Slime Mold Computation

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COSC 594
Unconventional Computation

ICL INNOVATIVE COMPUTING LABORATORY

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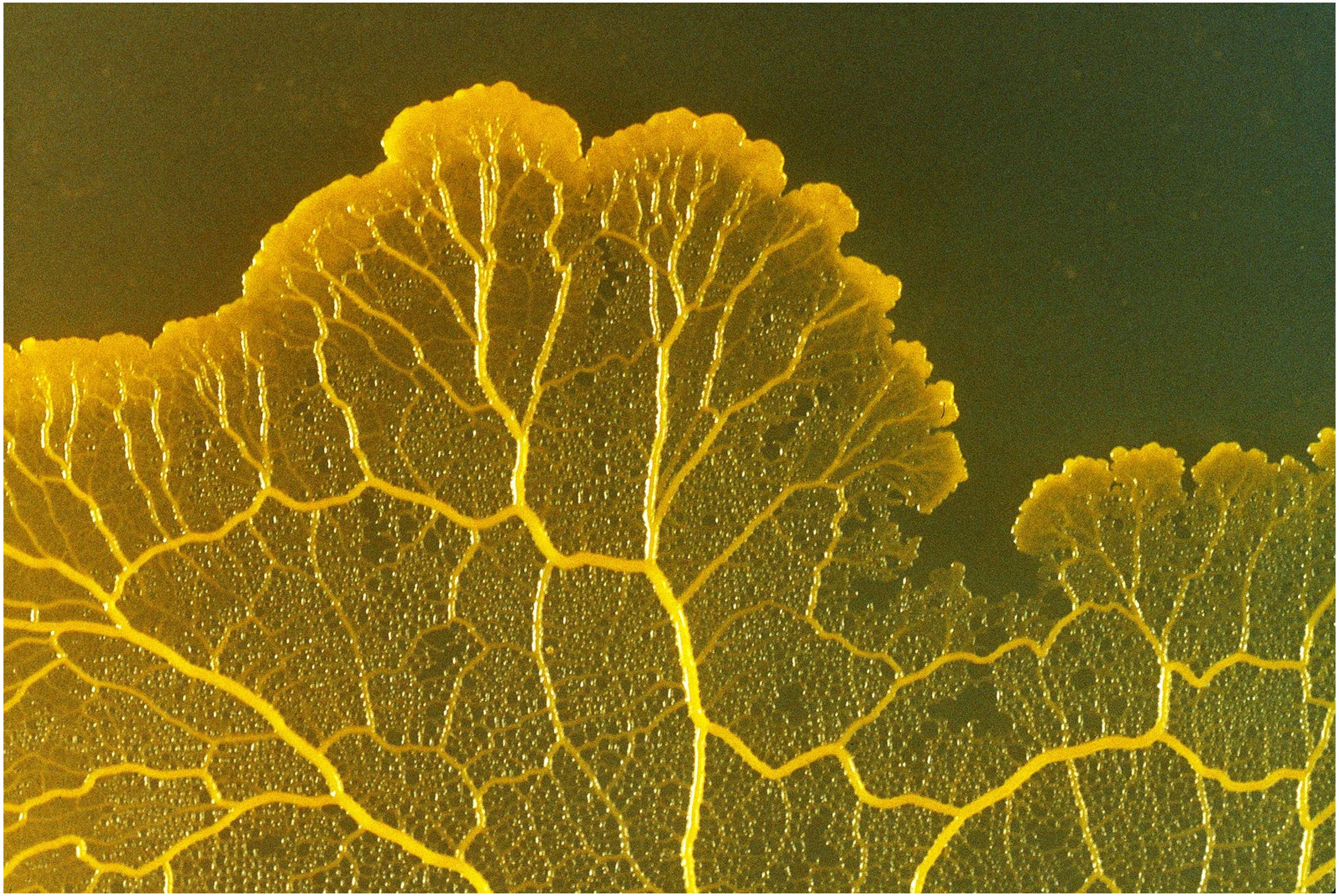
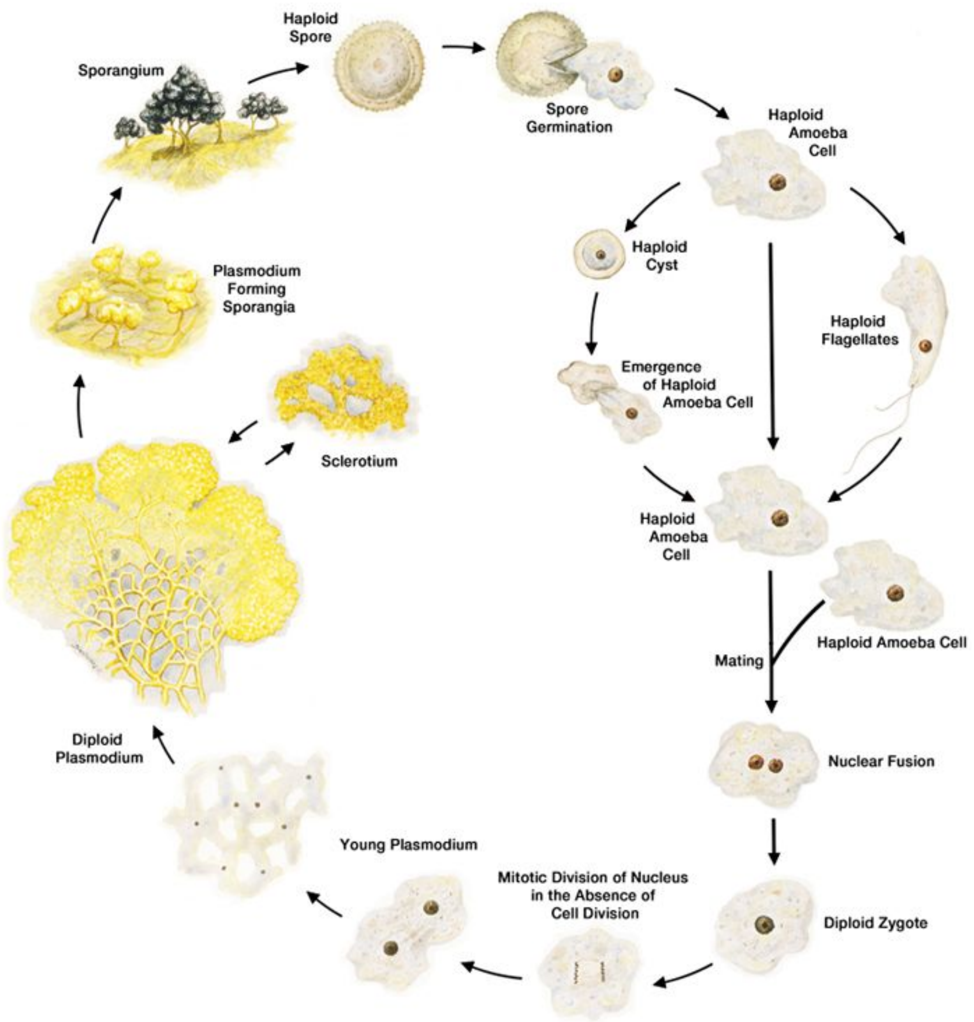
Physarum Polycephalum



