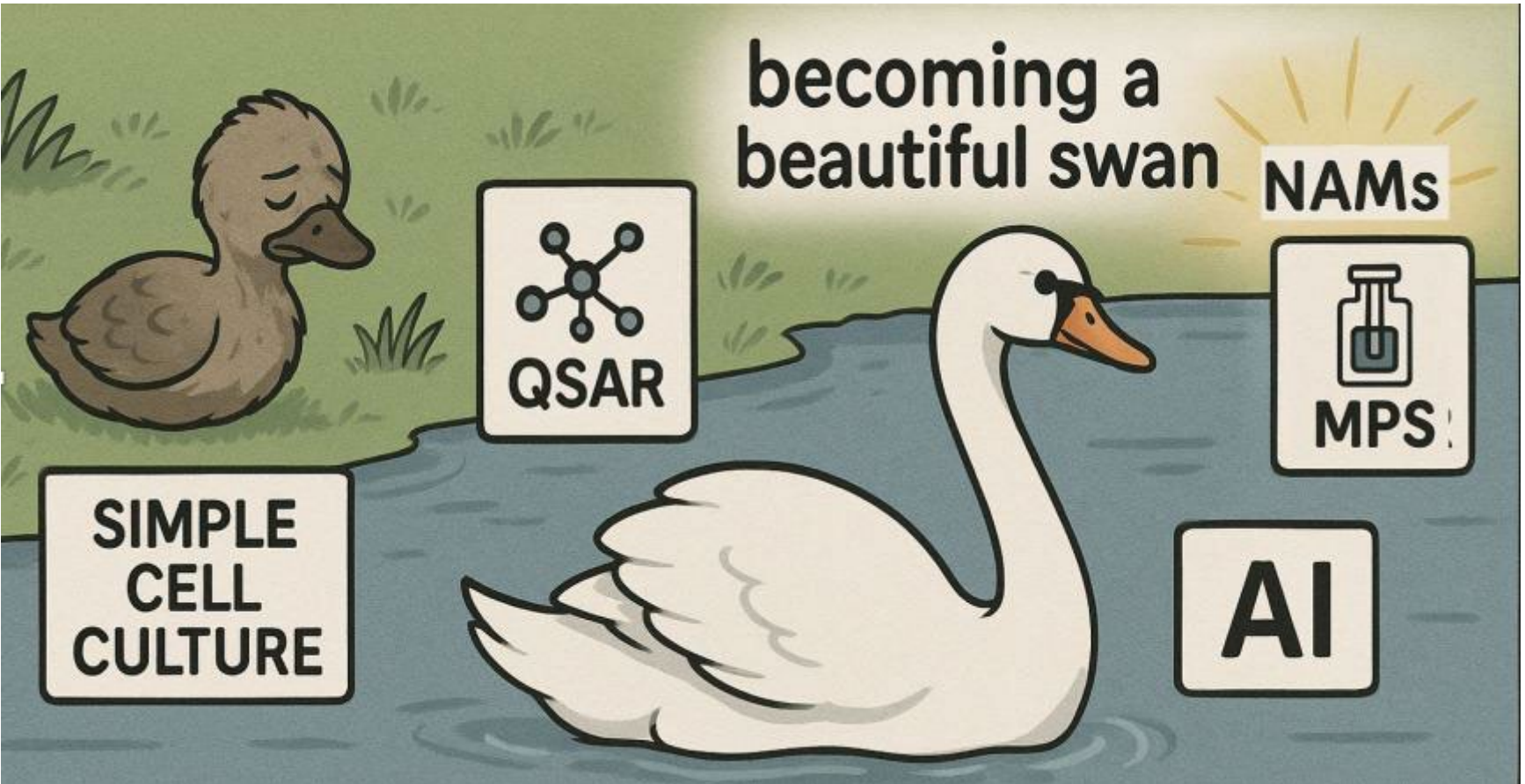
Disruptive Technologies: MPS & AI

Thomas Hartung & team

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH



Slides available:
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nature

NEWS FEATURE | 25 February 2026

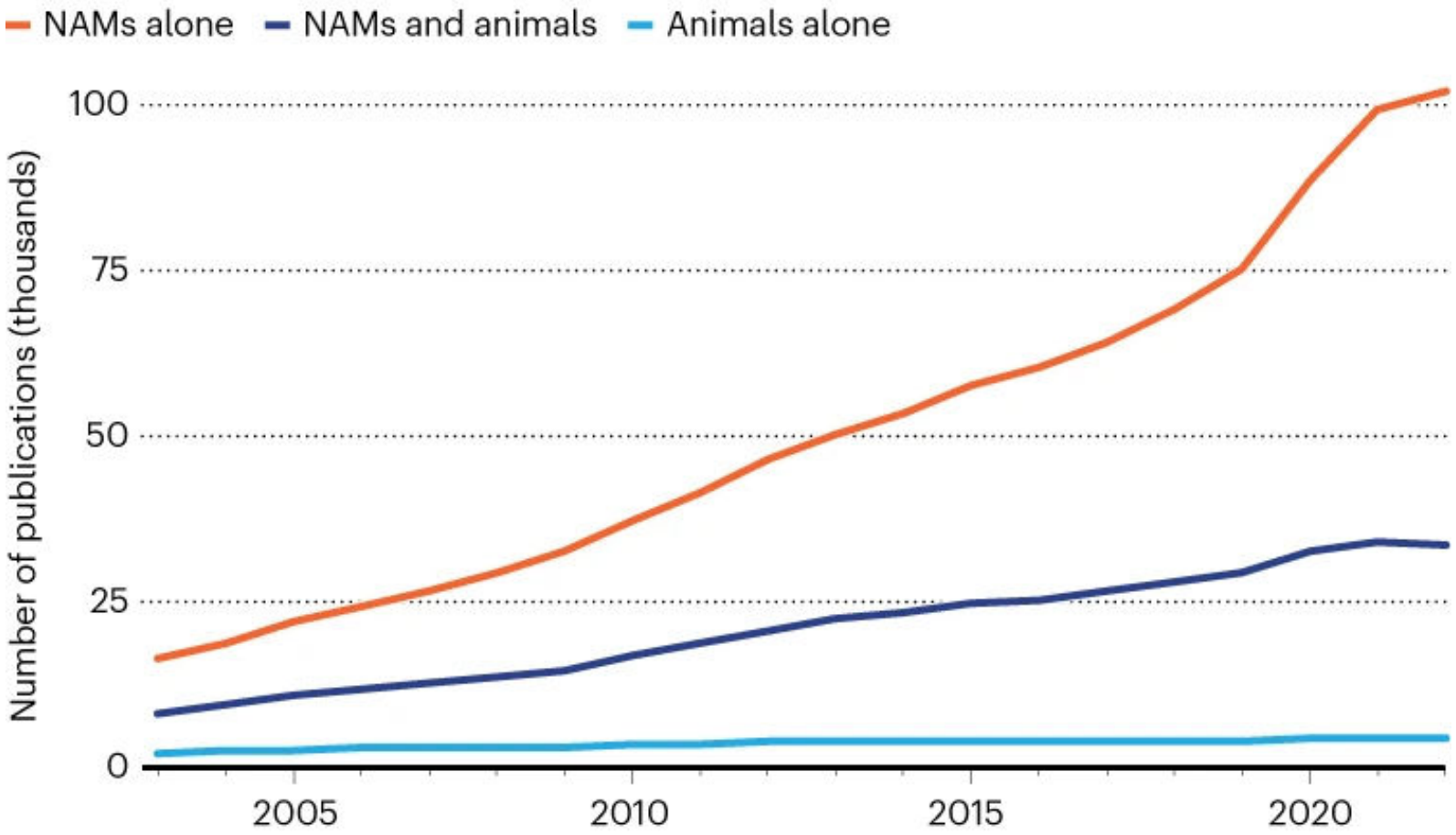
Governments have announced plans to reduce the number of animals, such as mice, used in experimental procedures.

