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AdaLab

AdaLab

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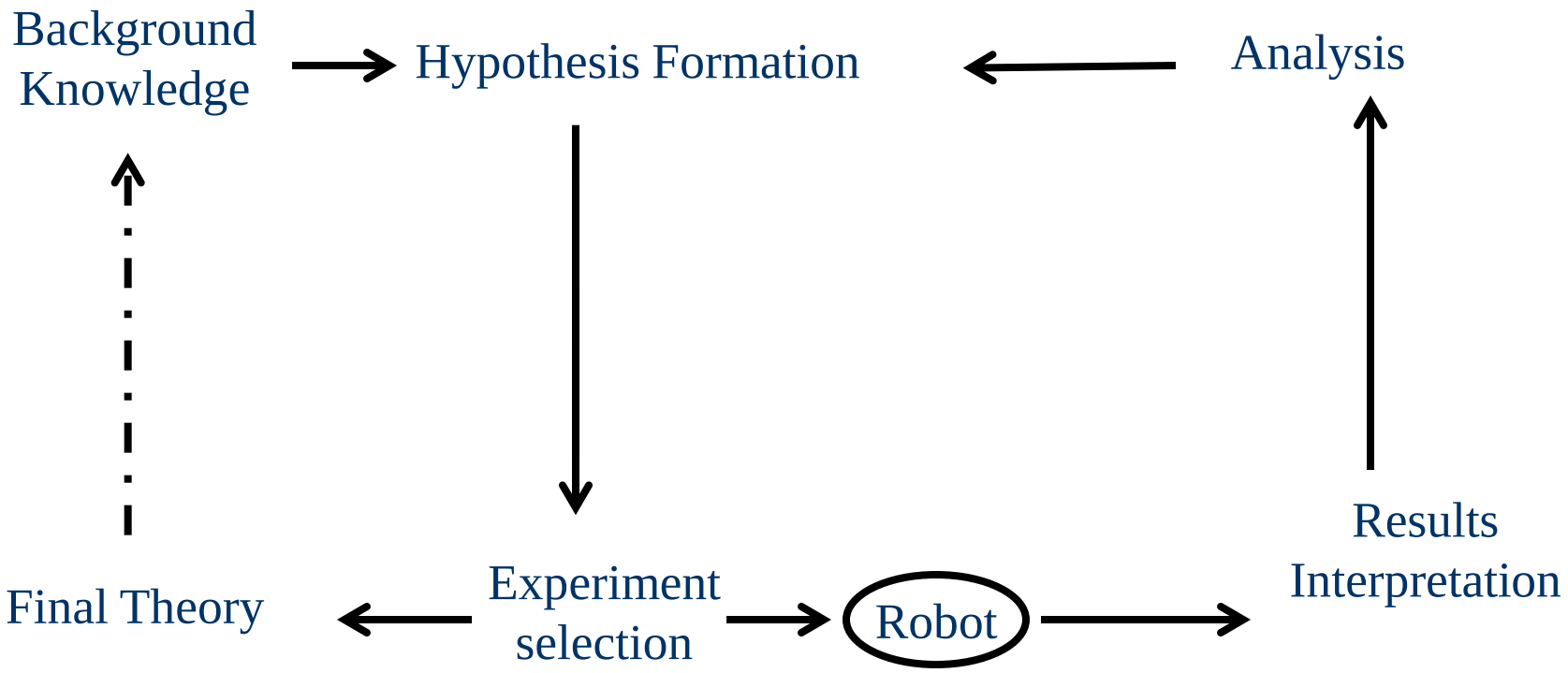
- Adaptive Automated Scientific Laboratory (AdaLab)
- Adaptive Machines in Complex Environments
- Start Date: 1.4.15

Scientific Background

The Concept of a Robot Scientist

Computer systems capable of originating their own experiments, physically executing them, interpreting the results, and then repeating the cycle.



Eve: Robot Scientist

The Reproducibility Crisis

- One of the most important current issues in biology is ‘The reproducibility crisis’ - Billions of euros wasted.

- ‘There is growing alarm about results that cannot be reproduced. Explanations include increased levels of scrutiny, complexity of experiments and statistics, and pressures on researchers.’ *Nature* 2016.

- *We require Automation to ensure reproducibility.*

Key Goals

Scientific Goals

- To make scientific discovery more efficient: cheaper, faster, better.

