Creating the Engine of Scientific Discovery

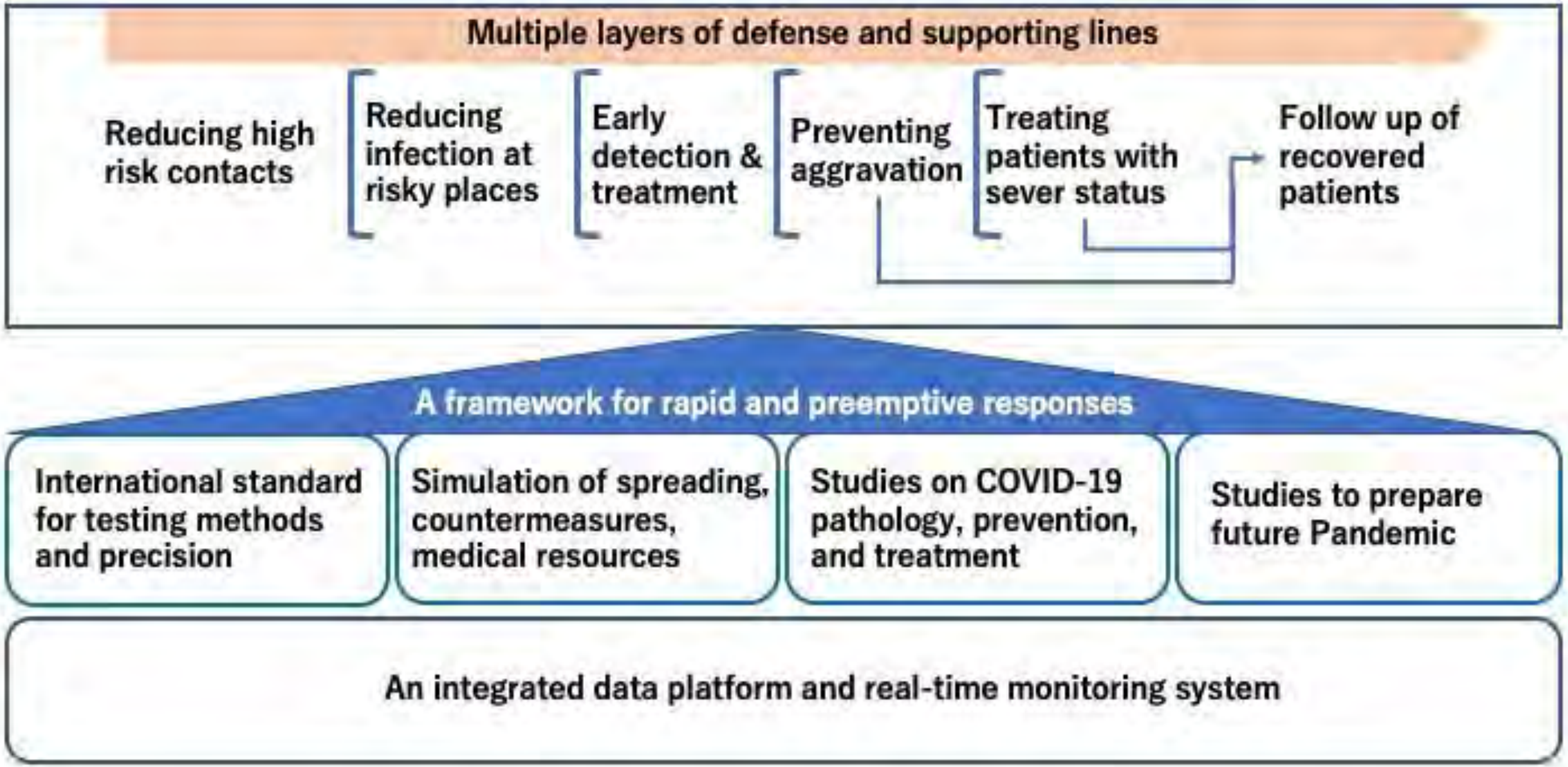
Hiroaki Kitano

Project Overview

Overview of the COVID-19 AI and Simulation Project

The spread of COVID-19, which is caused by the SARS-CoV-2 virus infection, continue pose a serious threat to our health and society both domestically and globally; hence, we must remain vigilant in relation to future developments. In the light of this situation, very high priority is being given to policies related to effective infection prevention, restriction of its spread, risk prediction, and swift development of treatment methods. Development and deployment of sophisticated, systematic, and flexible countermeasures at the earliest possible timing is the highest national priority.

The current aim of the project is to deploy a multiple layers of defense lines and supporting measures and a series of platforms to support them, as shown in Figure 1.


Multiple layers of defense and supporting lines
Reducing high risk contacts
Reducing infection at risky places
Early detection & treatment
Preventing aggravation
Treating patients with sever status
Follow up of recovered patients
A framework for rapid and preemptive responses
International standard for testing methods and precision
Simulation of spreading, countermeasures, medical resources
Studies on COVID-19 pathology, prevention, and treatment
Studies to prepare future Pandemic
An integrated data platform and real-time monitoring system

COVID-19 AI and Simulation Project Call for Proposal on Research and Contributing Data

In the Office for Novel Coronavirus Disease Control, Cabinet Secretariat, we are collecting the knowledge and wisdom available in our country, evolving countermeasures, and making a wide appeal for proposals of research topics and data that are effective for COVID-19 counter-measures including simulation, AI, and other technologies, to prevent the spread of infection and enable economic activity.

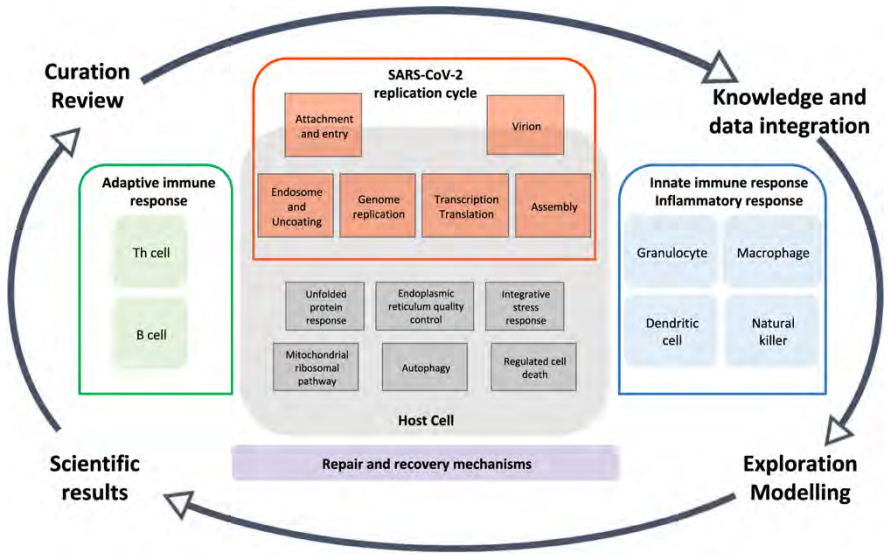
Comment | Open Access | Published: 05 May 2020

COVID-19 Disease Map, building a computational repository of SARS-CoV-2 virus-host interaction mechanisms

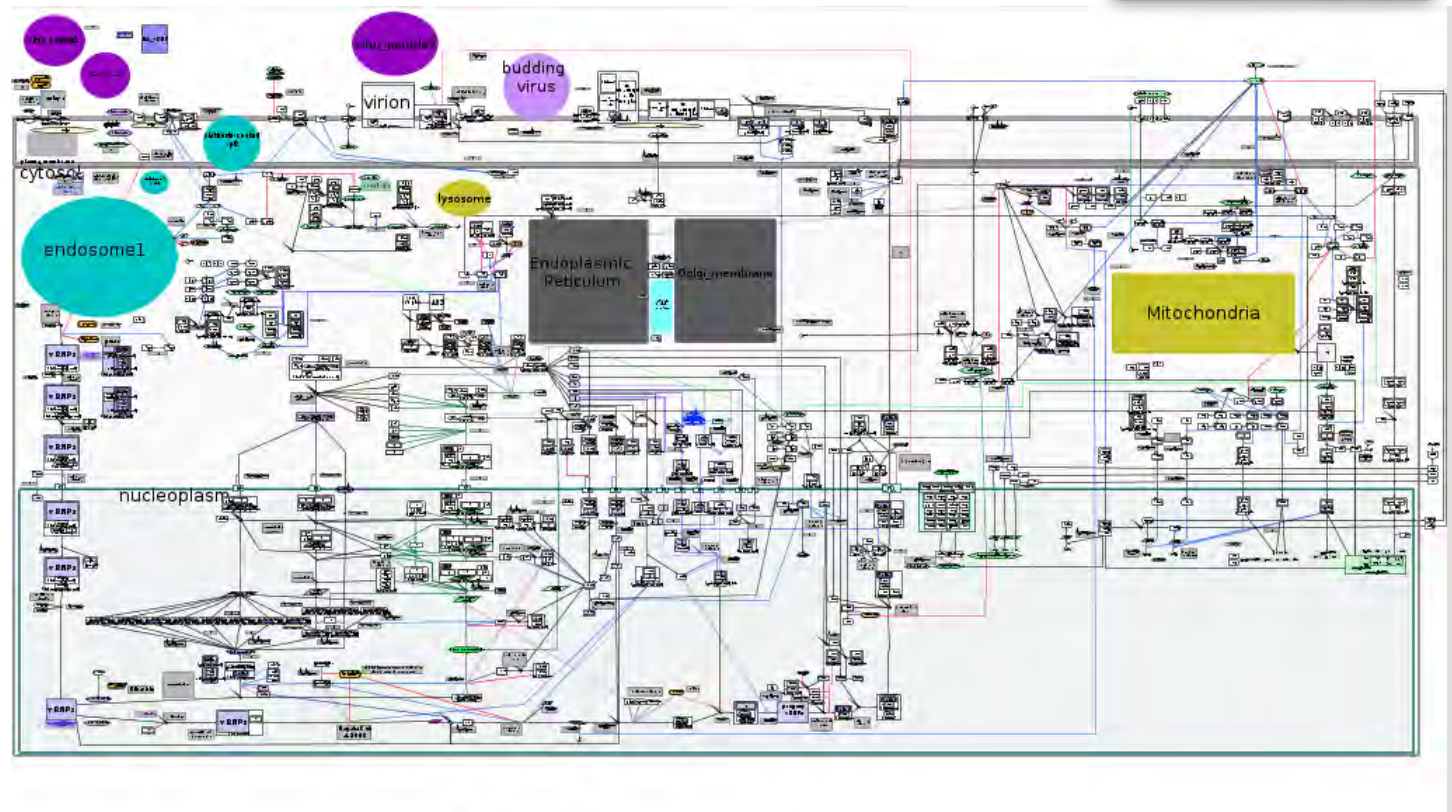
Marek Ostaszewski, Alexander Mazein, Marc E. Gillespie, Inna Kuperstein, Anna Niarakis, Henning Hermjakob, Alexander R. Pico, Egon L. Willighagen, Chris T. Evelo, Jan Hasenauer, Falk Schreiber, Andreas Dräger, Emek Demir, Olaf Wolkenhauer, Laura I. Furlong, Emmanuel Barillot, Joaquin Dopazo, Aurelio Orta-Resendiz, Francesco Messina, Alfonso Valencia, Akira Funahashi, Hiroaki Kitano, Charles Auffray, Rudi Balling & Reinhard Schneider

