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Institute for Complex Systems Simulation

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An EPSRC Doctoral Training Centre

Seth Bullock
March 18th 2009

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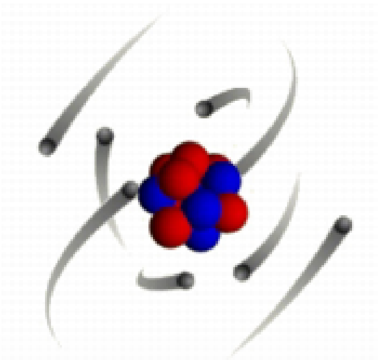
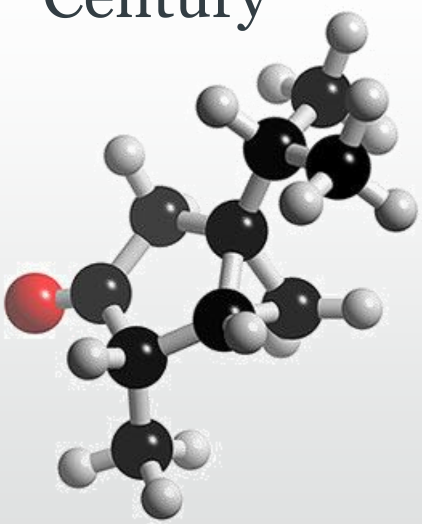
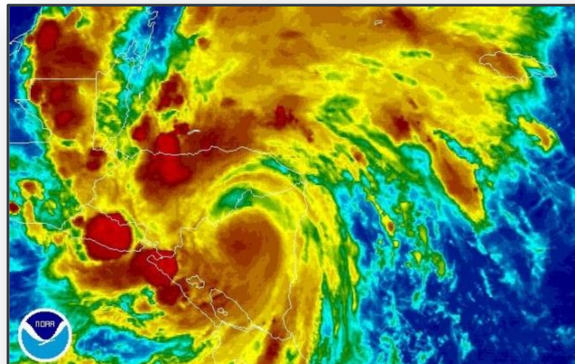
A Systemic Century

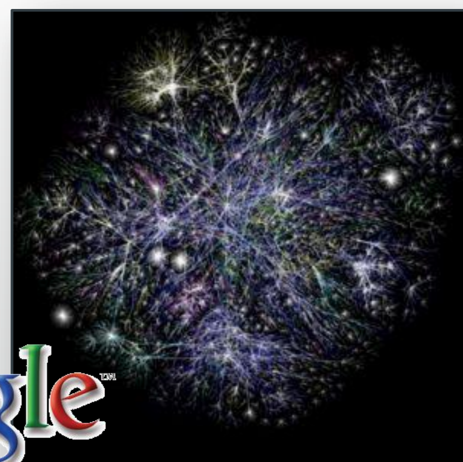


20th Century





21st Century



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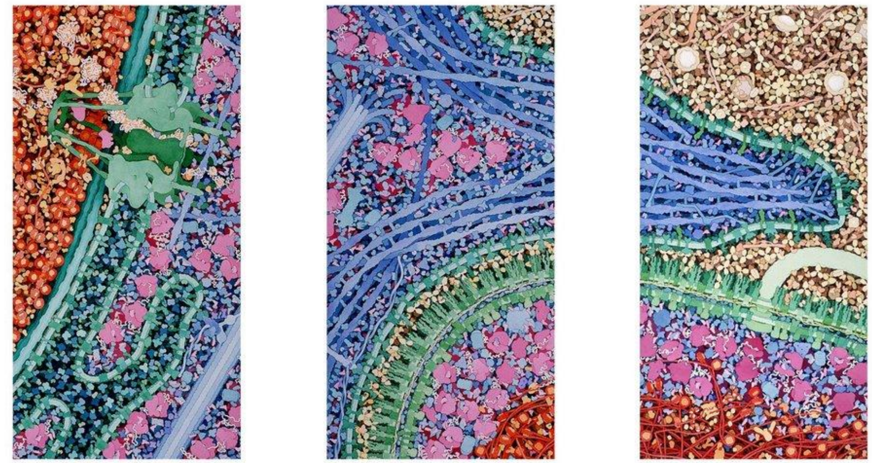
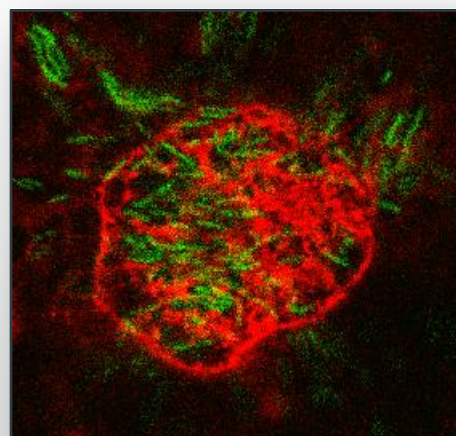
E.g., Systems Biology





