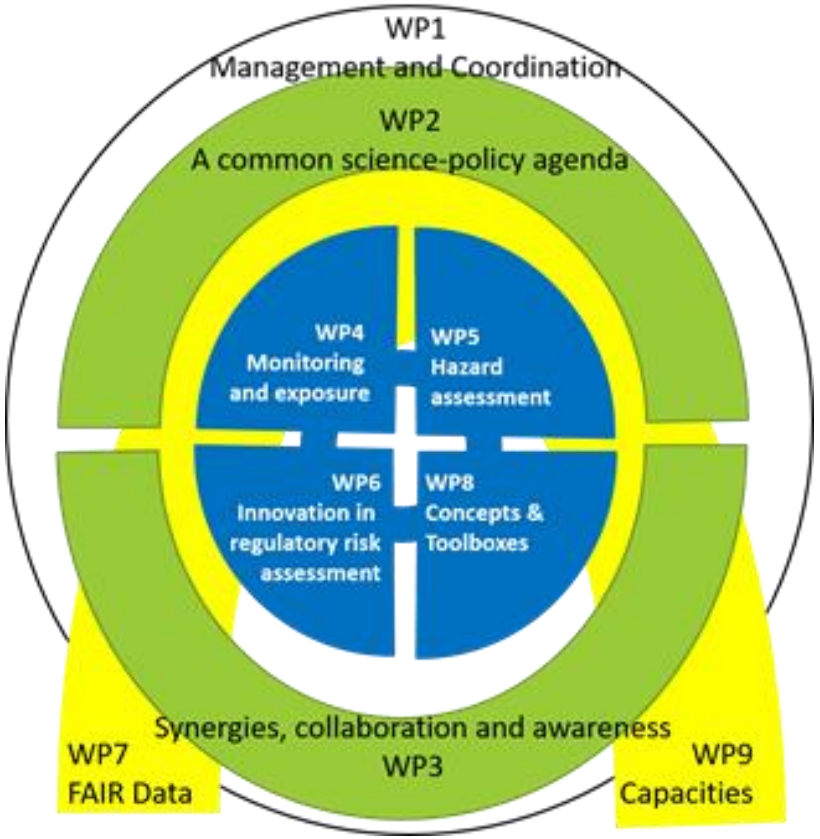
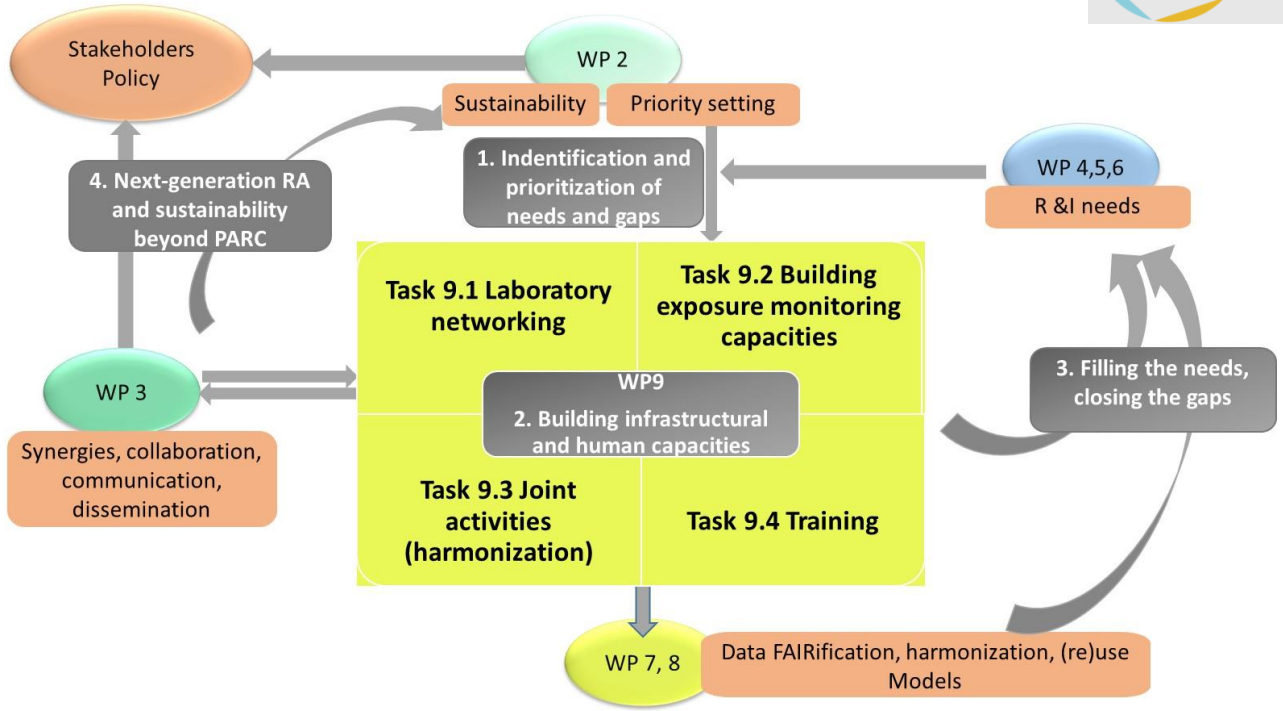
https://www.nexus-exposomics.org/

Partnership for Assessment of Risks from Chemicals (PARC)





HBM4EU science and policy for a healthy future

VISION: Building infrastructural and human capacities in PARC

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Thank you for your attention

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