Scientific Data **7**, Article number: 136 (2020) | Cite this article

4425 Accesses | **161** Altmetric | Metrics

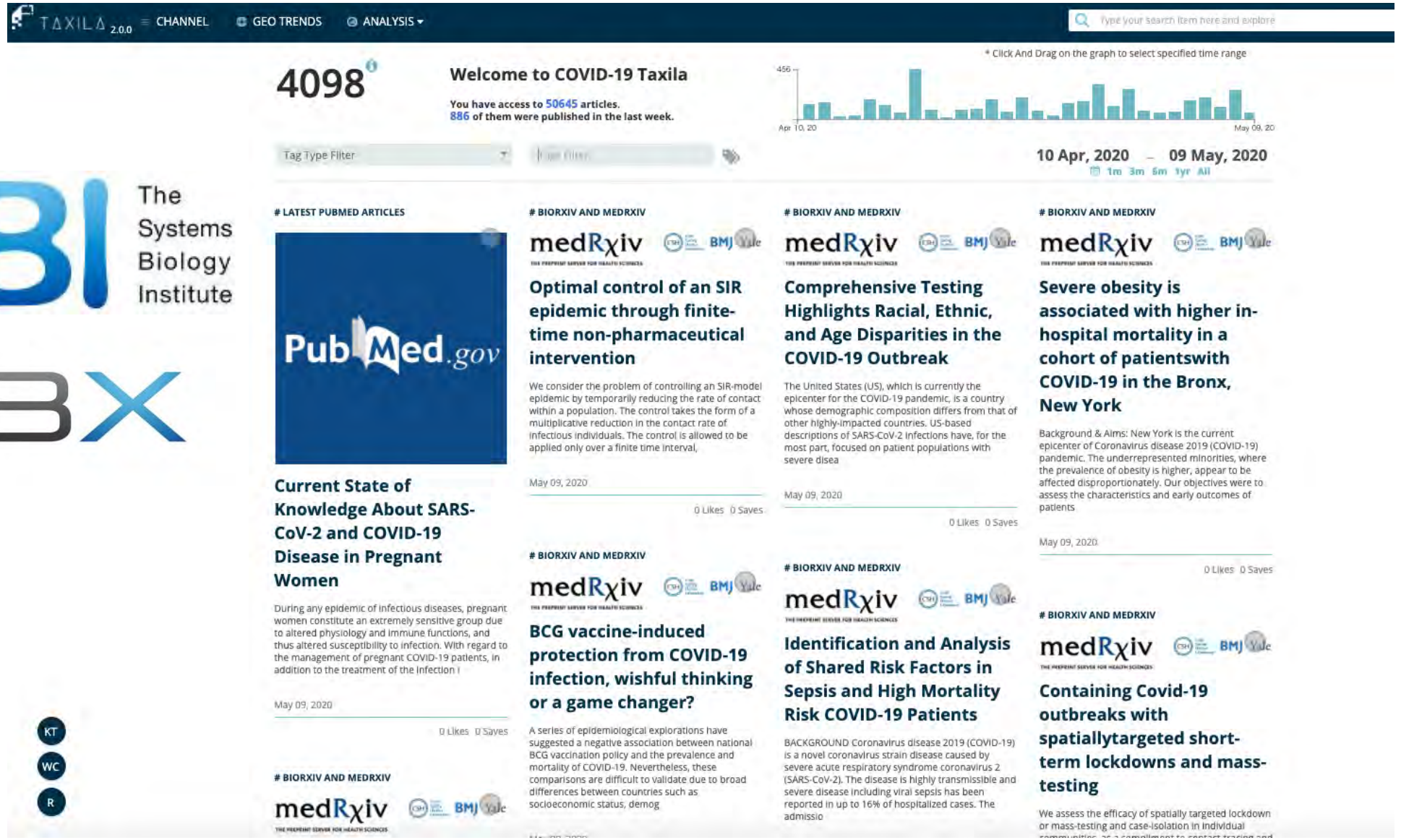


JST ERATO 北野共生システムプロジェクト並びに、JST ERATO河岡宿主応答ネットワークプロジェクトの成果を基盤に国際連携が行われている。



The Systems Biology Institute

Taxila COVID-19 AI/NLP Service (https://covid19.taxila.io/)



SBI The Systems Biology Institute

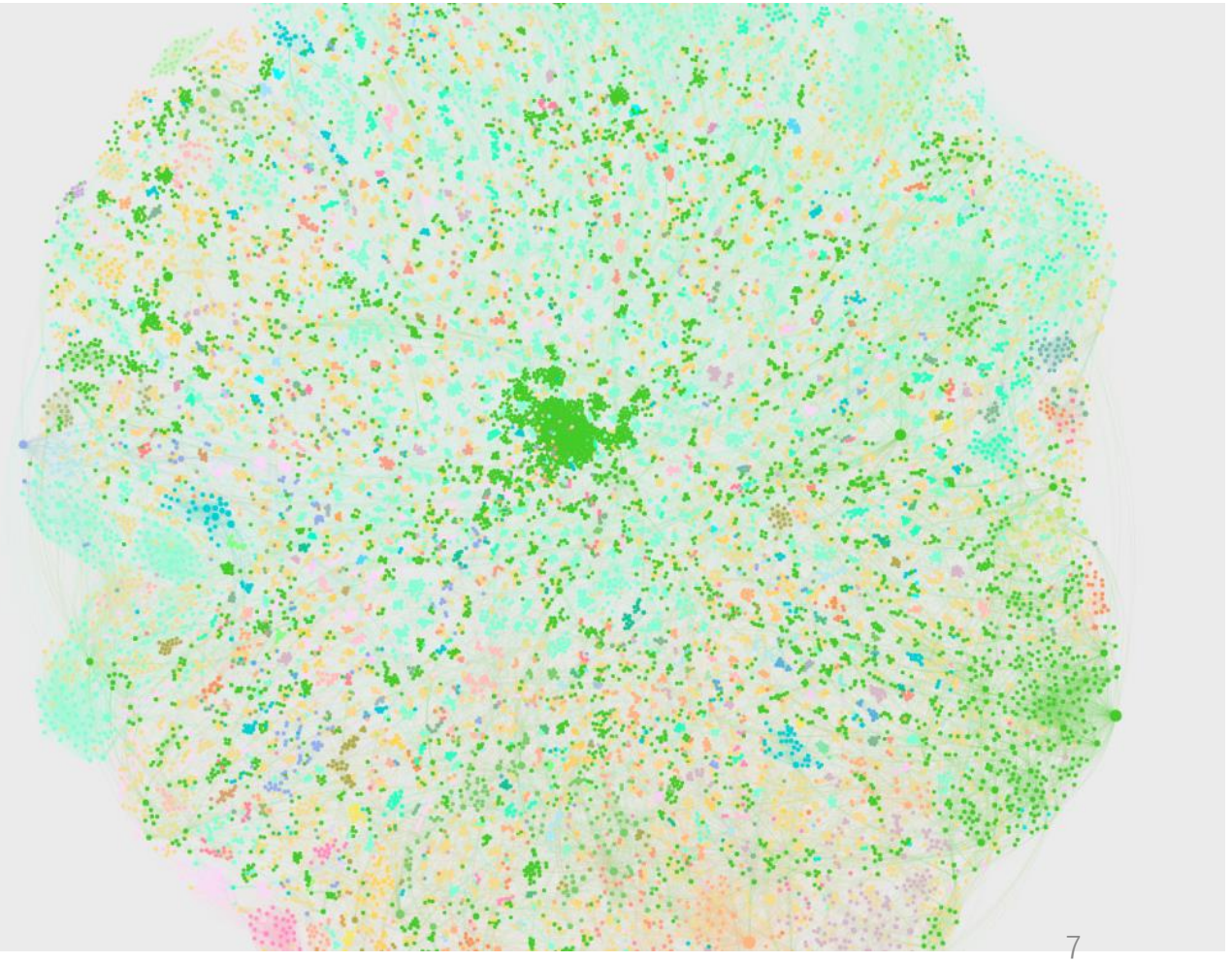
SBX

KT
WC
R

Global Network of Researchers

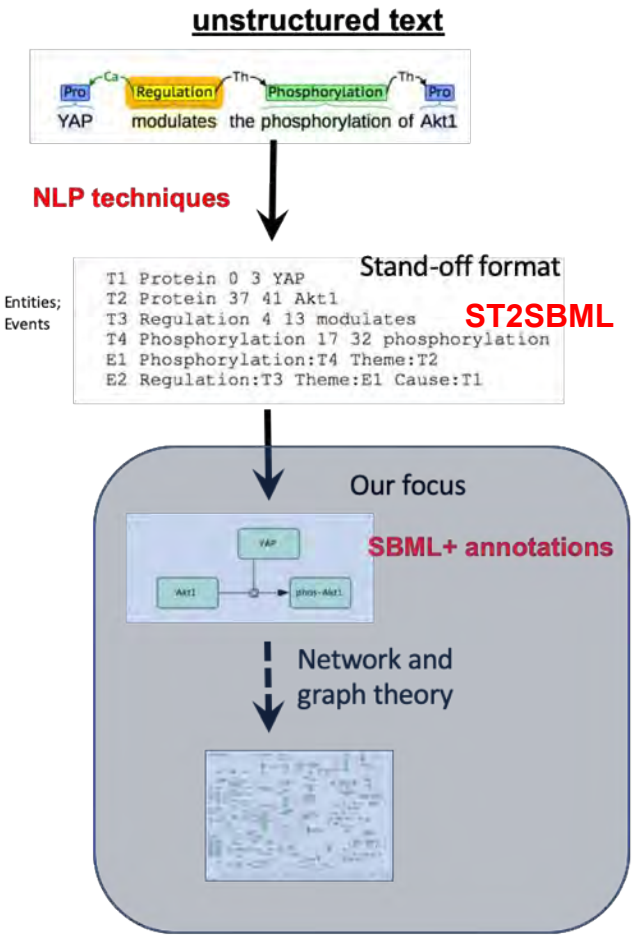
Who is working on which molecule?