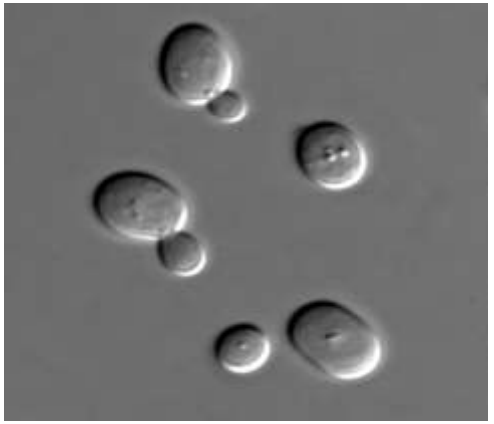
- Our vision is that within 10 years many scientific discoveries will be made by teams of human and robot scientists.
- This collaborations will produce scientific knowledge more efficiently than either could alone.

Scientific Goals

- A framework for semi-automated and automated knowledge discovery by teams of human and robot scientists.

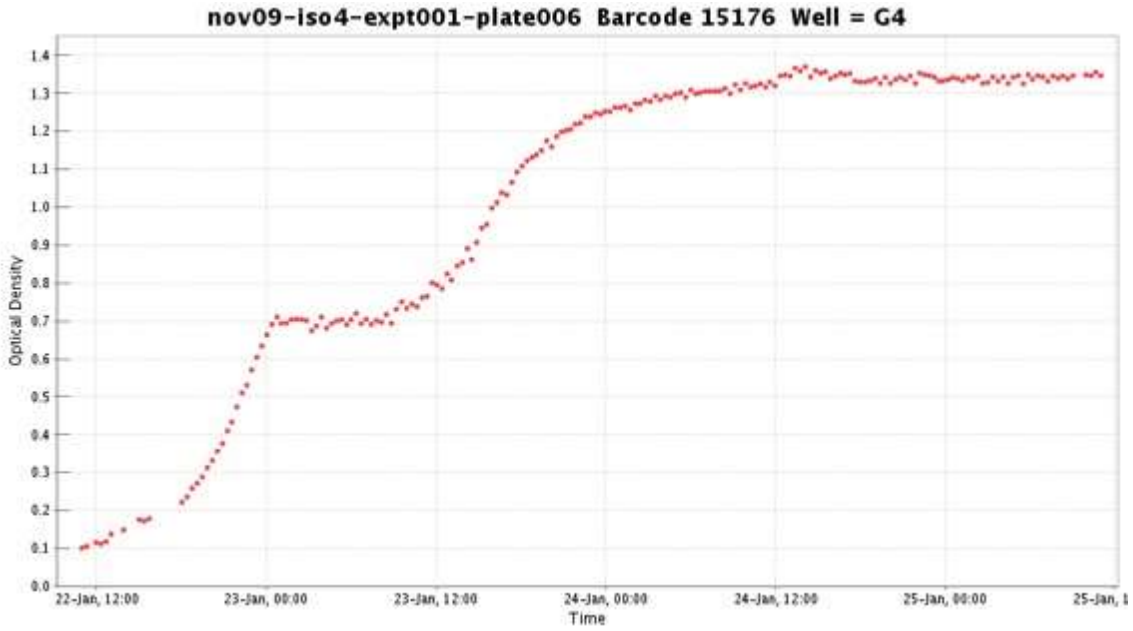
- Integrating advances in knowledge representation, ontology engineering, semantic technologies, machine learning, bioinformatics, and automated experimentation.

The Diauxic Shift



- Yeast (*S. cerevisiae*).
- First turn sugar into ethanol.
- Then turn ethanol into CO_2.

- Cancer
- Ageing



Key Challenges

Key Challenges

- The AdaLab system needs to be:
  - *autonomous and perceptive to human requirements* (its scientific collaborators).
  - *able to continuously learn, adapt and improve in the "real world" complex environment* of scientific research.
  - capable of continuous cycles of scientific hypothesis formation and experimentation that will improve its scientific knowledge (models).

Key Challenges

- Scientific knowledge is inherently uncertain.
- Within the AdaLab framework we are developing Bayesian methods that make inferences and plan experiments under uncertainty.

- Scientific knowledge is best represented using logic.
- To integrate logic with probabilities we will use statistical relational learning, and have developed an ontology for representing uncertain knowledge.