CAN WE REALLY GET RID OF ANIMAL TESTING IN RESEARCH?

Advances in organ and computer models are raising the prospect that some animal experiments could be eliminated. But there are still huge hurdles to overcome. By Diana Kwon

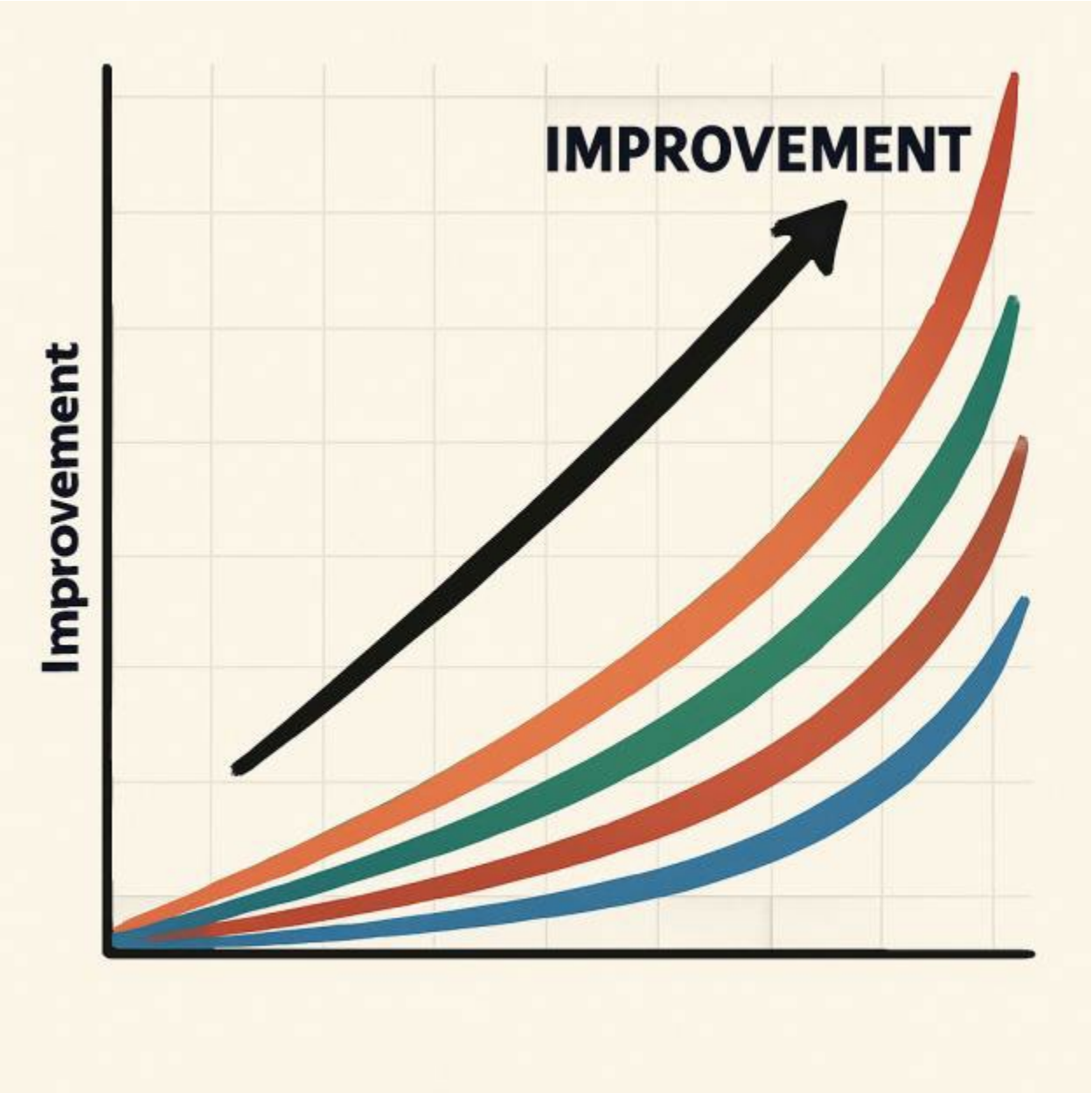
ALTERNATIVES ON THE UP

In research on seven diseases, the number of publications reporting the use of new approach methodologies (NAMs), which do not use animals, has grown since 2003.



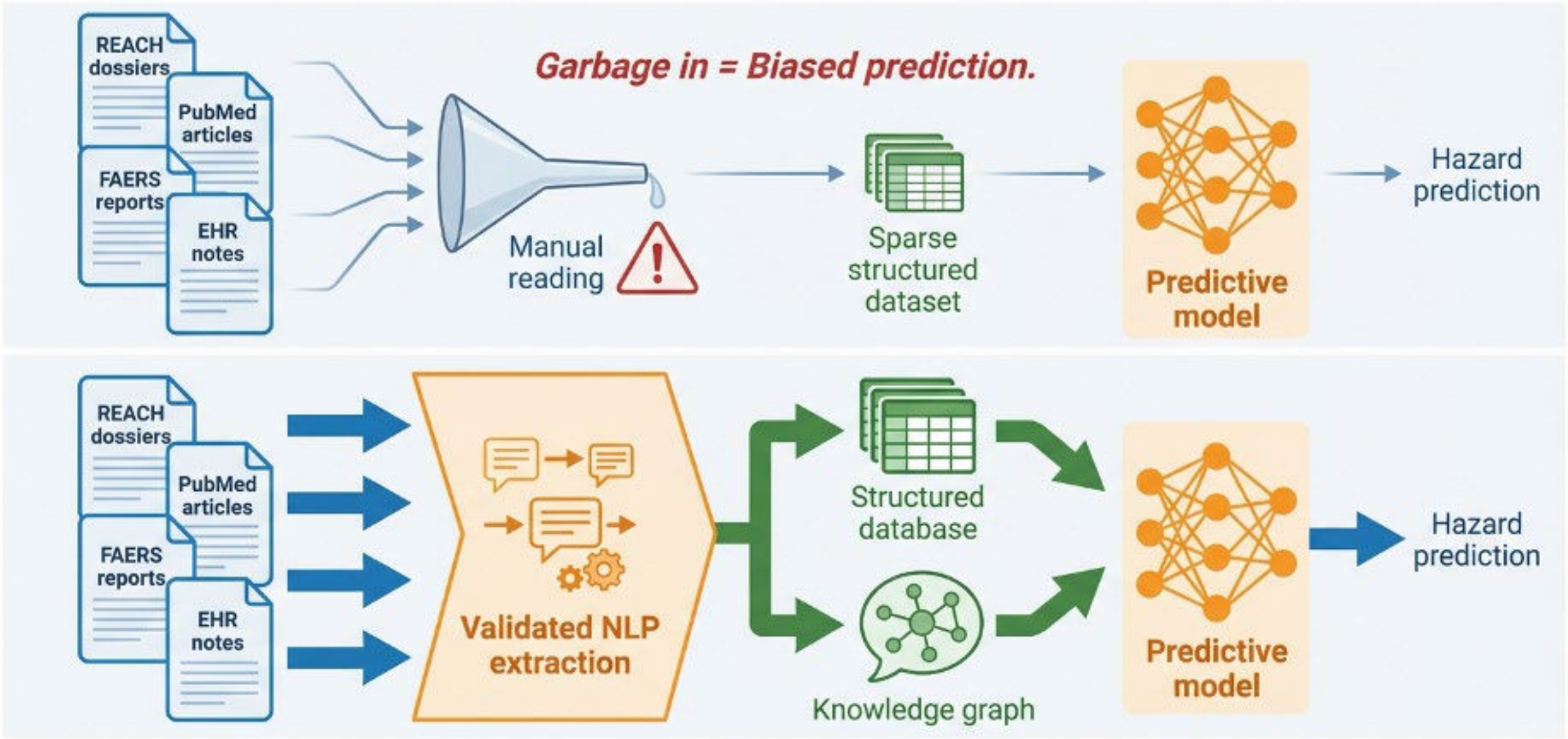
NAM use rising

Transformative (Disruptive) Technologies



- **Mass-spectroscopy** sensitivity doubling every 3-4 years
- **Microphysiological Systems** publications doubling every 4 years
- **Genome Sequencing** halving every 1.4 - 2 years
- **Computer** capacity doubling every two years (Moore's law)
- **Data** in the world are doubling every 18 months
- **AI** is doubling in capacity every 3 months since Deep Learning was introduced in 2010
- **AI price** falling 280x in last 18 months