Who is working with who?

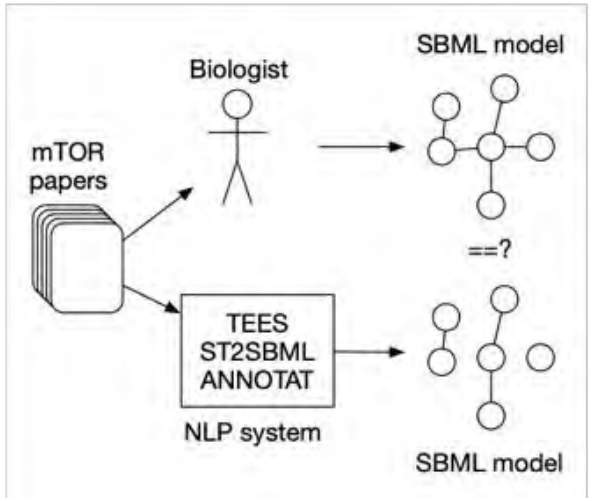


Text driven network/ pathway reconstruction

How good is automated curation vs expert curation?



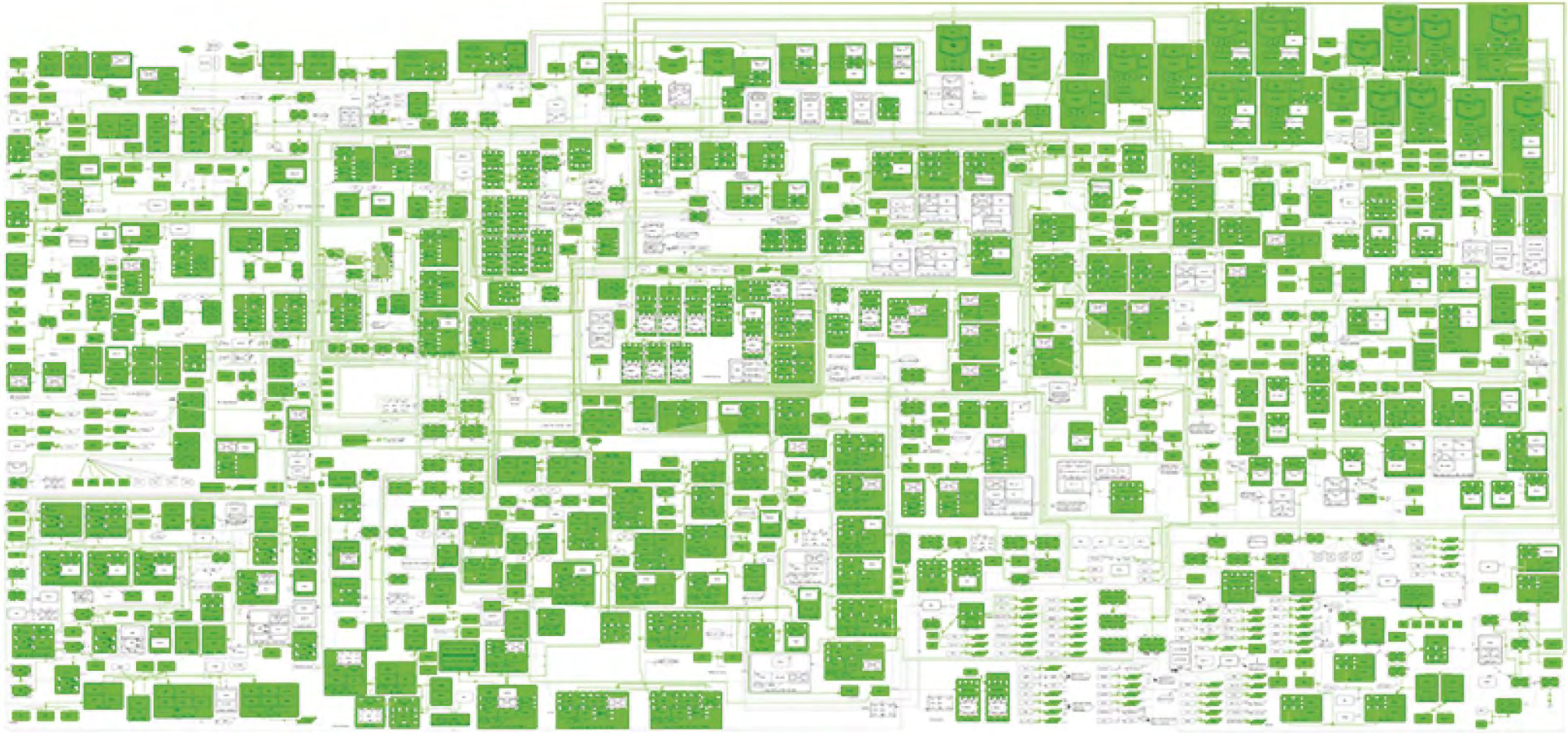
VS.



Expert curated map (Gold Standard)

mTOR pathway as a case study

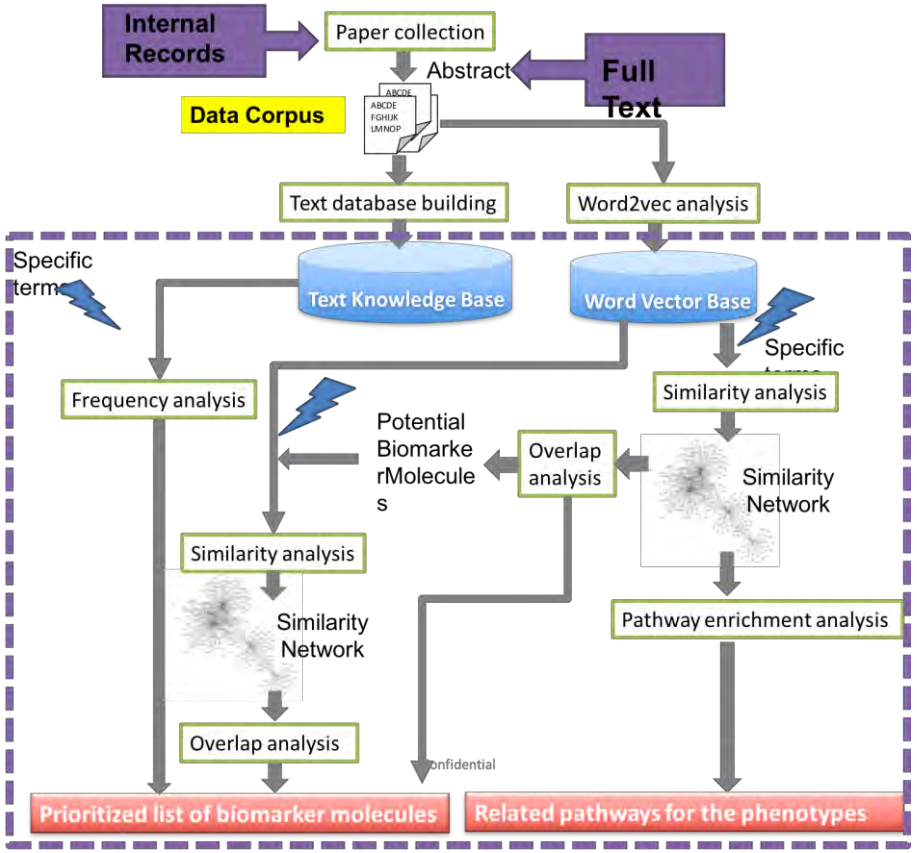
Spranger, M., Palaniappan, S., Ghosh, S.: Measuring the state of the art of automated pathway curation using graph algorithms - a case study of the mtor pathway. BioNLP 2016, pp. 119–128. ACL