P. Polycephalum Lifecycle



P. Polycephalum Capabilities

- Lifecycle responses
- Movement – obstacles and attractors
- Pseudopodia “channels” and streaming

P. Polycephalum for Computation

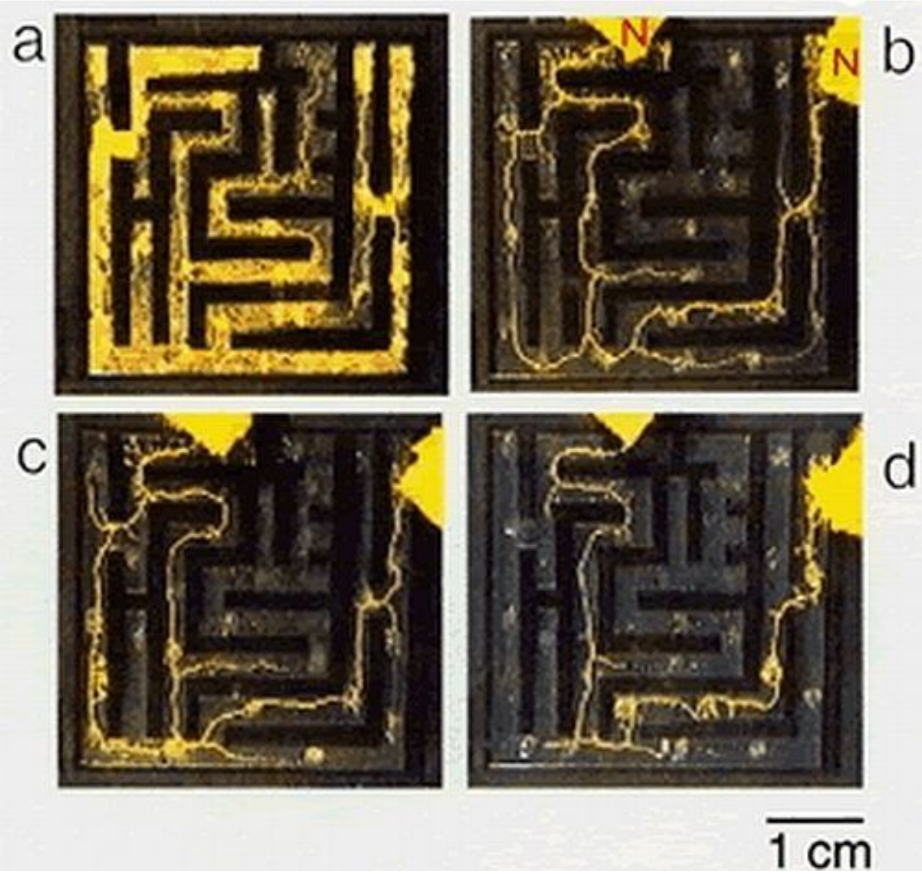
- Cheap, resilient, easy to culture
- Complex foraging behaviors
  - Networking food sources
  - Cross-channel construction
  - “Slime trail” navigation strategy
  - Optimization of diet
- Other interesting behaviors
  - Reassembly