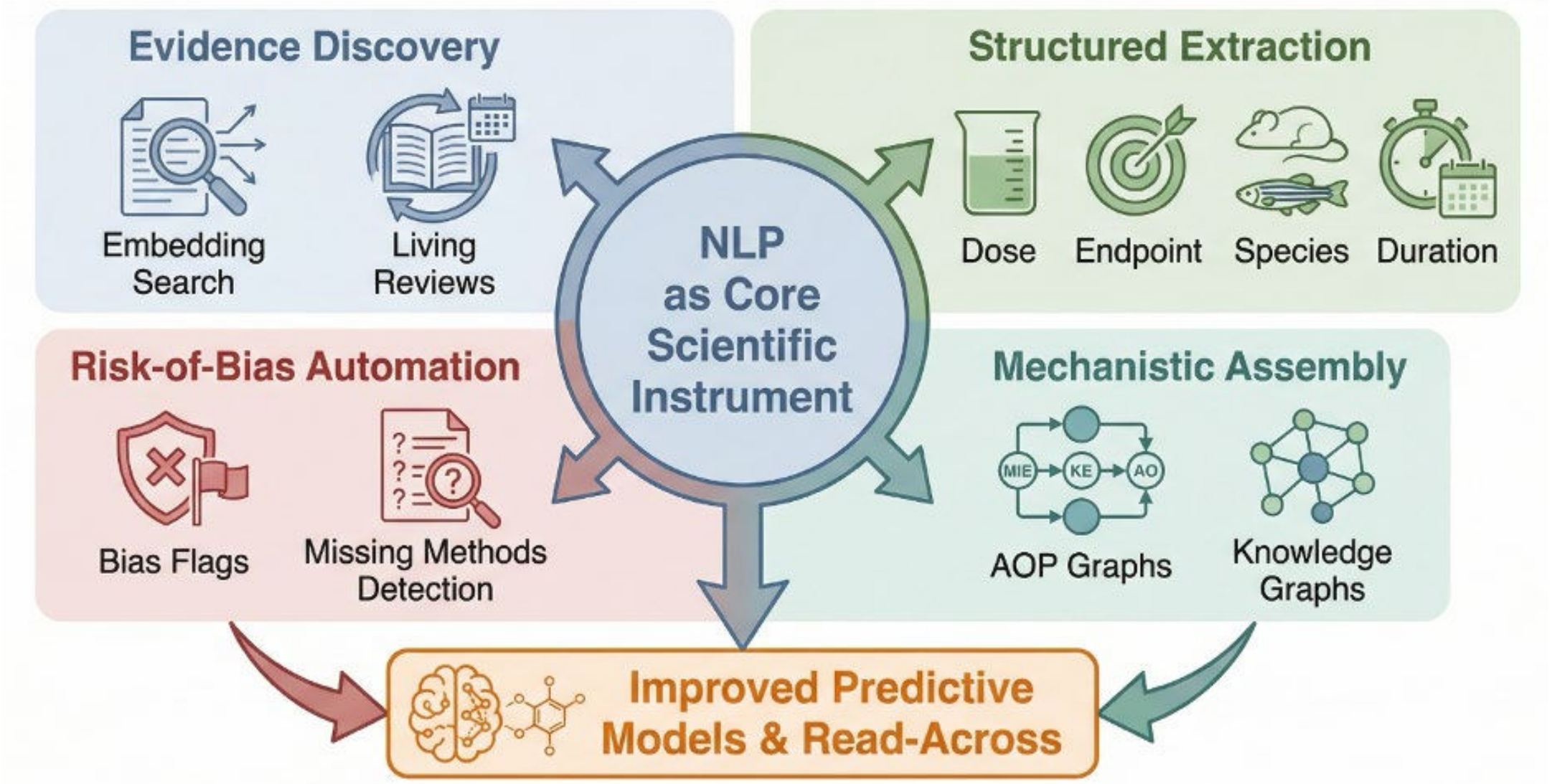
The Reading Bottleneck in Predictive Toxicology



Natural Language Processing in Predictive Toxicology: From Convenience Tool to Core Scientific Instrument

Weida Tong and Thomas Hartung, under review

Core NLP Applications in Predictive Toxicology



Natural Language Processing in Predictive Toxicology: From Convenience Tool to Core Scientific Instrument
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ToxAIcology

Big Data

- High-content (~omics & imaging)
- High-throughput (Robotized testing, e.g., Tox21 & ToxCast)
- Sensors
- Literature, Internet
- Legacy studies

Big Computer

AI & Machine Learning

- Natural Language Processing (Large Language Models)

Big Sense

- Data retrieval
- Evidence integration (systematic reviews, risk assessments)
- Predictive toxicology
- Digital pathology
- Reporting

1 toxicity
1,000 data
150 chemicals
65% correct

2015

9 toxicities
600,000 data
190,000 chemicals
87% correct

2018

4,000 properties
260 mill. data from 12 databases
26 mill. chemicals
91% correct

2025

6,000 properties
70 bill. data from 2,000 databases
Any chemical
t.b.d. % correct?