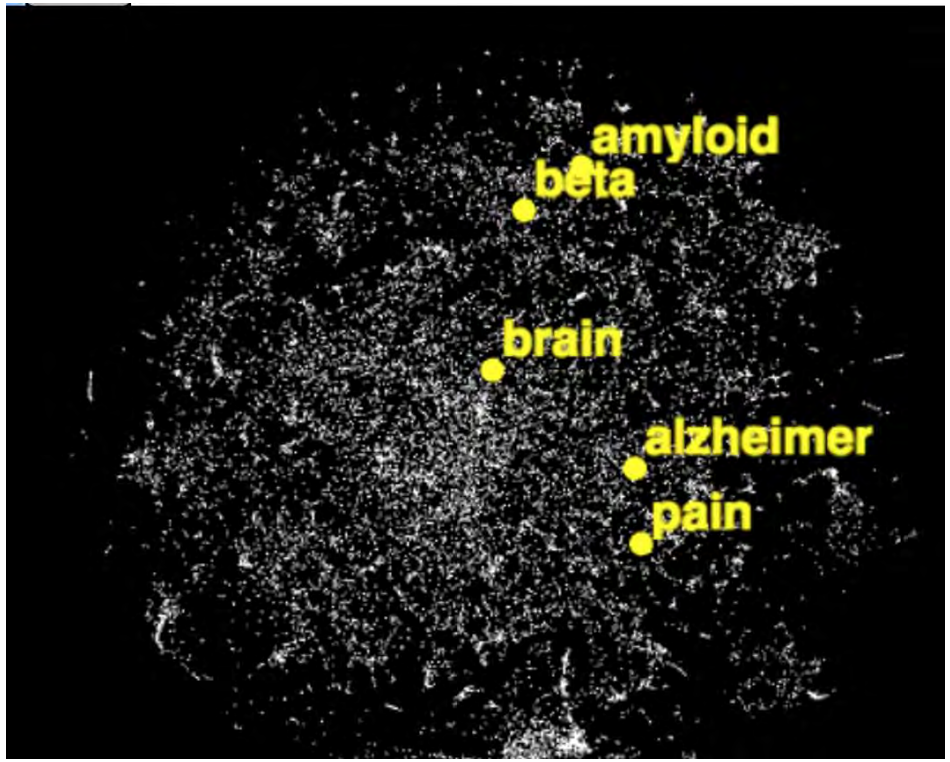
Key Case Studies

Text mining approach for BioMarker Discovery

Biomarker Knowledge Mining Pipeline

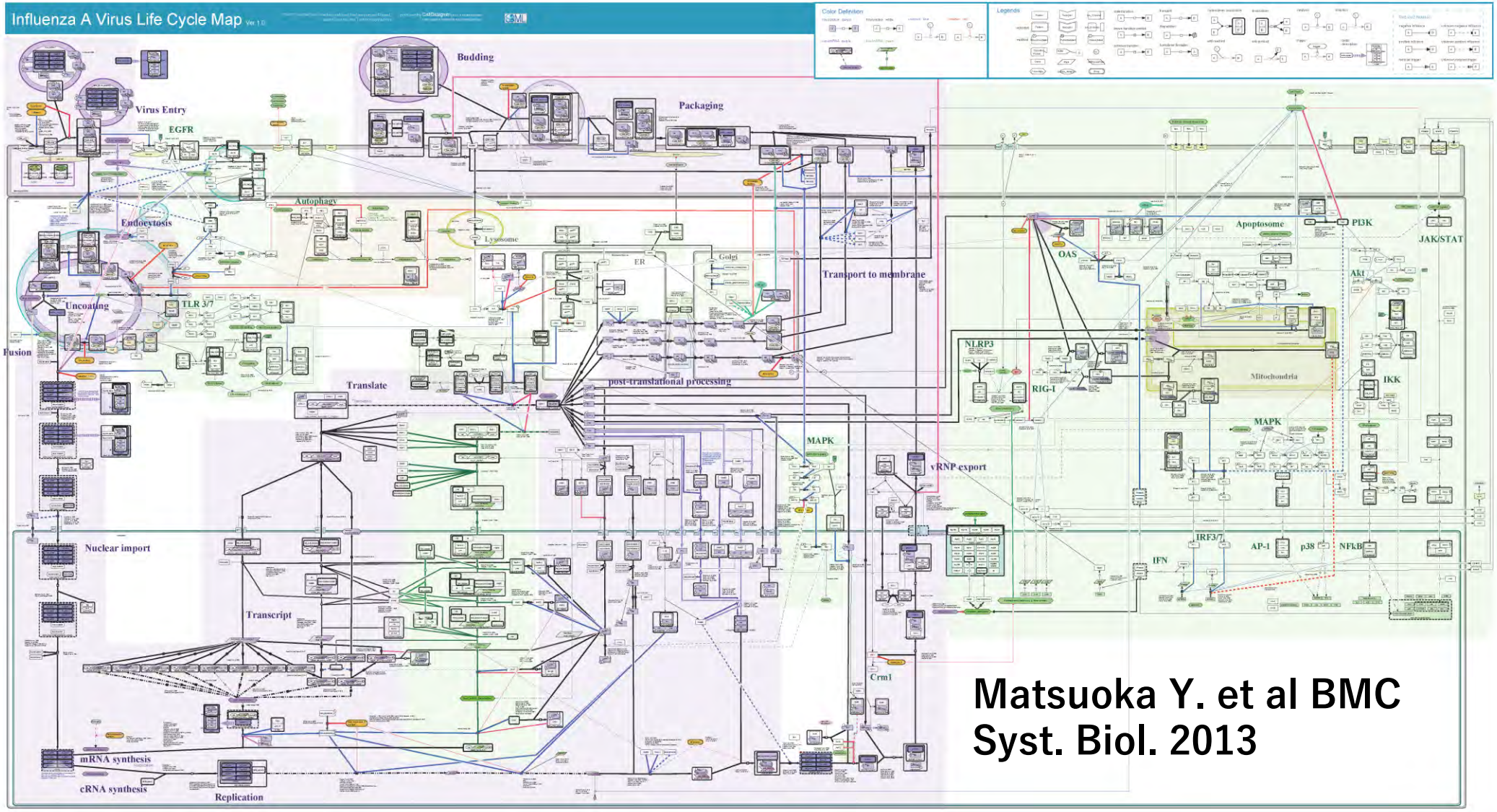


Biomarker Galaxy
Associate biomarkers with diseases



Literature-driven Approach

Influenza infection and replication network



Matsuoka Y. et al BMC Syst. Biol. 2013

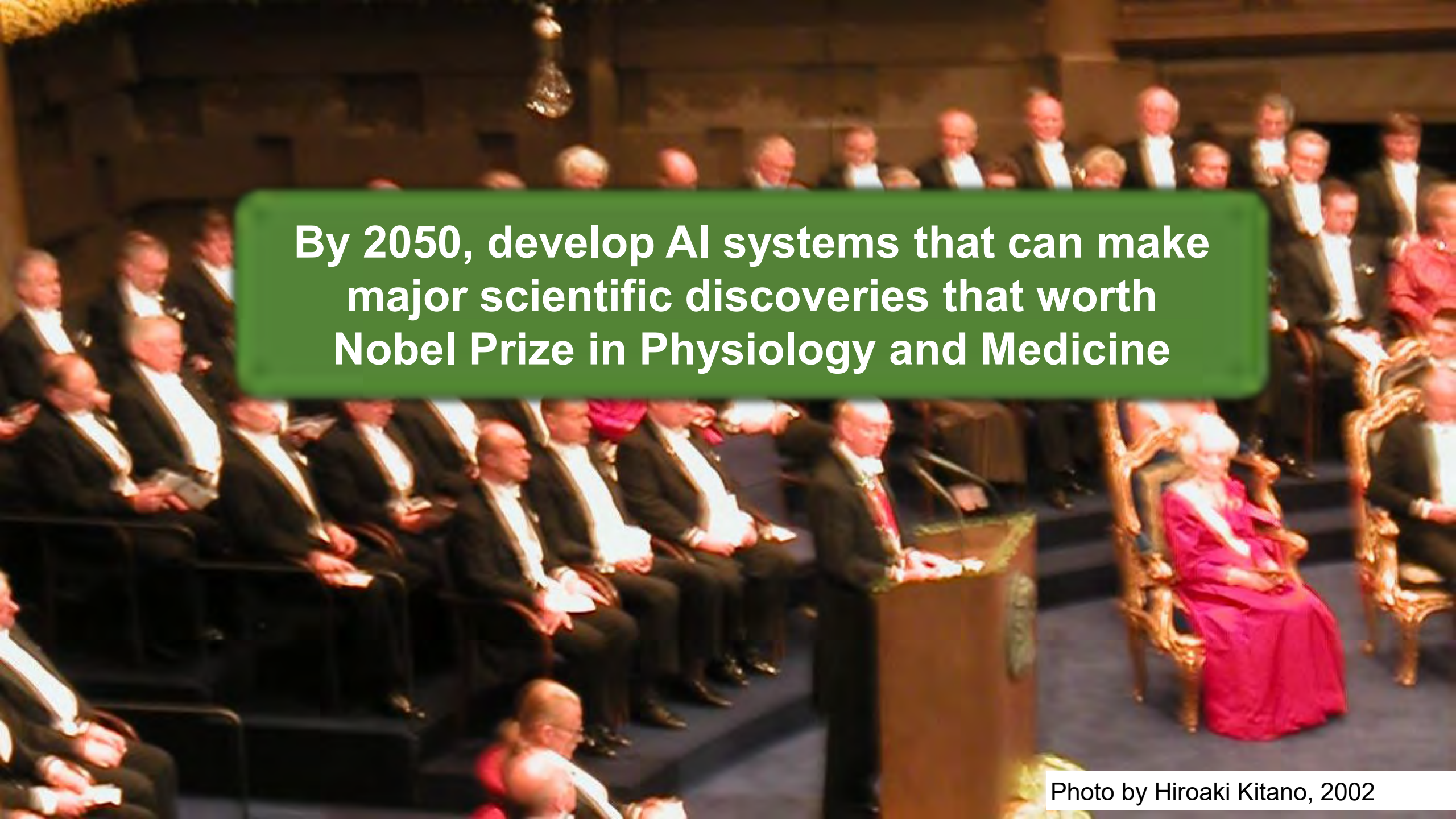


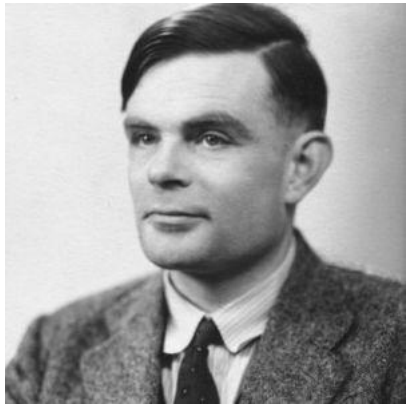
Photo by Hiroaki Kitano, 2002

Nobel Turing Challenge

The Nobel Committee to give AI system the Nobel Prize without noticing it is an AI system, not a human scientist.