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Complex Systems Science

"I think the next century will be the *century of complexity*" – Stephen Hawkins.

The Orthodoxy: Reductionism…

- isolate parts and understand them separately
- systems are typically the sum of these parts

Complex Systems Science:

- consider parts together and in place
- aggregation is not merely "summing"

Target: *understanding system organisation*

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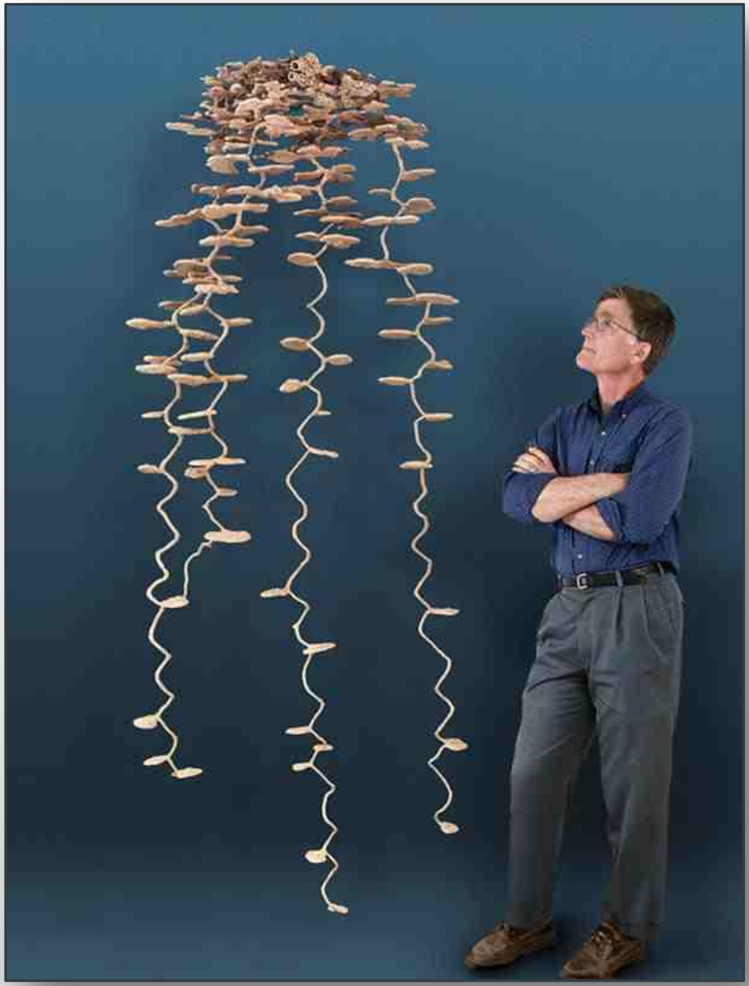
Complex Systems Science