2026

The Next
- Building trust
- Deploy ToxAlcology

npj | digital medicine

Perspective

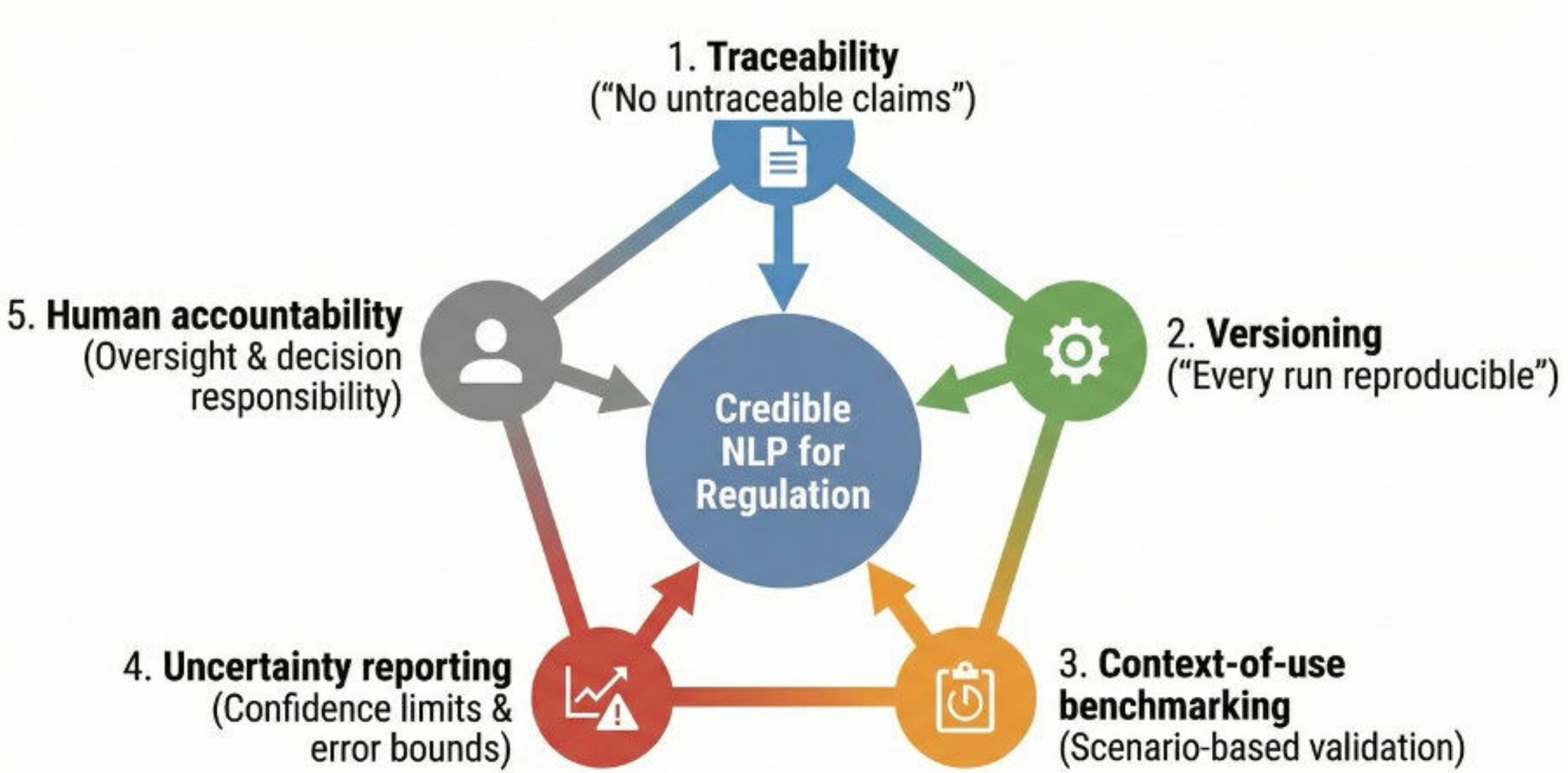
Published in partnership with Seoul National University Bundang Hospital

https://doi.org/10.1038/s41746-025-01596-0

Is regulatory science ready for artificial intelligence?

Check for updates

Thomas Hartung[1,2], Maurice Whelan[3], Weida Tong[4] ✉ & Robert M. Califf[5]



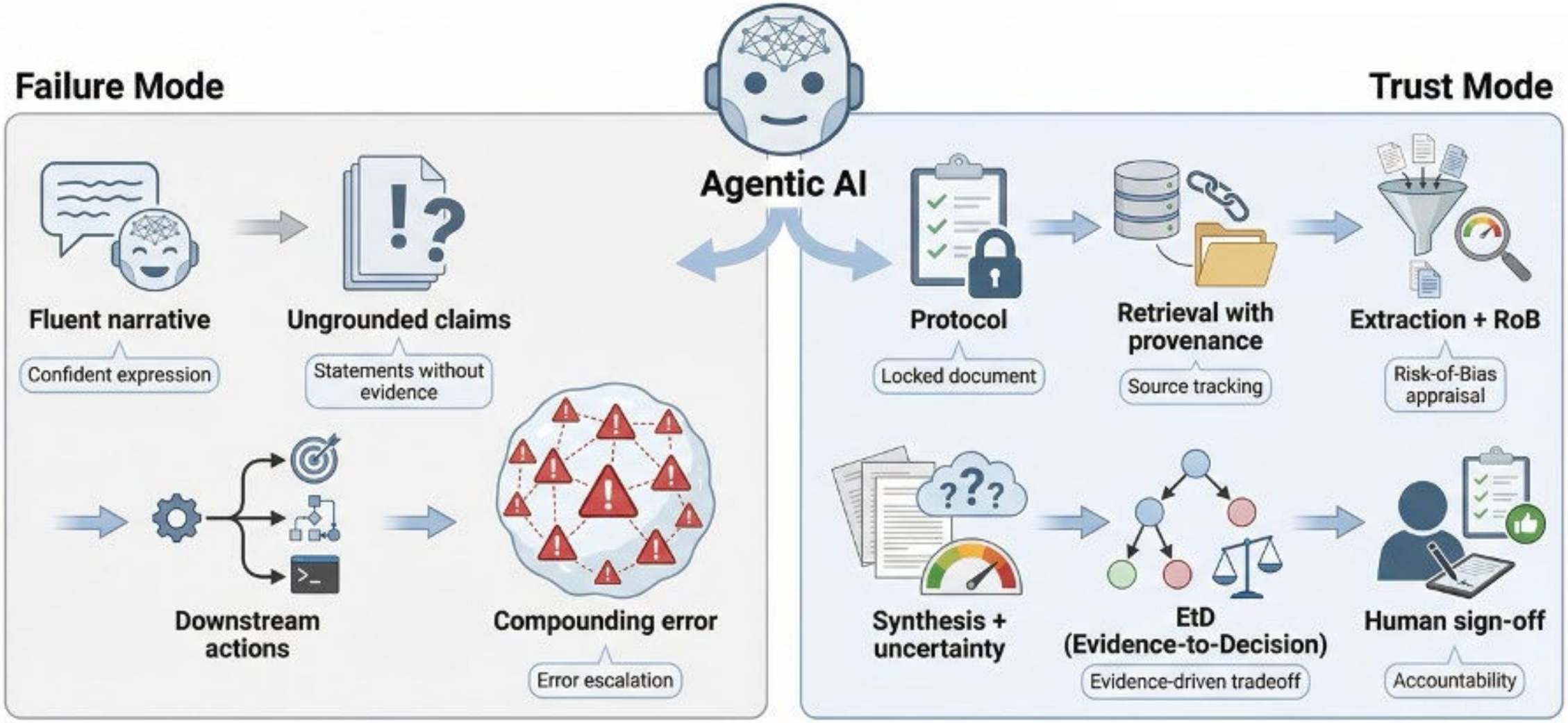
Natural Language Processing in Predictive Toxicology: From Convenience Tool to Core Scientific Instrument

Weida Tong and Thomas Hartung, under reveiw

From trailblazer to "*trustblazer*": two pathways for agentic AI

Evidence-based AI: from trailblazer to trustblazer?