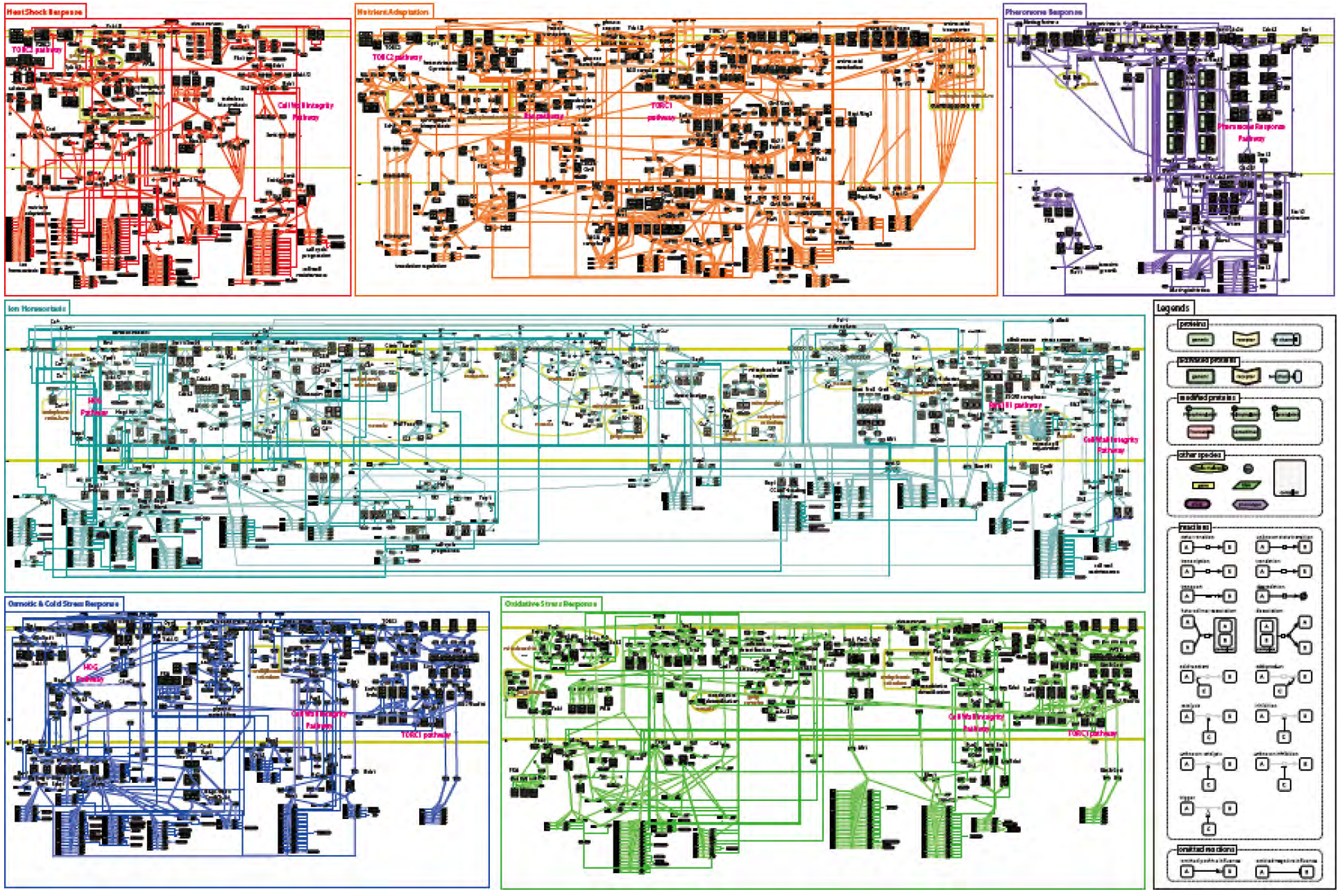
Alfred Nobel

The Turing Test at the Nobel-quality scientific activities

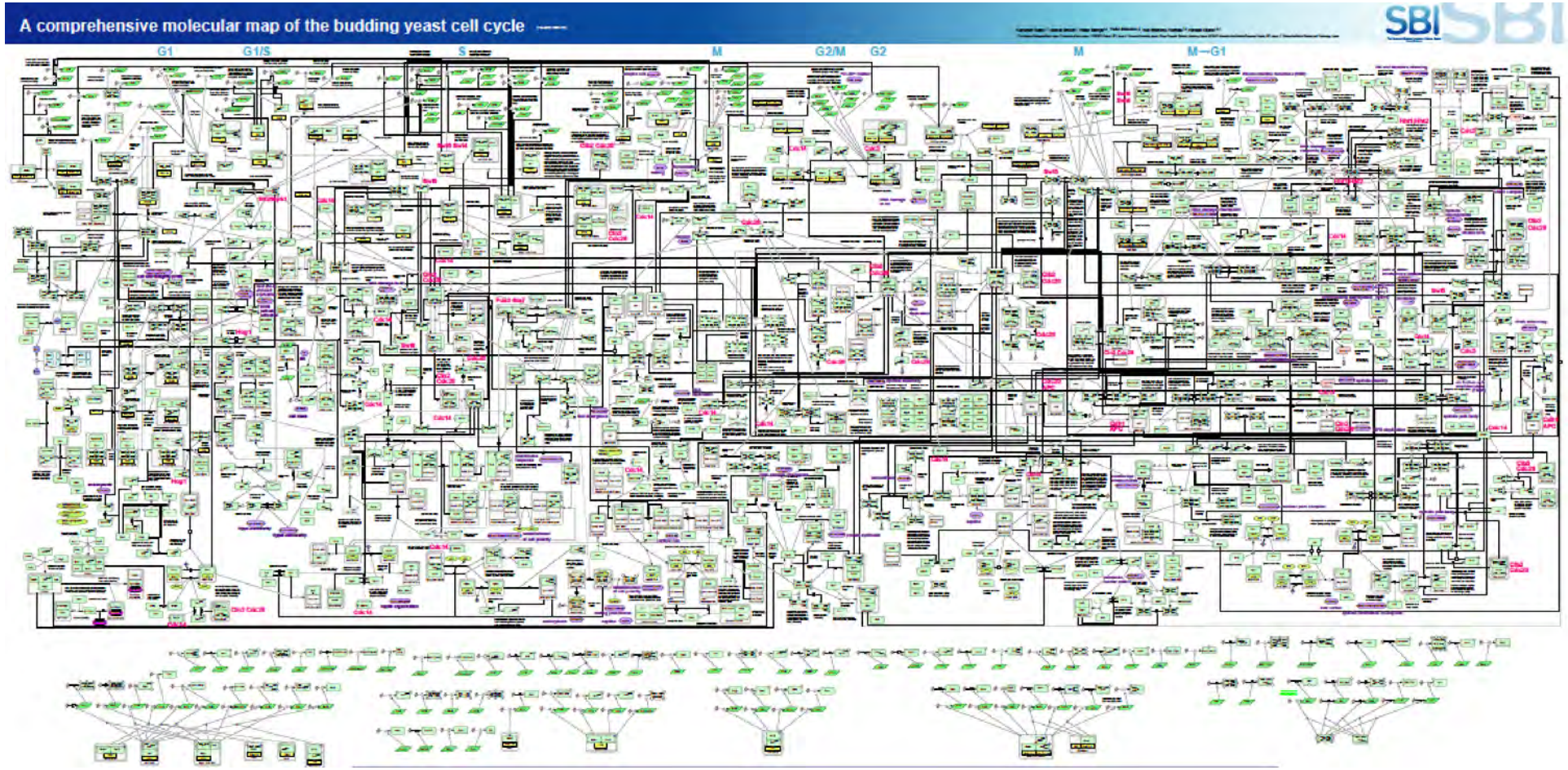


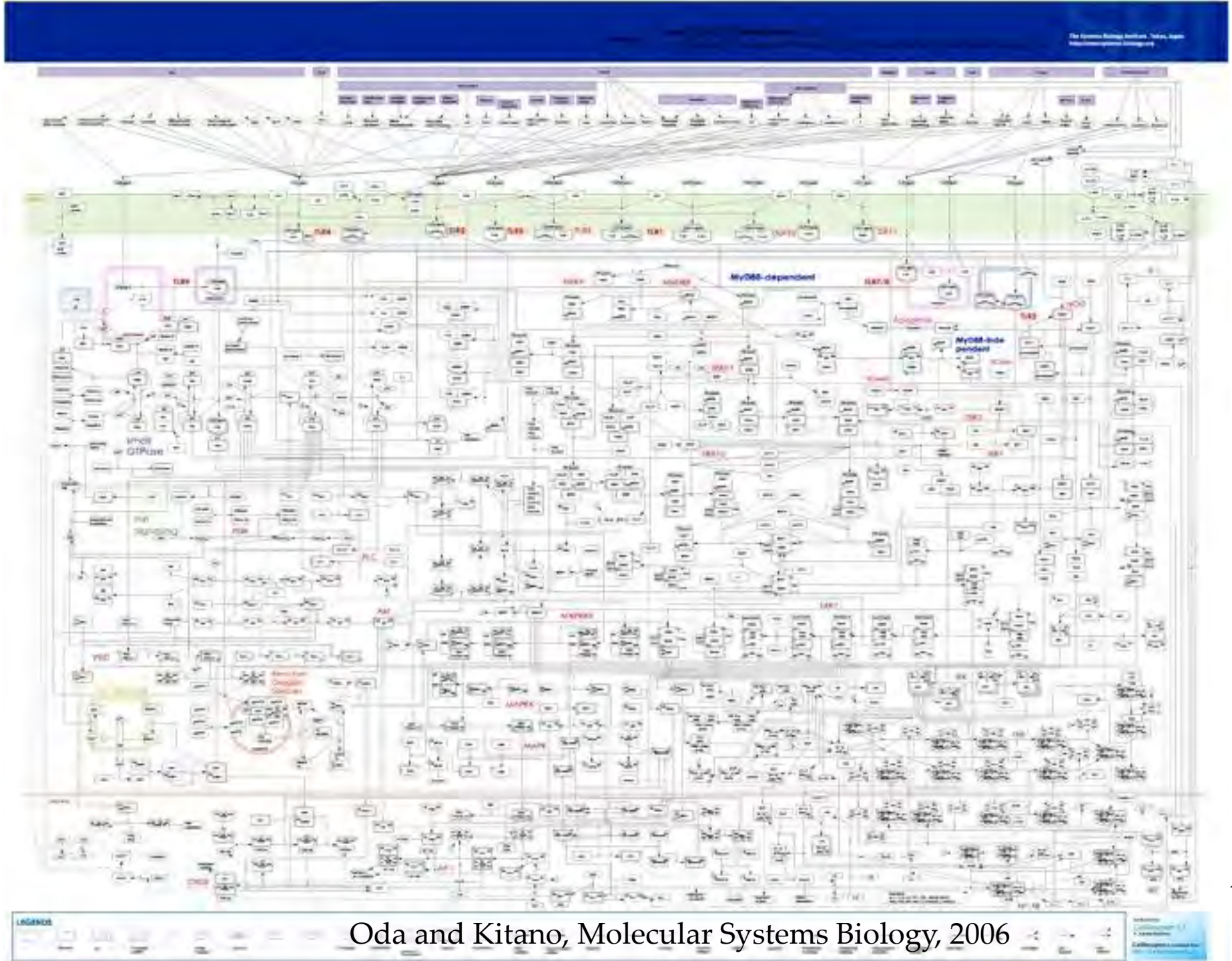
Alan Turing

Yeast Signaling

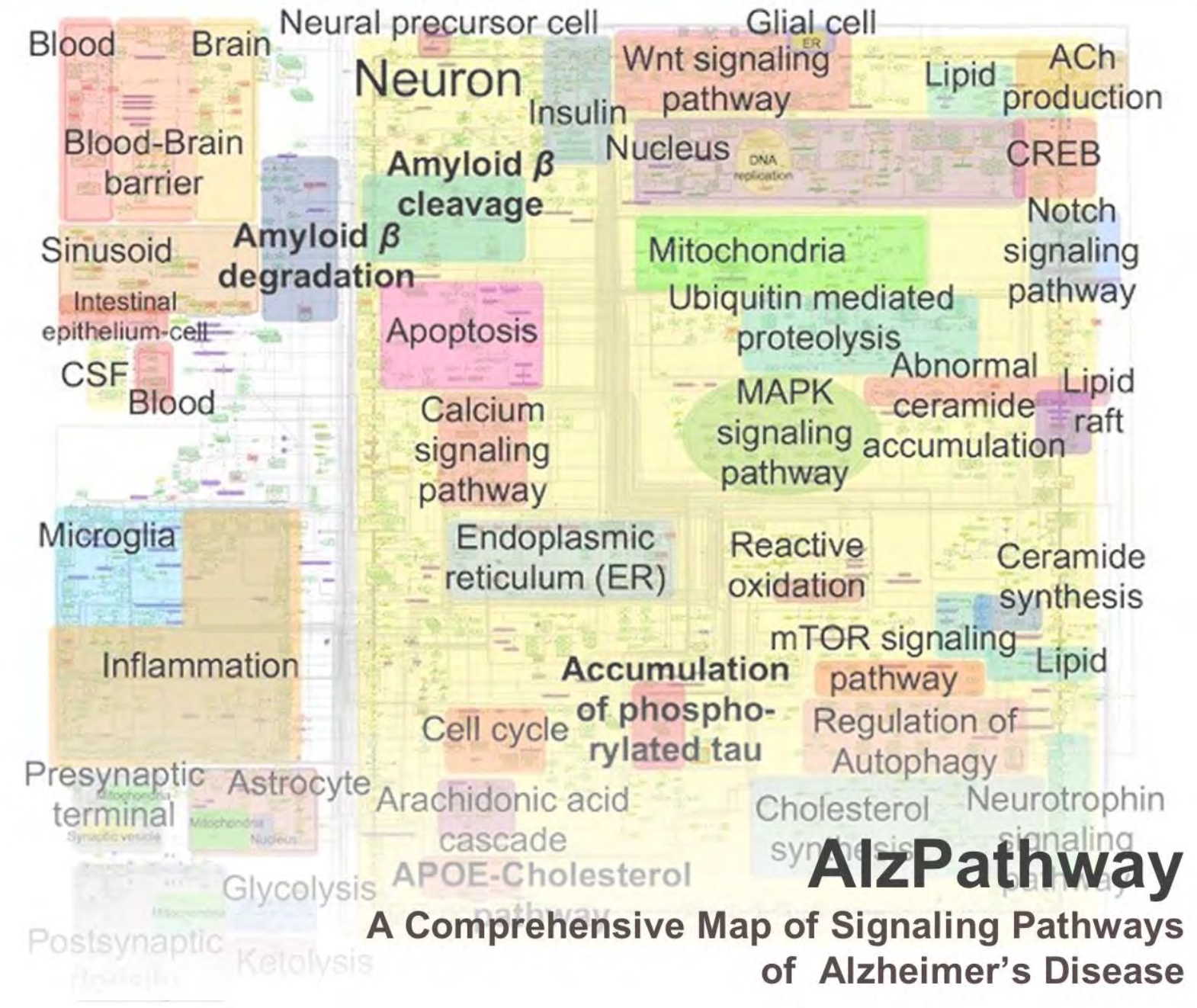


Yeast Cell Cycle

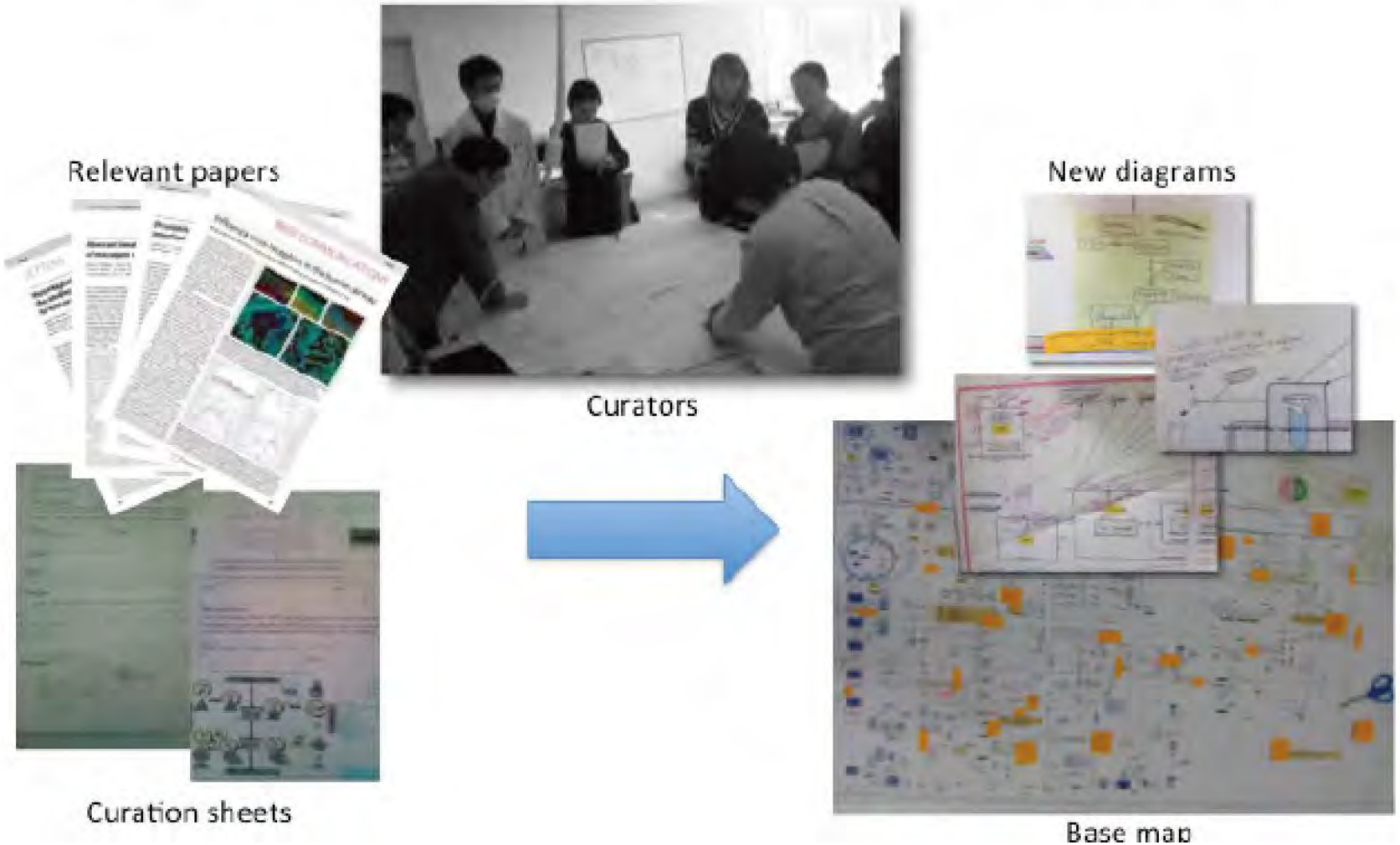




Oda and Kitano, Molecular Systems Biology, 2006


Blood
Brain
Neural precursor cell
Glial cell
Neuron
Wnt signaling pathway
Lipid
ACh production
Insulin
Blood-Brain barrier
Nucleus
CREB
Amyloid β cleavage
Amyloid β degradation
Sinusoid
Mitochondria
Notch signaling pathway
Intestinal epithelium-cell
Ubiquitin mediated proteolysis
Apoptosis
CSF
Blood
Abnormal ceramide accumulation
Lipid raft
MAPK signaling pathway