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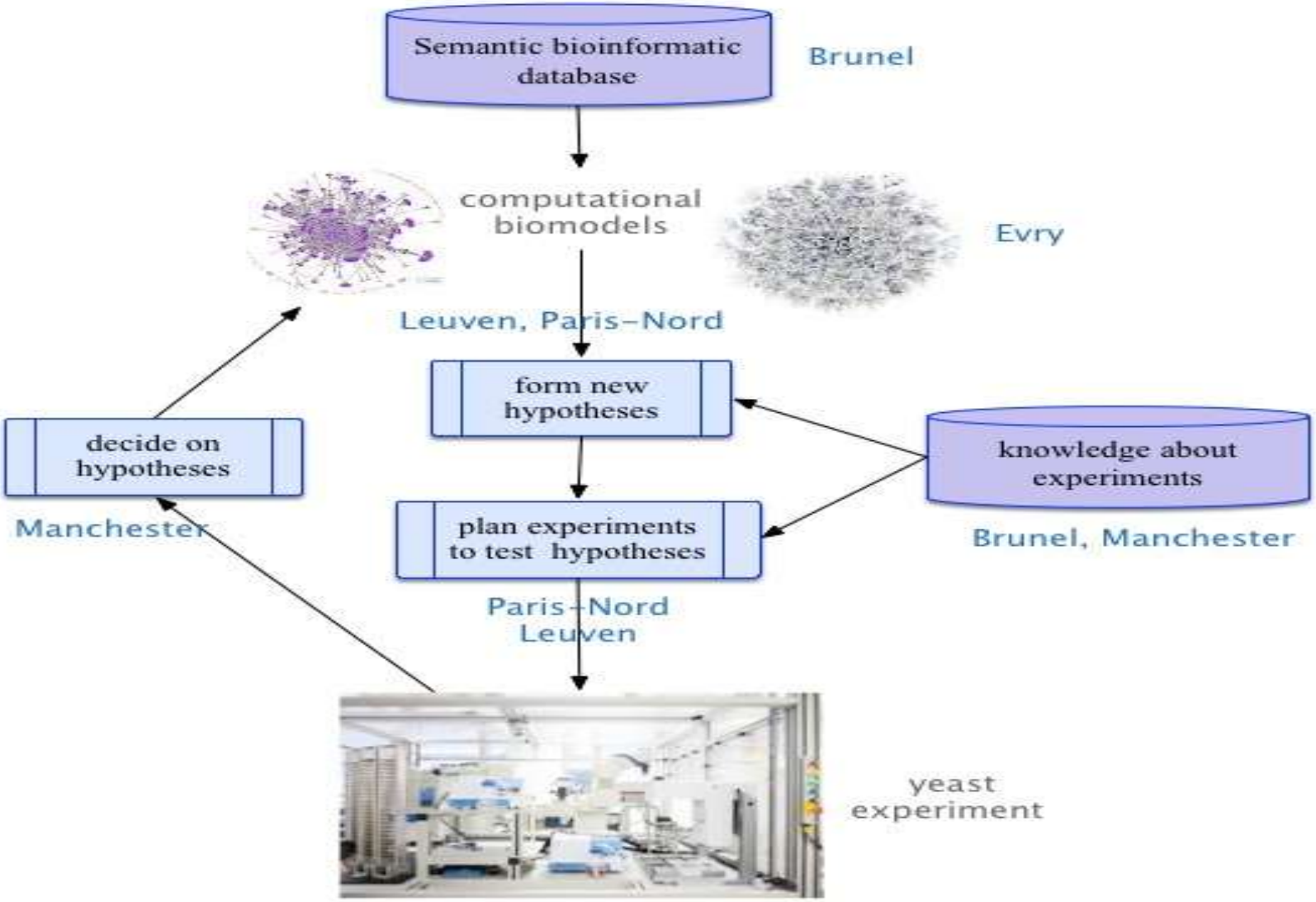
Structure/Partners

AdaLab Structure



Brunel University

- Coordination
- Knowledge representation – ontologies.
- Formalisation of the knowledge base on the yeast diauxic shift.
- A communication mechanism between robot and human scientists.

Universite Evry

- Bioinformatics: Collection of bioinformatic data about the yeast diauxic shift.
- Systems Biology: Development of an integrated metabolic and gene signalling network.

KULeuven (Belgium)

- Knowledge Engineering.
- Machine Learning: ILP.
- Probabilistic Inference.

Universite Paris-Nord

- Machine Learning
  - Inductive Logic Programming.
  - Incremental theory revision.

- Experiment planning
  - Active learning.
  - Cost minimisation.

University of Manchester: Robot Scientists

- Coordination of Research
- Experiments with the Robot Scientists ‘Eve’.
- Domain expertise - biological knowledge.

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Results

Key Outputs

- A novel ontology for modelling uncertain knowledge - 80%.
- An efficient communication mechanism between human and robot scientists – 20%.
- New machine learning methods for the generation and efficient testing of complex scientific – 40%.
- Novel biomedical knowledge about cell biology relevant to cancer and ageing –10%.

- AdaLab system – 30%

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Potential Impact

Potential Impact

- Science is the greatest generator of economic wealth (through developments in technology).
- Science is the greatest driver of better health (through development in biomedical science).

- The AdaLab system goal to be >20% more efficient at discovering scientific knowledge (within a limited scientific domain) than human scientists alone.