Thomas Luechtefeld[1,2] and Thomas Hartung[2,3¶]



MPS WORLD SUMMIT
CONNECT, EXCHANGE, EDUCATE

2022, 2023, 2024, 2025

INTERNATIONAL MPS SOCIETY
CONNECT, EXCHANGE, EDUCATE

2023

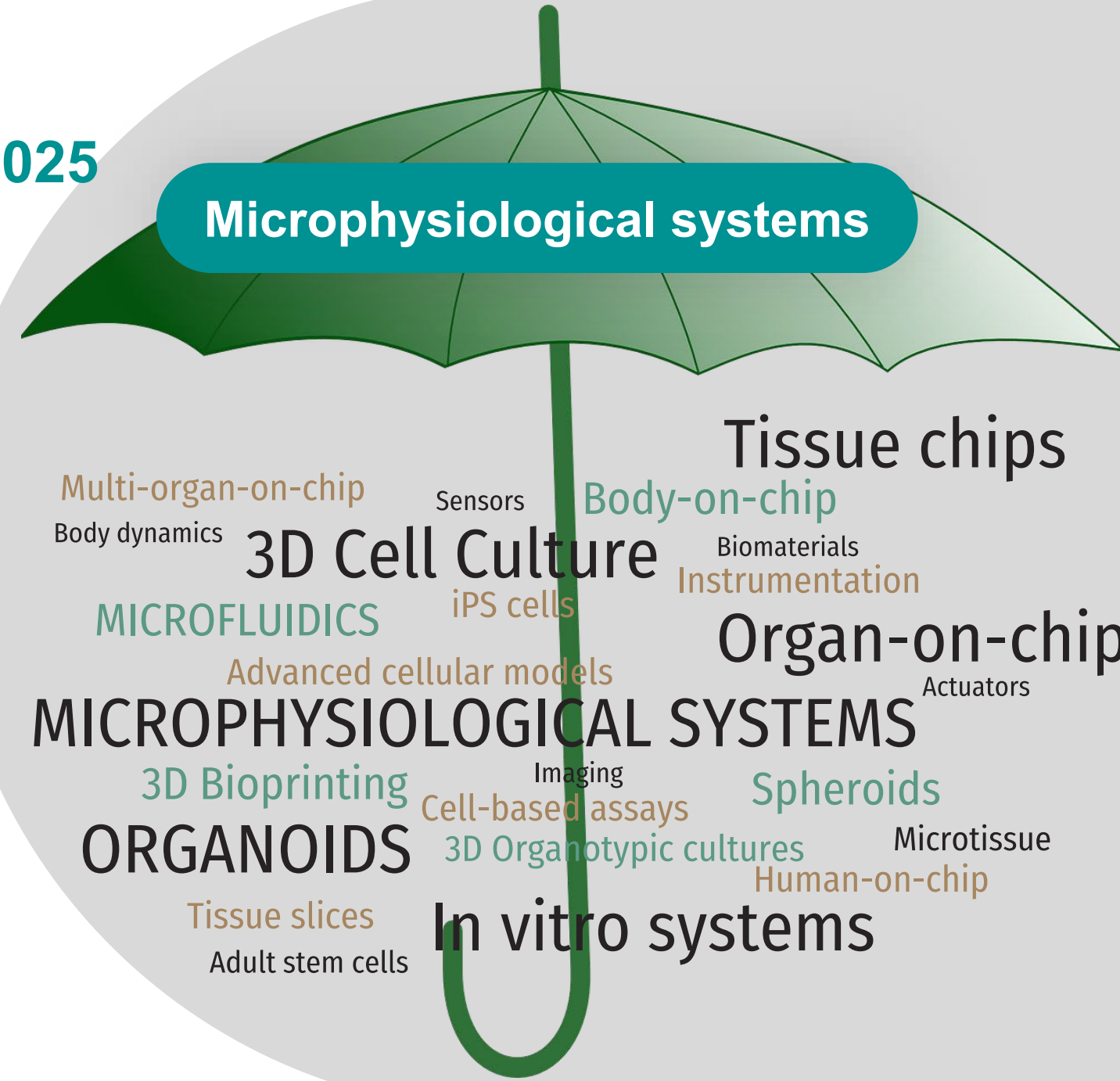
MPS

MPS workshops
2016, 2020, 2025

GCCP 2.0

2022

3D workshop 2014



Microphysiological Systems World Summit

WASHINGTON, DC
MAY 25–29, 2026

ABSTRACT SUBMISSION OPEN UNTIL **January 11th 2026**

CONNECT | EXCHANGE | EDUCATE

MPS WORLD SUMMIT
CONNECT, EXCHANGE, EDUCATE

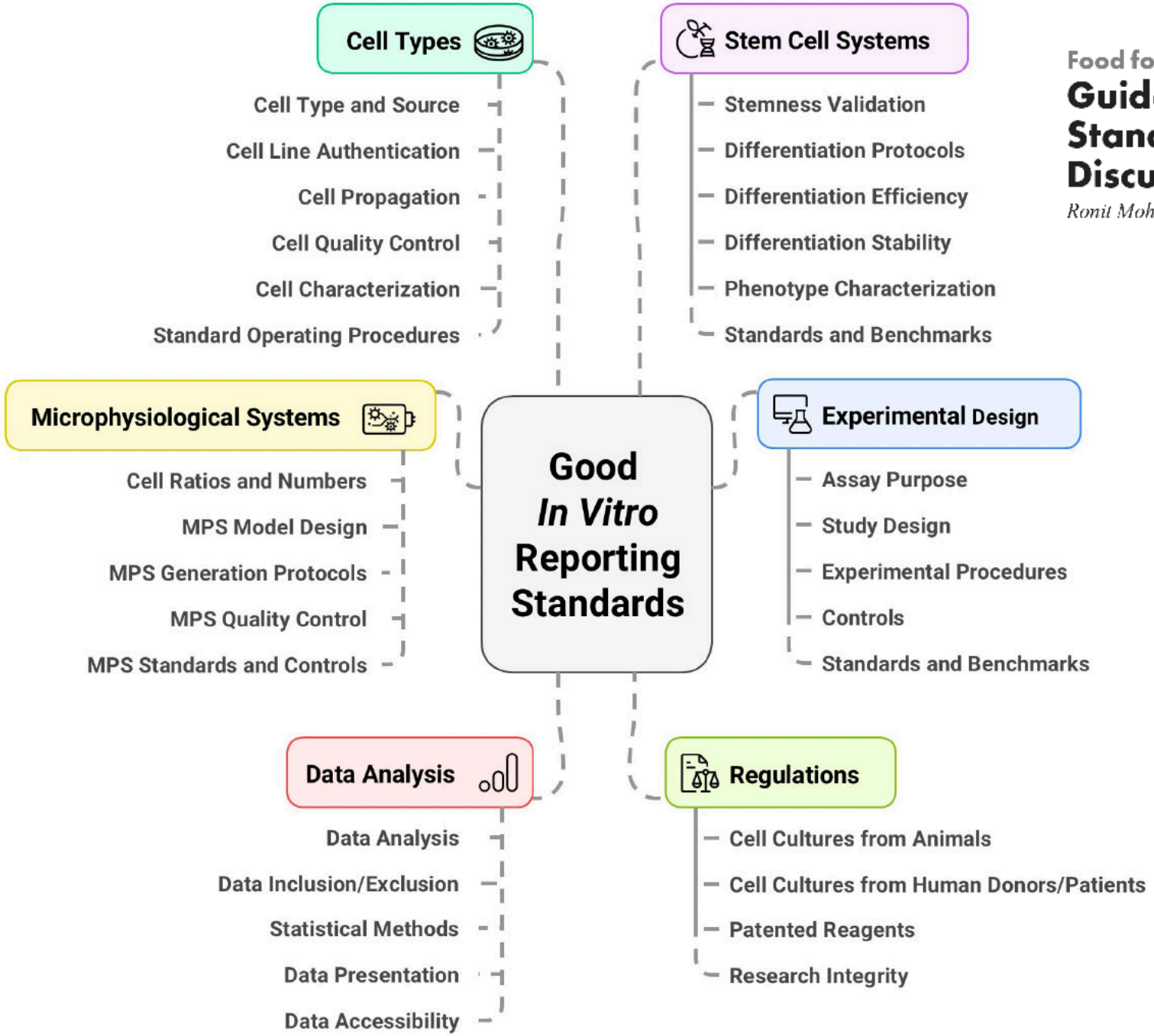
Discover more
www.mpsworldsummit.com

Guidance Document on Good Cell and Tissue Culture Practice 2.0 (GCCP 2.0)

ALTEX 2022, 39:30-70

David Pamies[1], Marcel Leist[2,3], Sandra Coecke[4], Gerard Bowe[4], Dave Allen[5], Gerhard Gstraunthaler[6], Anna Bal-Price[4], Francesca Pistollato[4], Rob deVries[7,8], Helena T. Hogberg[9], Thomas Hartung[2,9] and Glyn Stacey[10,11,12]

- **Quality of cell model (GCCP)**
- **Quality of reporting (GIVReSt)**
- **Quality of results (validation)**



Food for Thought ...