Calcium signaling pathway
Microglia
Endoplasmic reticulum (ER)
Reactive oxidation
Ceramide synthesis
mTOR signaling pathway
Lipid
Inflammation
Accumulation of phospho-rylated tau
Cell cycle
Regulation of Autophagy
Presynaptic terminal
Astrocyte
Arachidonic acid cascade
Cholesterol
Neurotrophin signaling
APOE-Cholesterol
Glycolysis
Postsynaptic
Ketolysis
AlzPathway
A Comprehensive Map of Signaling Pathways of Alzheimer's Disease

"Mapathon" = Mapping Marathon

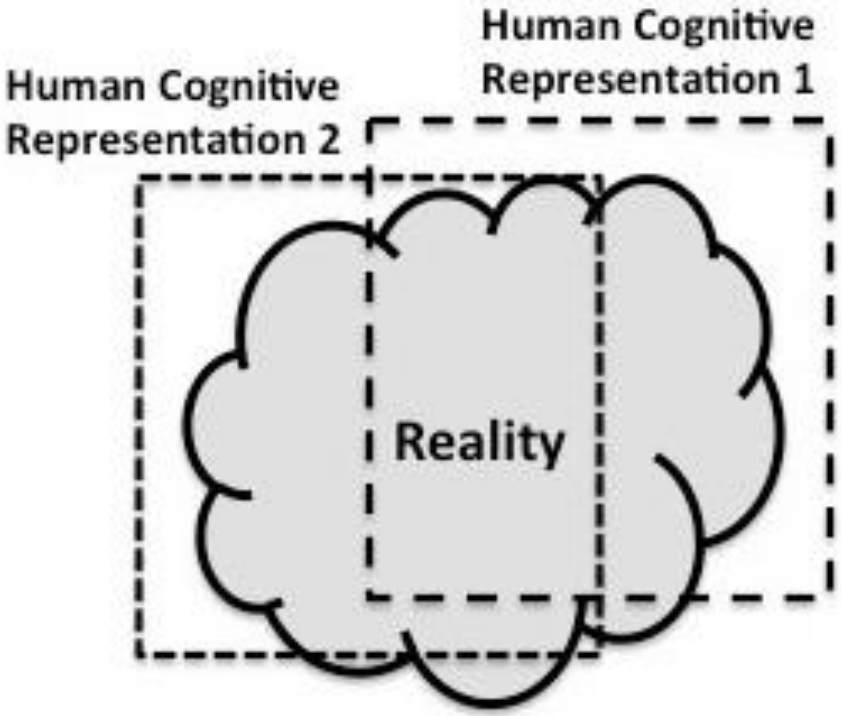


Matsuoka, et al., Weaving Knowledge of Biochemical Pathway in collaboration, to appear in Computational Systems Toxicology

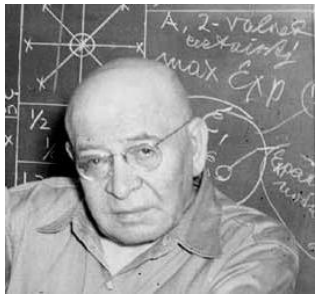
Human Cognitive Bias and Limitations of Semantic Mapping