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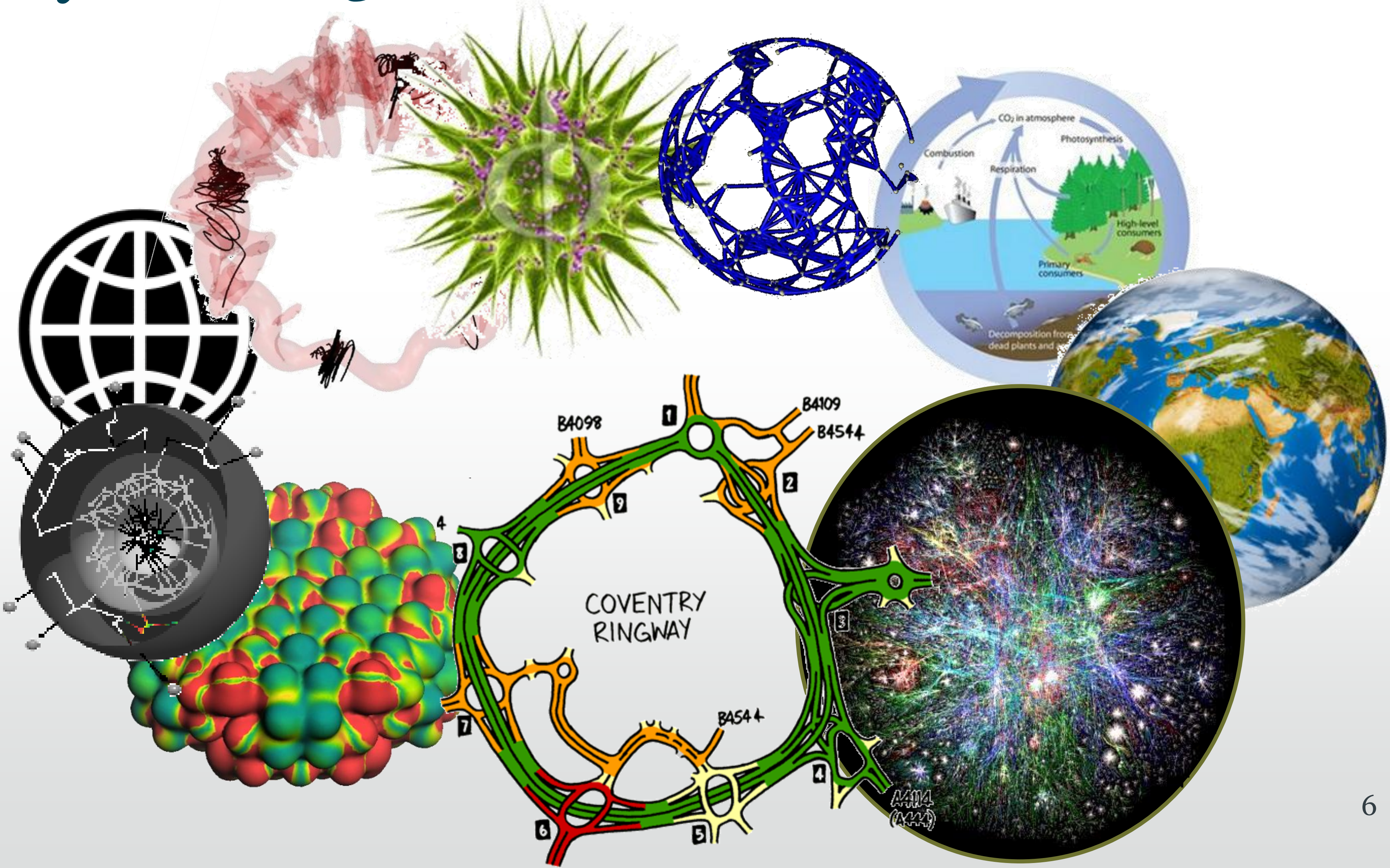
Systemic Questions



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The Synthetic Method

...perhaps inside a computer.

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"Artificial Worlds"?

Increasingly, science is being carried out within larger and more complex "artificial worlds".

- *Micro-simulated Traffic*: "a better, and 'purer', representation of actual driver behaviour"?
- *In silico Oncology*: "multi-scale, 4-dimensional, patient-specific computer simulation models of the biological behaviour of malignant tumours"
- *Homeland security*: in 2002 the US invested $1bn in realistically simulating battle conditions.
- + Drug Testing, Climate Change, Financial Prediction…

Should we trust them? How can we guard against *hubris*?