Guidance for Good *In Vitro* Reporting Standards (GIVReSt) – A Draft for Stakeholder Discussion and Background Documentation

Ronit Mohapatra[1], Marcel Leist[2,4], Sonja von Aulock[5] and Thomas Hartung[1,2,3]

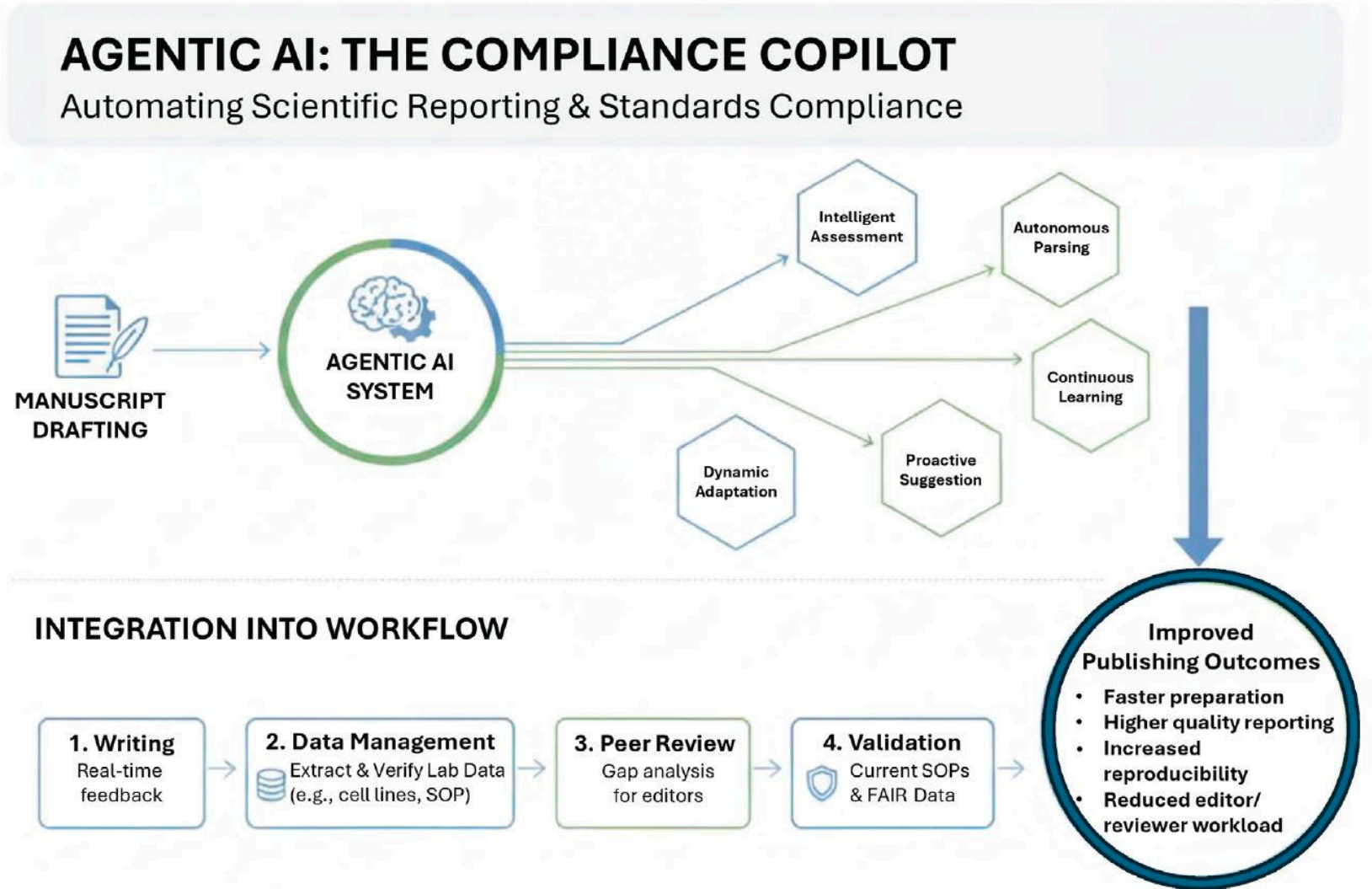
Food for Thought ...

Custom GPTs to Aid in Compliance Checking for Reporting Standards in Academic Publishing

Ronit Mohapatra[1] and Thomas Hartung[1,2,3]

Agentic AI to check compliance with:

- GIVReSt
- Tox-R-Tool
- ARRIVE guidance

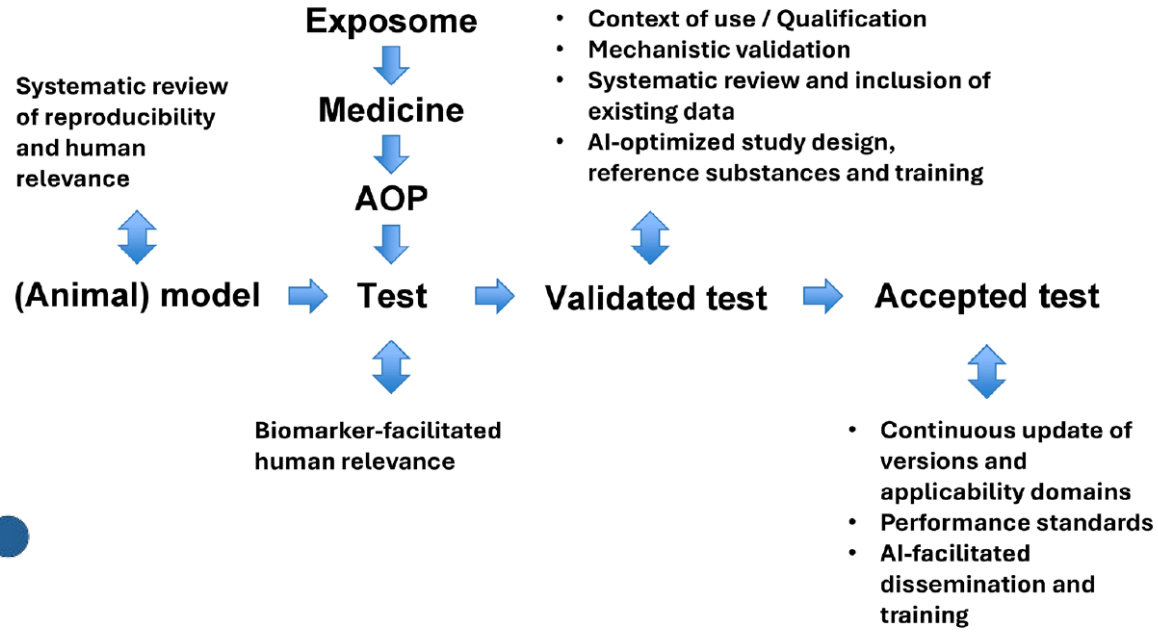


Emerging Ontologies for MPS

Item	Form	Covers organoids?	Covers MPS/OoC?	What it contributes to ontology-building
NAMO (2025–)	Ontology + LinkML schema (generates OWL/JSON schema, etc.)	Yes	Yes	A unifying semantic framework spanning organoids + OoC + other NAMs
MPS-Db (2016; 2020)	Structured database + metadata framework	Indirect	Yes	Published, operational metadata structure for describing/analyzing MPS experiments
GIVReSt (2025)	Reporting standard	Yes	Yes	Defines minimum reporting elements that can be formalized into ontology properties
MIOR (2025)	Organoid reporting standard	Yes	Indirect	Organoid-focused minimum information standard aligned with FAIR interoperability goals
MISpheroID (2021)	Knowledgebase + “minimum information string”	Spheroids (related)	Indirect	Concrete parameter set for 3D model identity; useful pattern for organoid/MPS identity metadata
MIACARM (2016)	Minimum information standard (cell assays)	Mentions organoids	Indirect	Explicitly promotes use of controlled terms/ontologies for exchangeable assay metadata
ISO/CD 25448 (2026 stage)	Vocabulary standard (in development)	Often under “MPS” umbrella	Yes	Canonical definitions and terminology scope that an ontology can align to
Piergiovanni et al. (2021)	Standards/roadmap analysis paper	Yes (as part of “MPS” scope)	Yes	Establishes the need for harmonized terminology and classification

Next Generation Validation for Next Generation Risk Assessment

NGV 4 NGRA



Food for Thought ...