Research Pathways

- Biology research into Physarum Polycephalum lifecycle/behavior extends back to at least 1930s
- Computational research on slime molds began with geometric problem/optimization work around 1999
- Other work, including biocomputation/biorobotics published about the same time

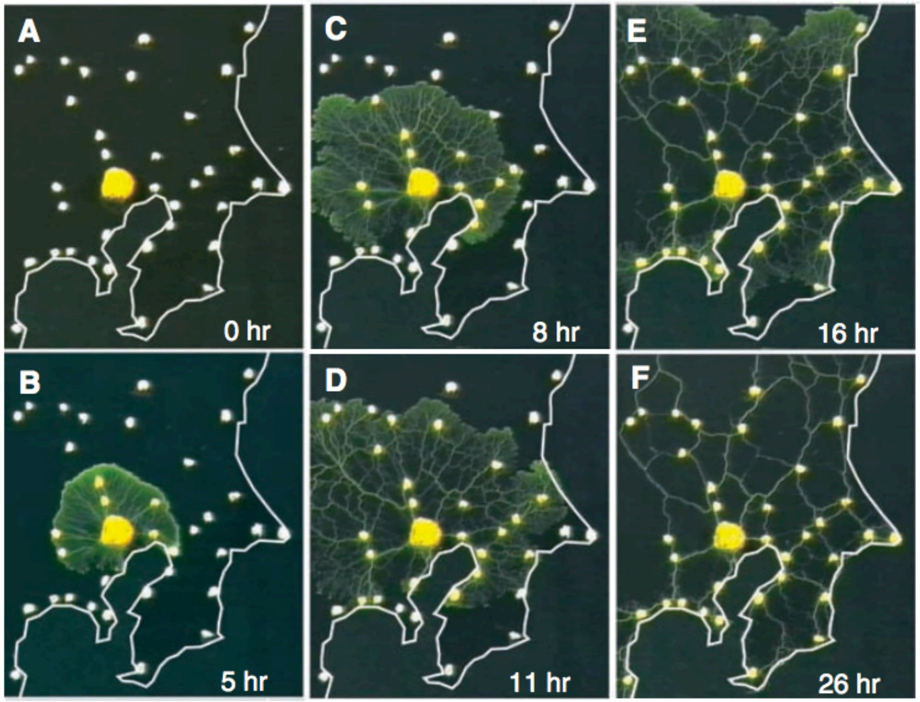
Results: Shortest Path (2000)

- Nakagaki, Yamada, and Tóth
- Slime mold reassembled, found food sources in maze, and created shortest path network to link them



Results: Optimized Networks (2010)

- Atsushi Tero et al (including Nakagaki)
- Experimental setup similar to original shortest-path paper – but structured for real world problem: Tokyo transportation networks



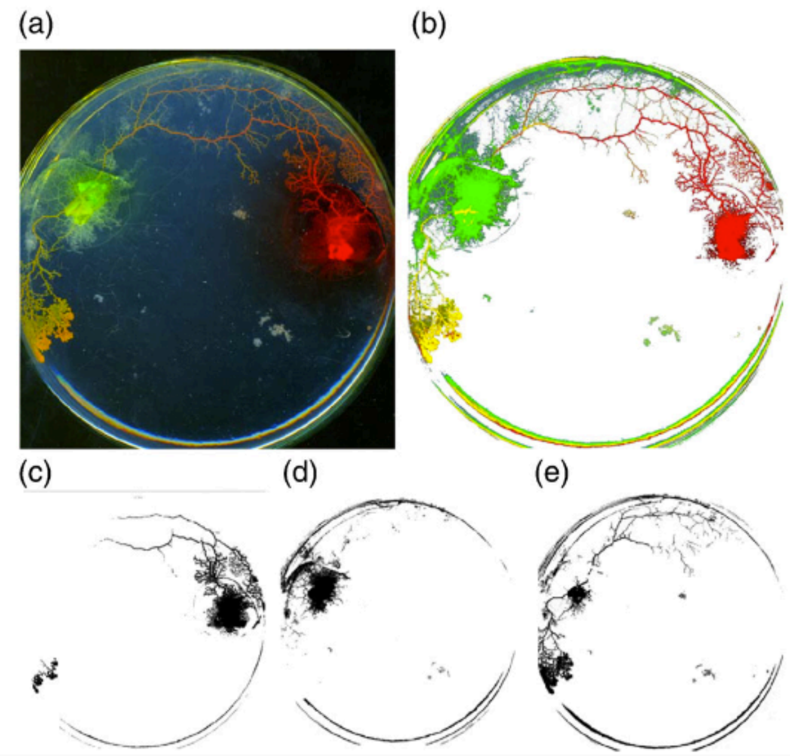
Results: Mold/Robot Hybrid (2006)