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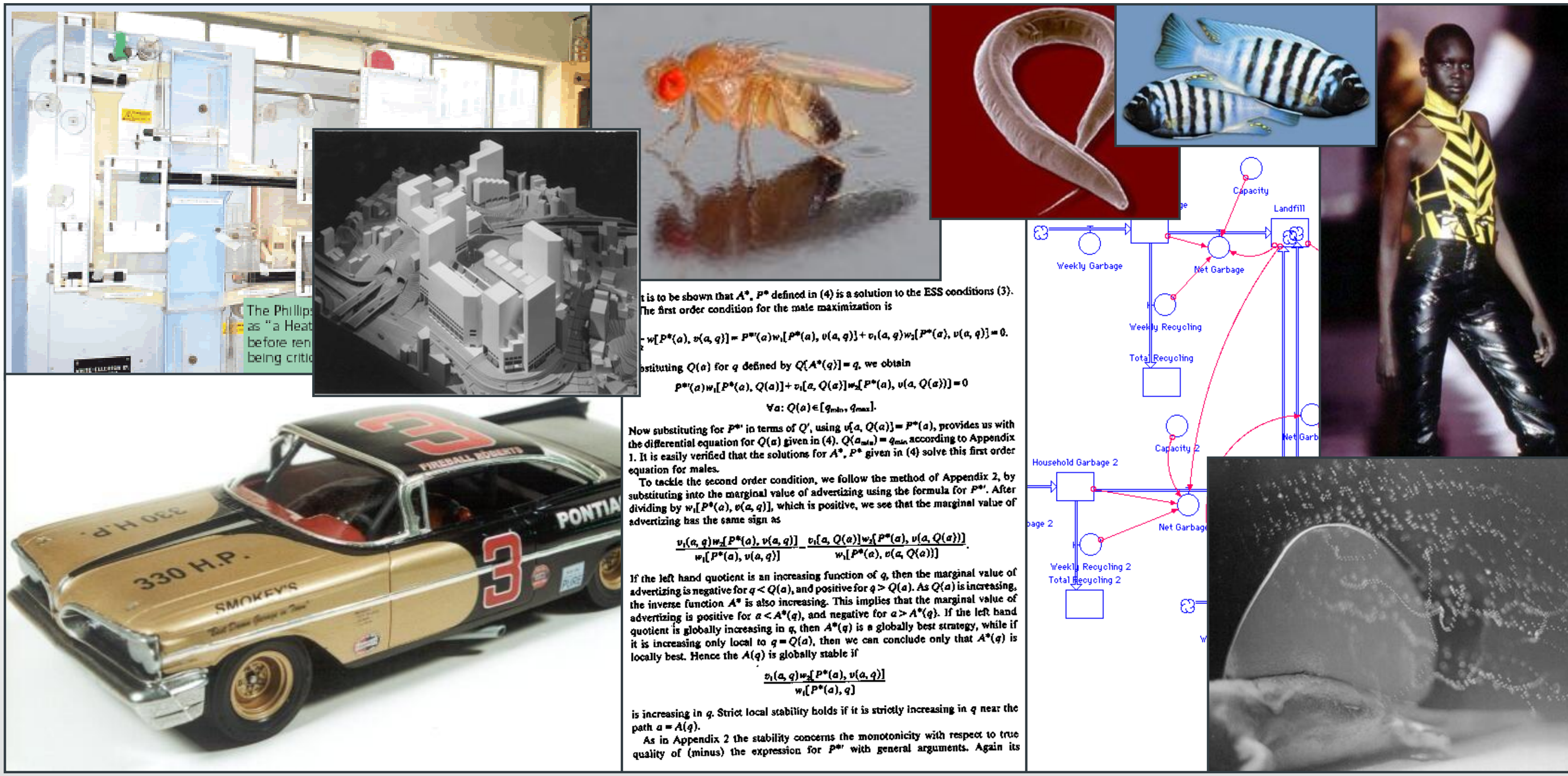
Models, models…



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ICSS

Interdisciplinary Research

EPSRC-funded PhD Programme

ECS, Engineering, Maths, Physics, Chemistry, Biology, Geography, Earth Sciences, Medicine, Civil Engineering

Airbus, BAE, BT, CCG, DfT, Eurobios, Hitachi, IBM,Met Office, MoD, Microsoft, NAG, Rolls Royce, Telecom Italia, TRL, Unilever, …