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Dissemination

Dissemination

- Public Engagement
  - London Science Museum Event
  - Interview for Belgian television channel
- Dissemination to non-specialist audiences
  - Project Website and promotional literature
  - Newsletters
  - Public lectures and seminars (e.g. Pint of Science; Pendle Science café; Summer School of Science)
- Dissemination via specialist media
  - Conference presentations (10 given to date)
  - Journal publications (3 generated to date)
- International Workshop - planned

Sustainability/Valorisation

Sustainability

- Industrial links
  - European Laboratory Automation companies
  - European Pharmaceutical companies.

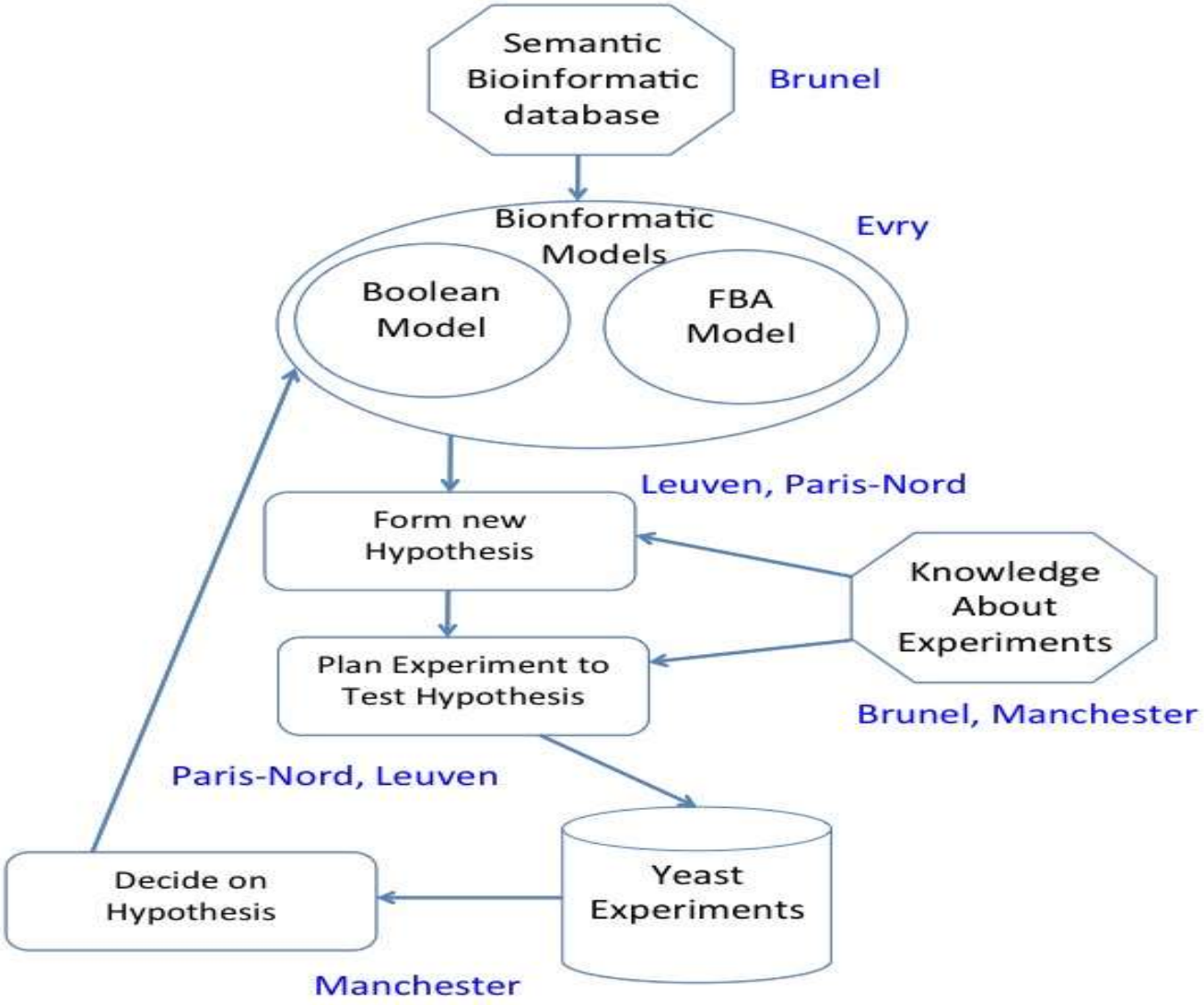
Valorisation

- 5 Postdocs trainning.
- 1 PhD student.

- Social Science
  - 1 PhD student sociology
  - 1 PhD student anthropology

Thanks

AdaLab Structure



Key Challenges 2

- Integrates: robotics, machine learning, logical and probabilistic inference, semantic technologies, and yeast microbiology.
- Integrating: high-level reasoning about scientific knowledge with the control of low-level robotic movements to execute experiments.
- Developing a protocol for communication between human and robot scientists.