- Tsuda, Zauner, and Gunji
- Exploiting mold's sensitivity to light to control the movement of a robot through a course defined by light intensity
- Robot transmits information to slime mold; its response controls robot behavior

Results: Materials Mixing (2010)

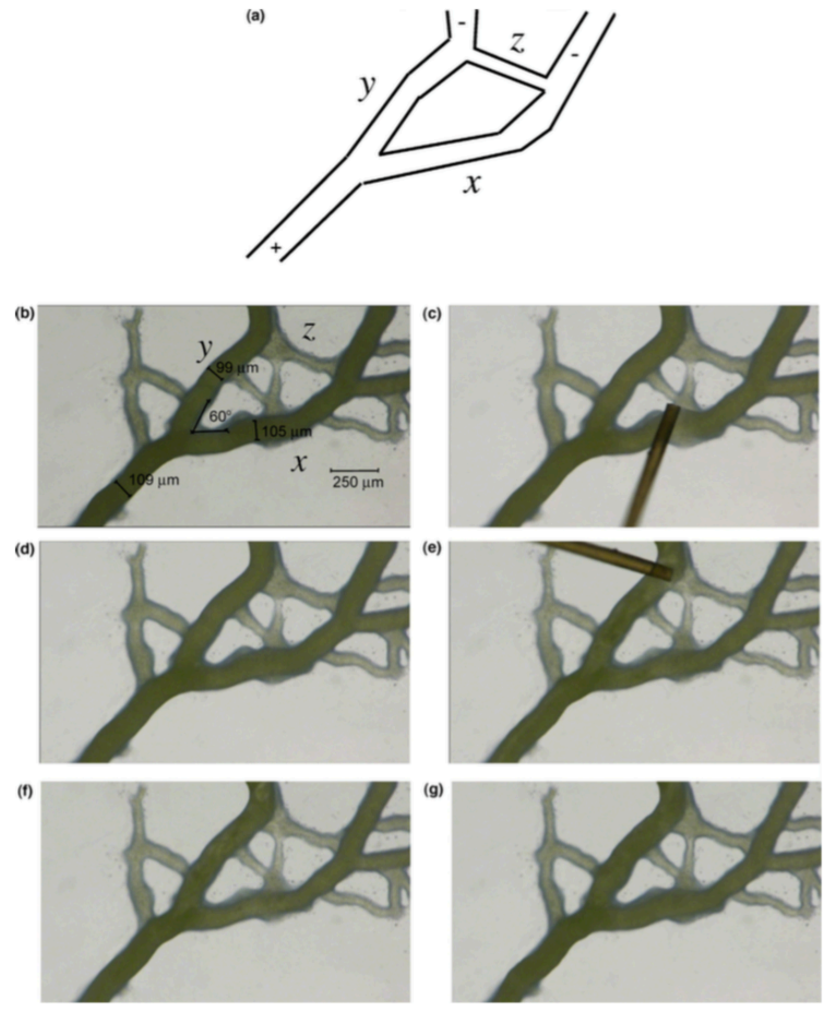
- Adamatzky

- Introduction of colored dyes into the plasmodium through food, use attractors and repellants to control transport/mixing of dyes to generate “outputs”, and other tasks



Results: Logic Gates (2014)

- Adamatzky and Schubert
- Shaped the growth of 100mcm protoplasmic tubes into desired structure for logical operations
- Mechanical stimulation required for operation



Other Results

- Microbial Fuel Cells (Taylor et al including Adamatsky, 2015)
- Mathematical models for slime mold behavior (many teams, 2004-2017)
- Reversible gates (Schumann 2017)
  - Includes Fredkin, CNOT, Toffoli

Outlook - Challenges

- Researchers attempting complex problems find mold diverges from models
- Current results cover limited set of computational problems/tasks
- More biological research required to fully understand nuances of organism's behavior

Outlook - Opportunities

- Techniques for manipulating slime mold are now mature
- Low power, small-scale systems
- Huge possibilities for certain applications
  - Medical lab-on-a-chip, biorobotics

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