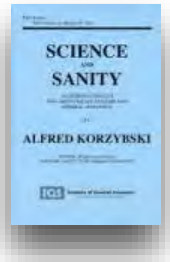
Cognitive Bias in Clinical Reasoning

- **Anchoring Bias**
- **Availability Bias**
- **Confirmation Bias**
- **Premature Closure**
- **Representativeness**

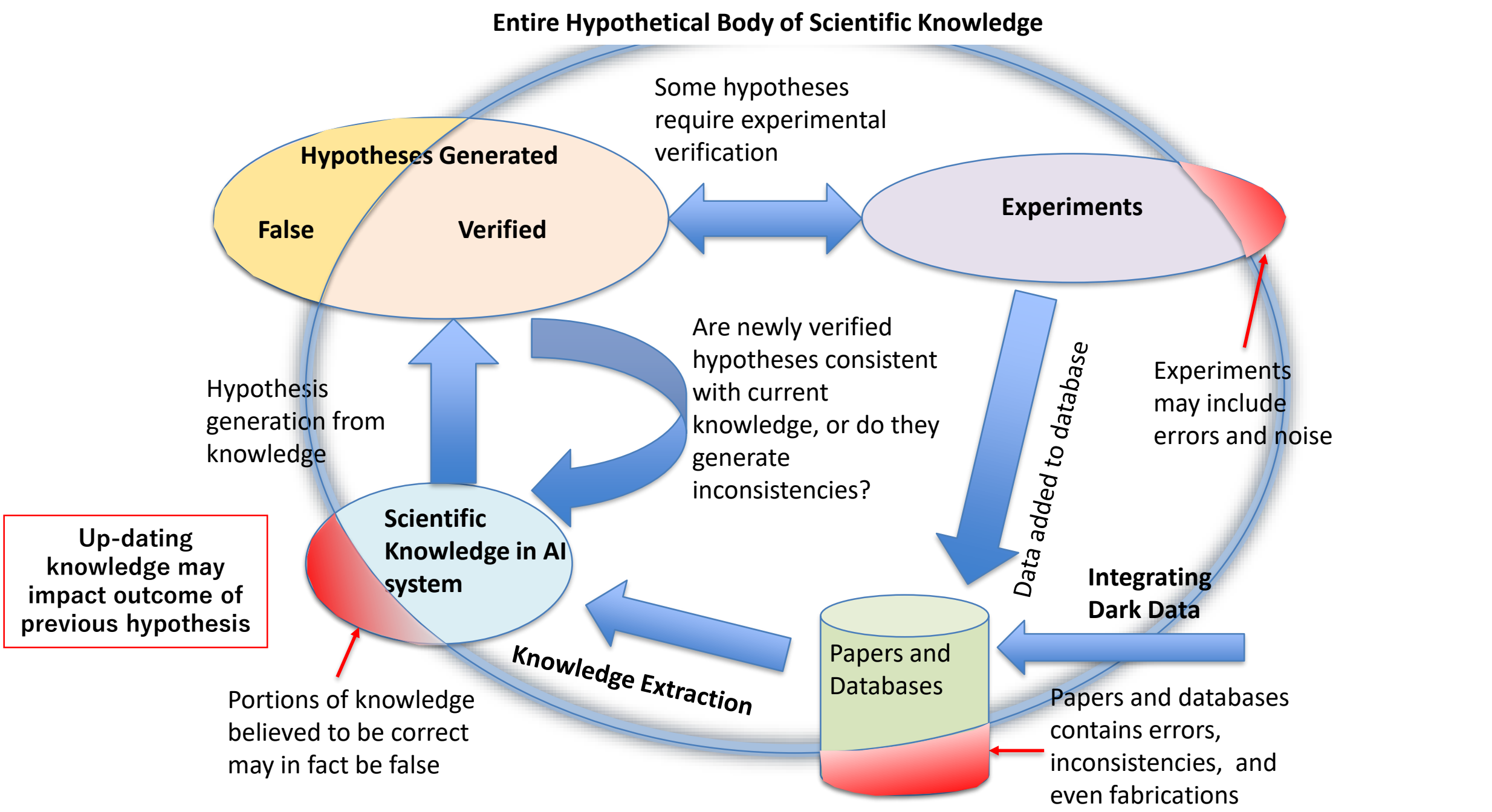


Map is not the territory



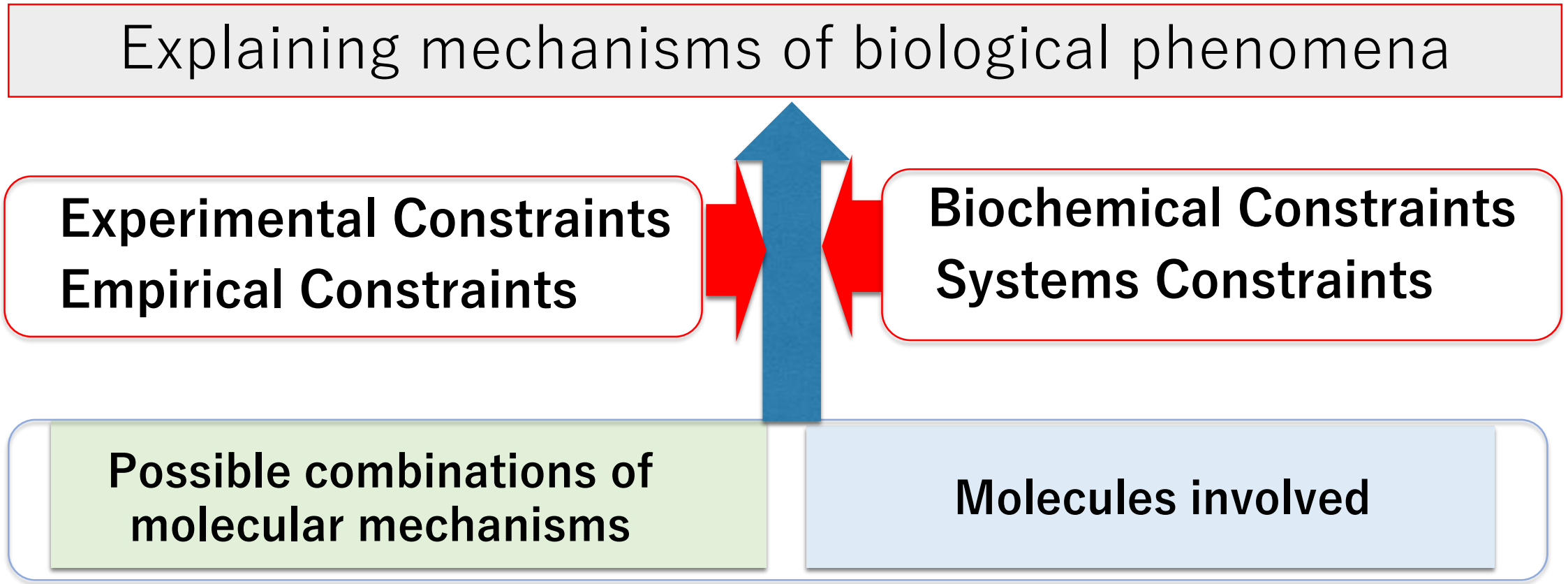


Alfred Korzybski



Kitano, H., AI Magazine, March 2016

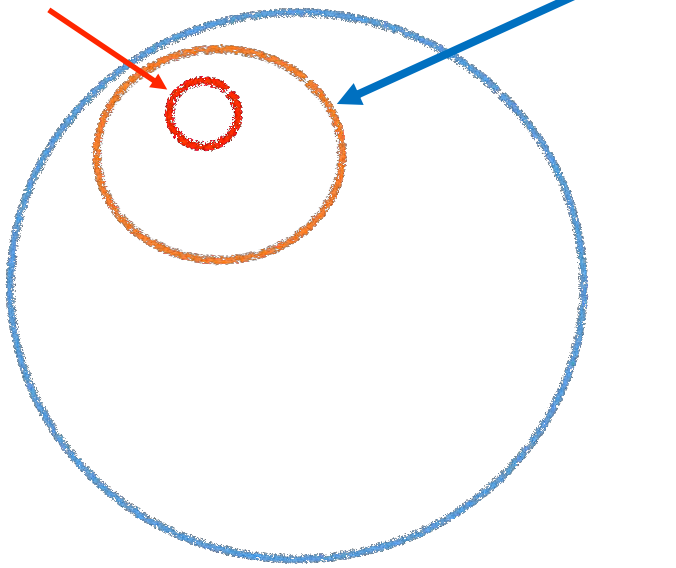
An Example of Knowledge Structure of Biological Discovery