The Validation of Regulatory Test Methods – Conceptual, Ethical, and Philosophical Foundations

Thomas Hartung

Food for Thought ...

E-validation – Unleashing AI for Validation

Thomas Hartung[1,2], Alexandra Maertens[1] and Thomas Luechtefeld[1,3]

Food for Thought ...

Leveraging Biomarkers and Translational Medicine for Preclinical Safety – Lessons for Advancing the Validation of Alternatives to Animal Testing

Thomas Hartung[1,2], Nicholas M. P. King[3], Nicole Kleinstreuer[4], Marcel Leist[2,5] and Danilo A. Tagle[6]

Food for Thought ...

Challenges and Opportunities for Validation of AI-Based New Approach Methods

Thomas Hartung[1,2] and Nicole Kleinstreuer[3]

ADVANCED HEALTHCARE MATERIALS
www.advhealthmat.de

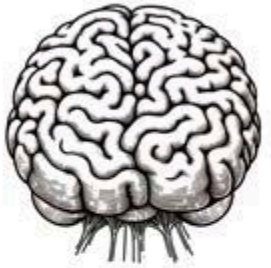
The Promise and Potential of Brain Organoids

Lena Smirnova and Thomas Hartung**

Lena Smirnova

BRAIN ORGANOID OPPORTUNITIES

BRAIN ORGANOID AND BRAINSPHERE VARIANTS

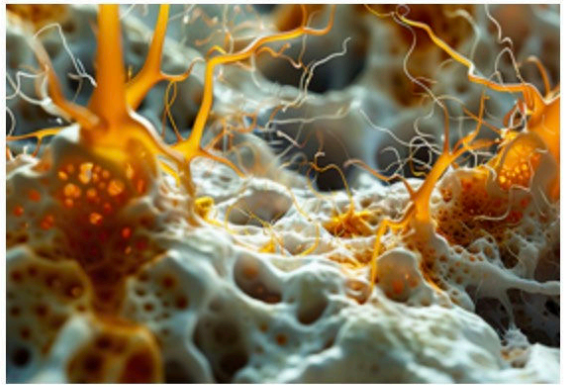


- Different species; patient-derived or healthy; genetically modified or not
- Reaggregation of tissue-derived cell suspension or stem cell-derived (embryonic stem cells or iPSC)
- Use of extracellular matrix, hydrogels or none
- Scaffold or none; possible electrode integration
- Use of growth factors to induce differentiation or not; addition of cell types (micro-glia)
- Gravity-based aggregation (e.g., hanging drop or microtiter plates) or bioreactor (e.g., spinner or shaker)
- Brain region-specific organoids; addition of blood-brain-barrier
- Fusion and assembloids of different brain regions or organs (cell lineages)
- Use of microfluidics and vascularization for perfusion or not

FNIH
Foundation for the National Institutes of Health

For best mobile view, please rotate your phone

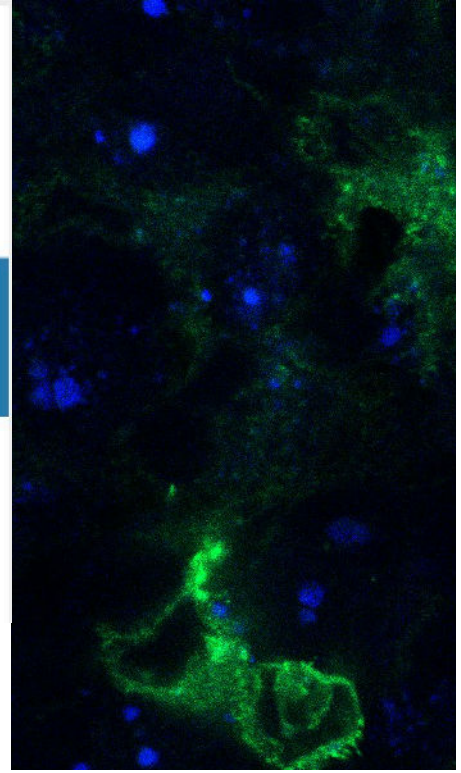
Four Pilot Projects Selected to Advance Human-Based Research Models



Developmental Neurotoxicity

This lab-based system is designed to assess how the brain develops and reacts to harmful chemicals. It combines advanced genetic tools with fluorescent markers to track six essential processes, including how neurons form, how brain cells connect with each other, and how brain networks take shape. Once validated, this system could provide a reliable, cost-effective alternative for assessing developmental brain toxicity.

Announced Last month!