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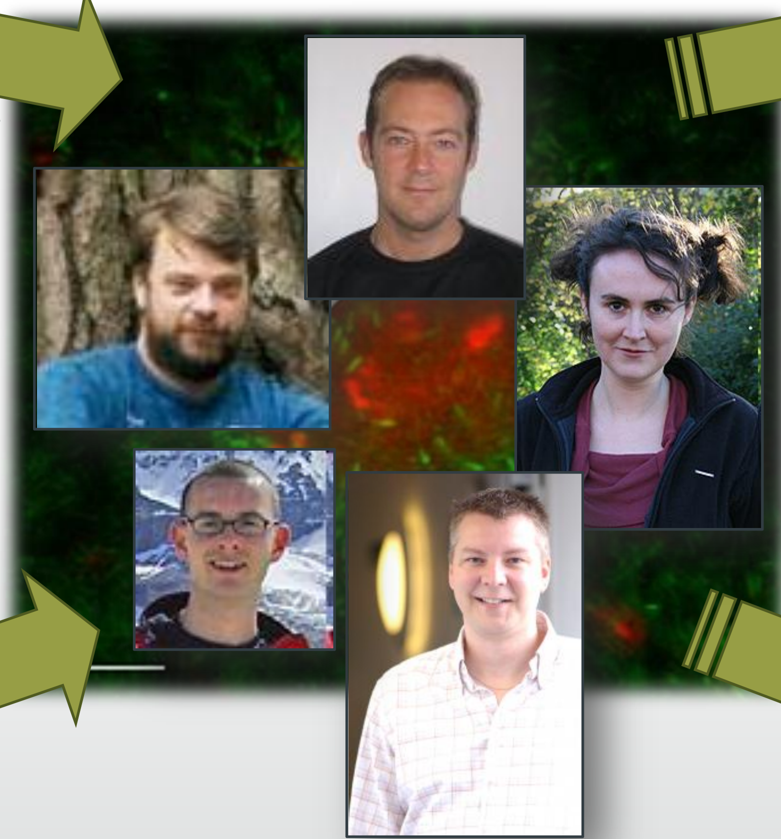
Collaborative Research: Biofilms

Experiments

Confocal Microscopy

Plasmids, DNA



Multicellularity

Self-organisation

Major Evolutionary Transitions

Theoretical Biology

Simulation

Complexity Science

Maths

Climate Processes

MRSA

Bioremediation

Biofuels

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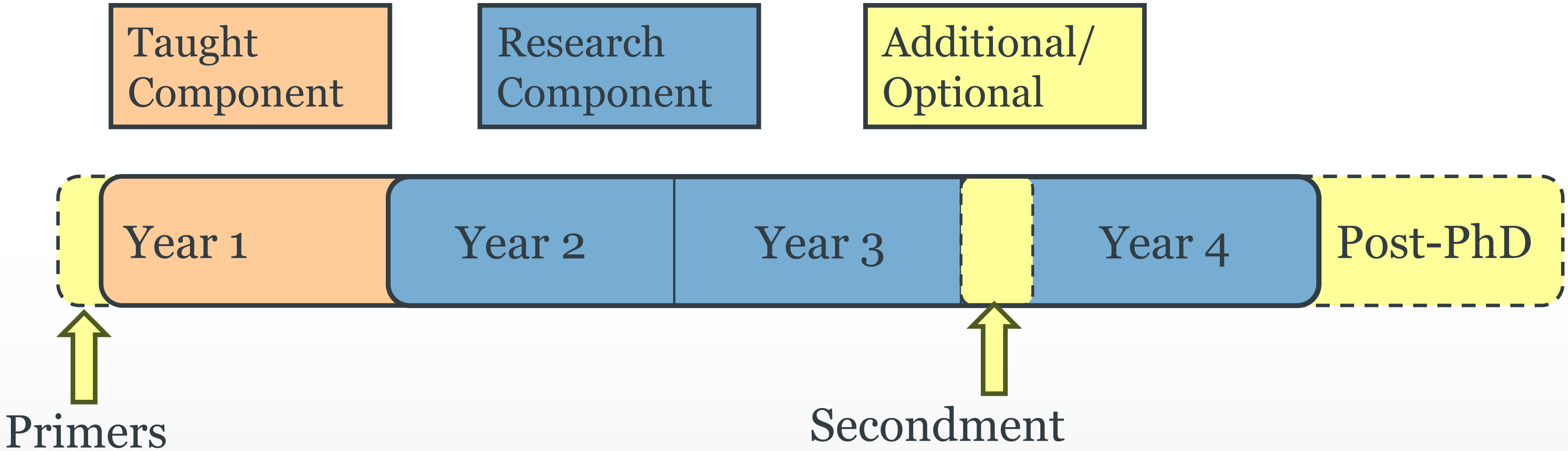
PhD Programme