AlphaGo

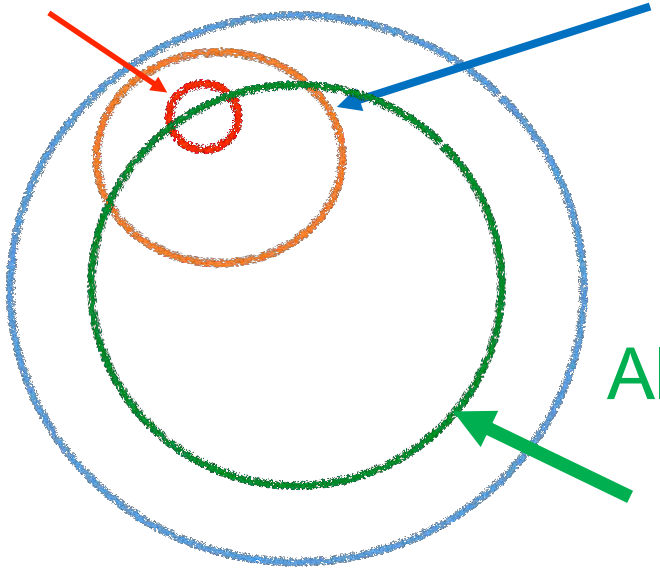
Human played games in the record

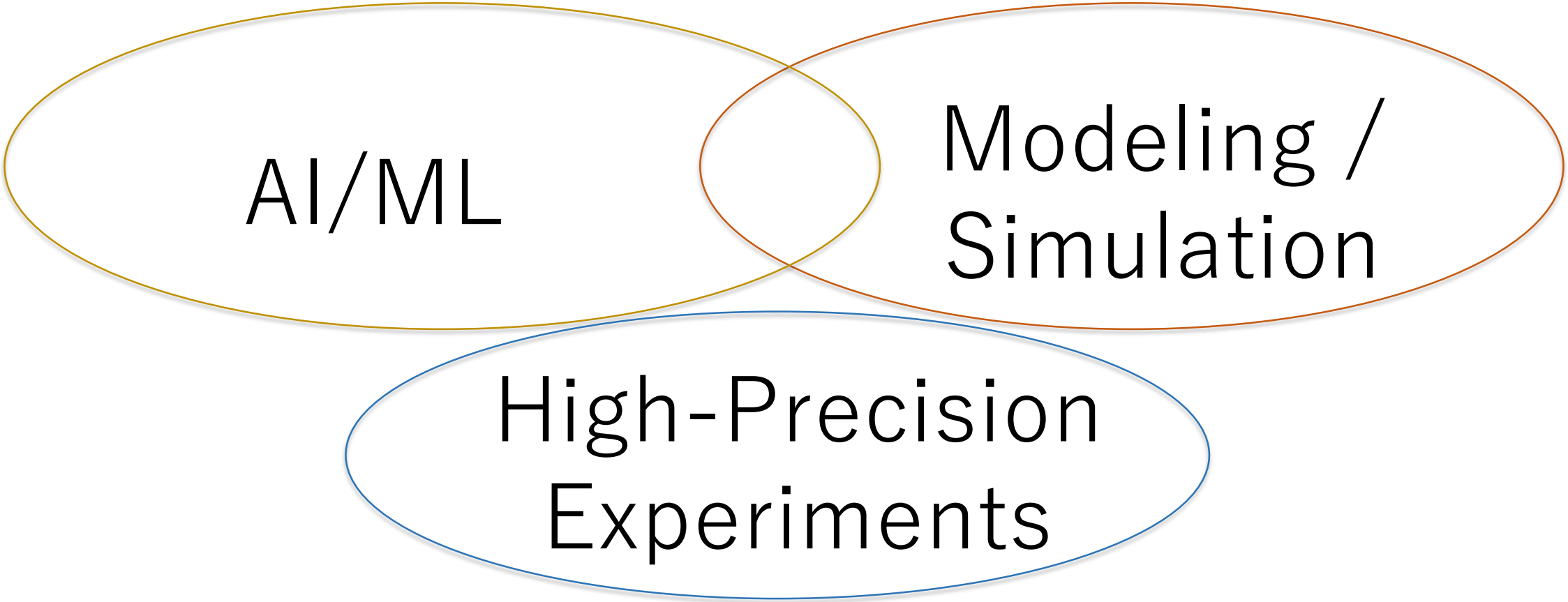
Possible moves based on past human played games

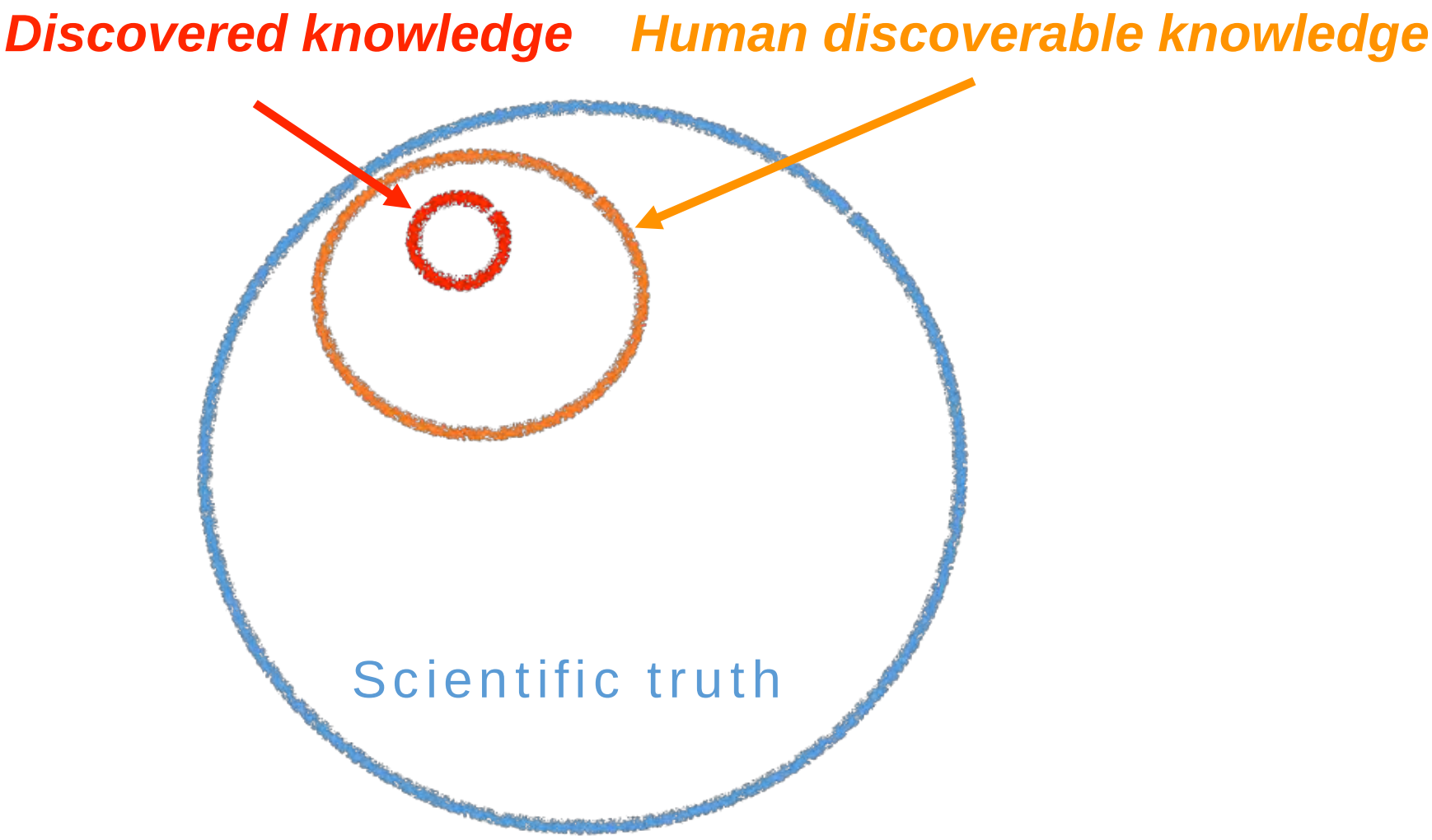


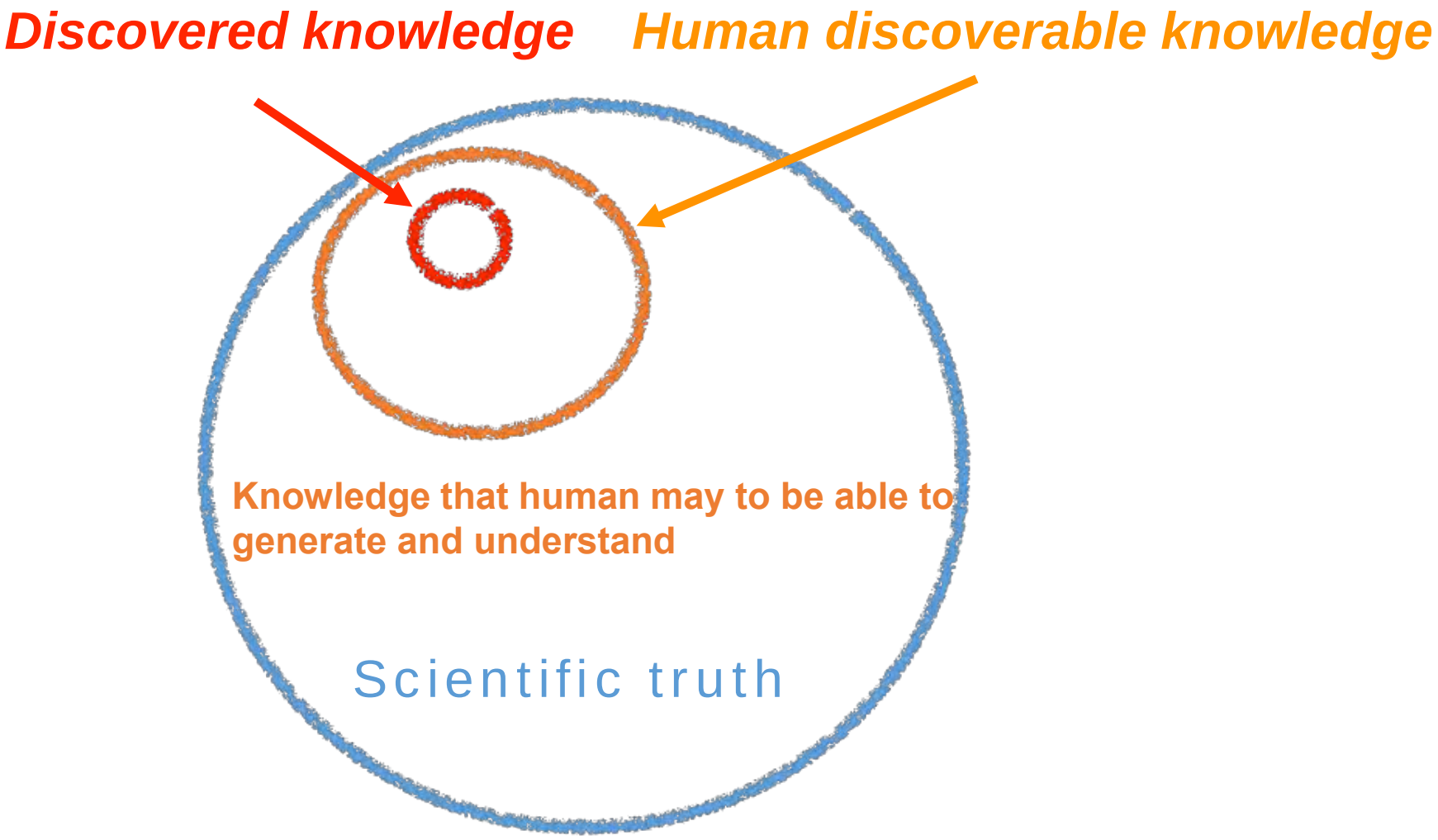
All possible moves on GO

AlphaGo ZERO




AI/ML
Modeling /
Simulation
High-Precision
Experiments


Discovered knowledge
Human discoverable knowledge
Scientific truth


Discovered knowledge
Human discoverable knowledge
Knowledge that human may to be able to generate and understand
Scientific truth

Implications

- Alternative forms of scientific discovery
- Alternative forms of intelligence
- Accelerating sciences at unprecedented speed
- Machines to evolve by itself?