Mini- Brainbow

Neurons Astrocytes

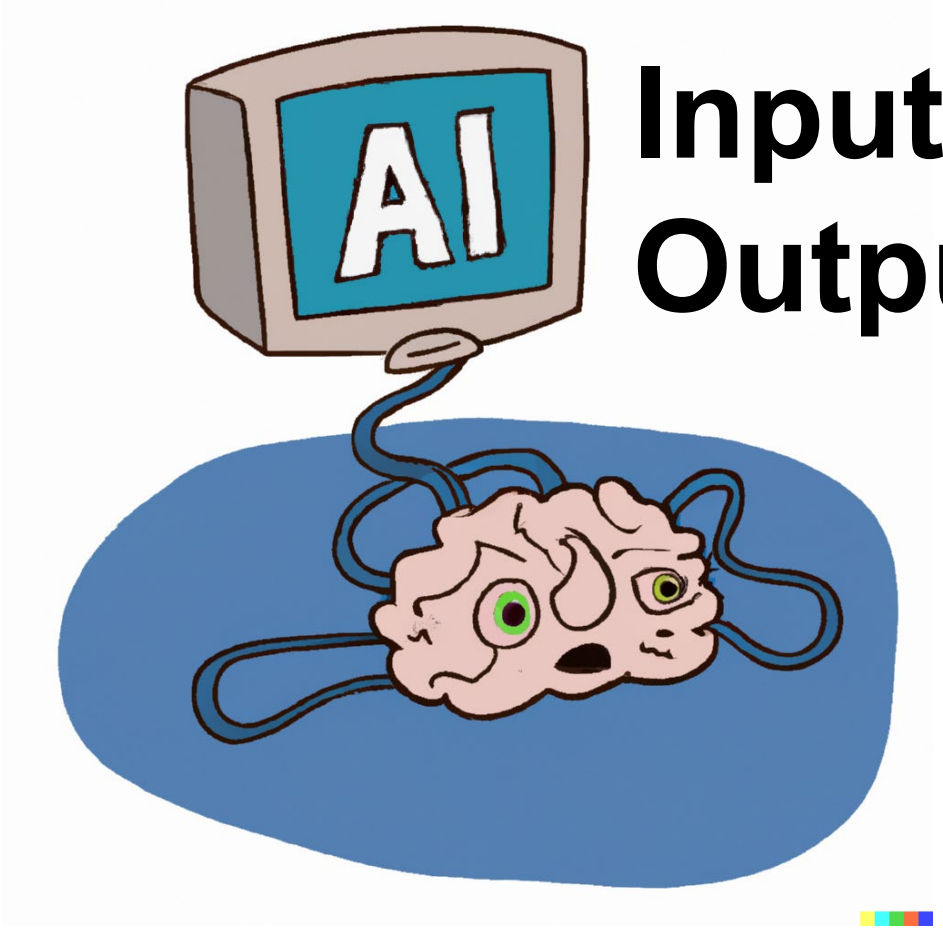
Oligodendrocytes

Synapses 3D electrophys

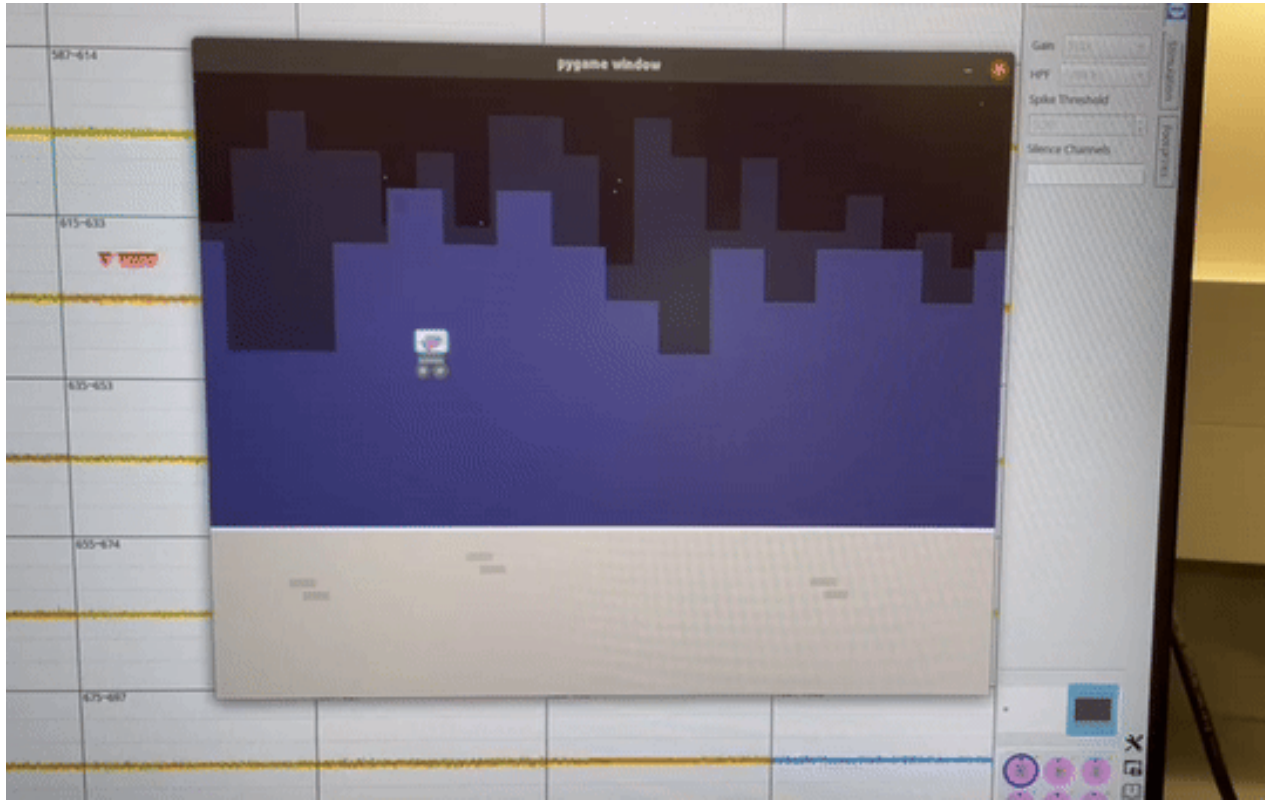
Oligodendrogenesis and myelination tracing in a CRISPR/Cas9-engineered brain microphysiological system

July Carolina Romero[1], Cynthia Berlinicke[2], Sharon Chow[1], Yukan Duan[2], Yifei Wang[1], Xitiz Chamling[2] and Lena Smirnova[1*]

Combining MPS, sensors and AI = Organoid Intelligence (OI)



Input & Output



INTERNATIONAL CONFERENCE ON ORGANOID INTELLIGENCE

Mark your calendars for a first-of-its-kind, in-person event bringing together the brightest minds and boldest leaders working across OI, biological and wetware tech.

Featuring targeted talks, hands-on sessions, and interactive demonstrations, this will be an incredible opportunity to learn, connect and help lead this field forward.

SAVE THE DATE

10.26.26
— 10.27.26

Johns Hopkins Bloomberg Center

Washington, D.C.

washingtondc.jhu.edu/bloomberg-center/

The next big step

OI and Medicine

Food for Thought ...

Organoid Intelligence (OI) – The Ultimate Functionality of a Brain Microphysiological System

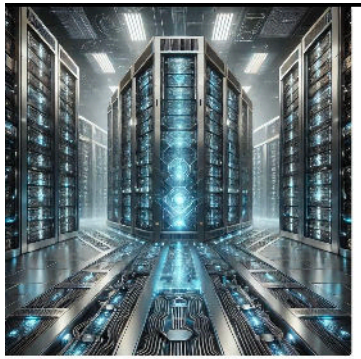
Neurodevelopmental & cognitive disorders

- Autism
- Intellectual disabilities
- Neurological rare diseases associated with cognitive impairment

Neurodegeneration

- Alzheimer's disease
- Amyotrophic Lateral Sclerosis
- Multiple Sclerosis

Public Health

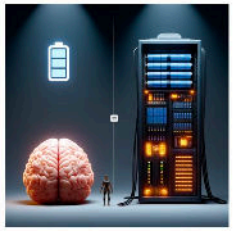


$600 million; 680 m²

One million time more energy

Fake Intelligence

Only in June 2022, the Frontiers supercomputer exceeded the estimated computational capacity of one human brain, i.e., 1 ExaFlop.



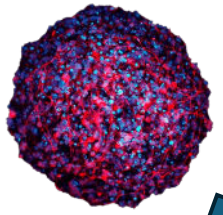
The work of a supercomputer with the energy of a laptop

1.4 kg
Storage ~ 2.5 PetaByte

Actual Intelligence

Disruptive Technologies

Microphysiological systems (MPS)
and other data-rich technologies

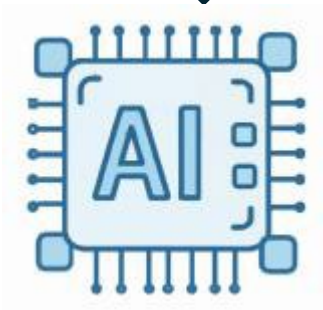


(open) Scientific literature
& Data

Big Data

Exposome Intelligence (EI)

Early Testing with small amounts



Benign by design

Green Toxicology
& Drug fail-early

"safer products"

Personalized Medicine

"better treatments"

Human Exposome

"safer people"

Generated with DALL-E and LeiaPix

- Integrate Disruptive Technologies with Existing Knowledge
- Accelerate Drug Development
- Optimize Prevention and democratize Healthcare Access

AI, MPS, ~omics, sensors….
Green Toxicology
Human Exposome

Slides available:
https://share.zight.com/KouXyZpl