- 4-year programme: taught training in skills, concepts, tools…
- …followed by three years of doctoral research
- £16k stipend, industrial secondments, follow-on fellowships
- 20 students per year for the next five years

Breadth

Core: Complexity, Mathematics, Simulation

Physical Systems: Quantum Chromodynamics, Turbulence, Functional Nanodevices

Biological Systems: Evolution and Ecology, Biomedical Systems, Biomolecular Organisation, Nanoscale Assemblies

Environmental Systems: Climate, Transport, Ecosystems

Socio-Technological Systems: Value-Driven Design, Pervasive Computing, Massive Multi-Agent Systems

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Depth

- 60+ Academics … from across 10 UoS Schools
- Menu of 40 taught module options
  - From *Climate Dynamics* to *Advanced Quantum Physics*
- 100+ PhD Titles
  - dynamic road pricing, viral self-assembly, models of wound healing, biodiversity, dragonfly-inspired UAVs, open information systems, RNA computing, heart-rate variability, gene therapy vectors, spintronic nanostructures, 3D biomimetic structures, sustainability
- 20+ External Partners
  - including multinationals and SMEs from across multiple sectors, boutique complexity companies, and government departments.

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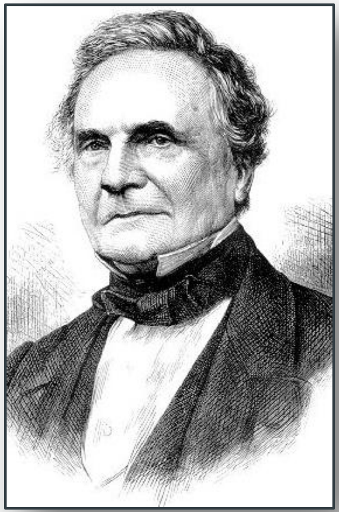
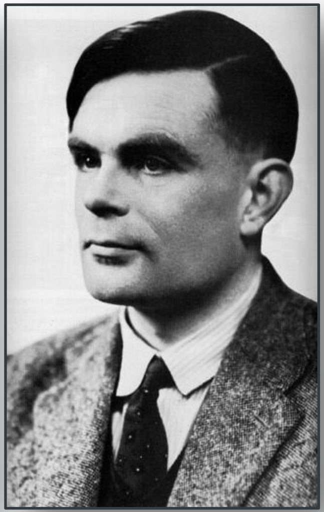
From Toys to Tools

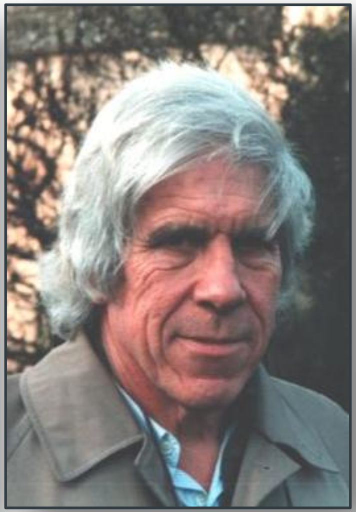


Babbage
(1791-1871)

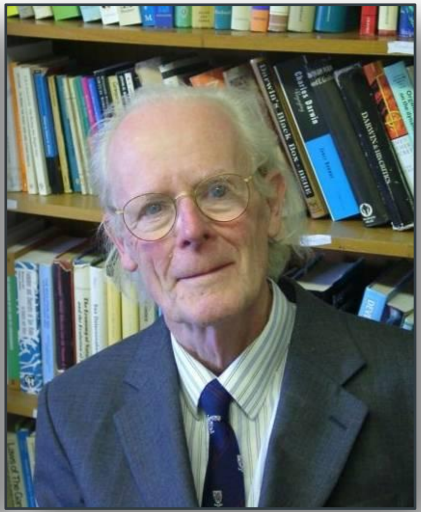


Turing
(1912-1954)

Von Neumann
(1903-1957)



Hamilton
(1936-2000)



Maynard Smith
(1920-2004)

Thankyou

ICSS