


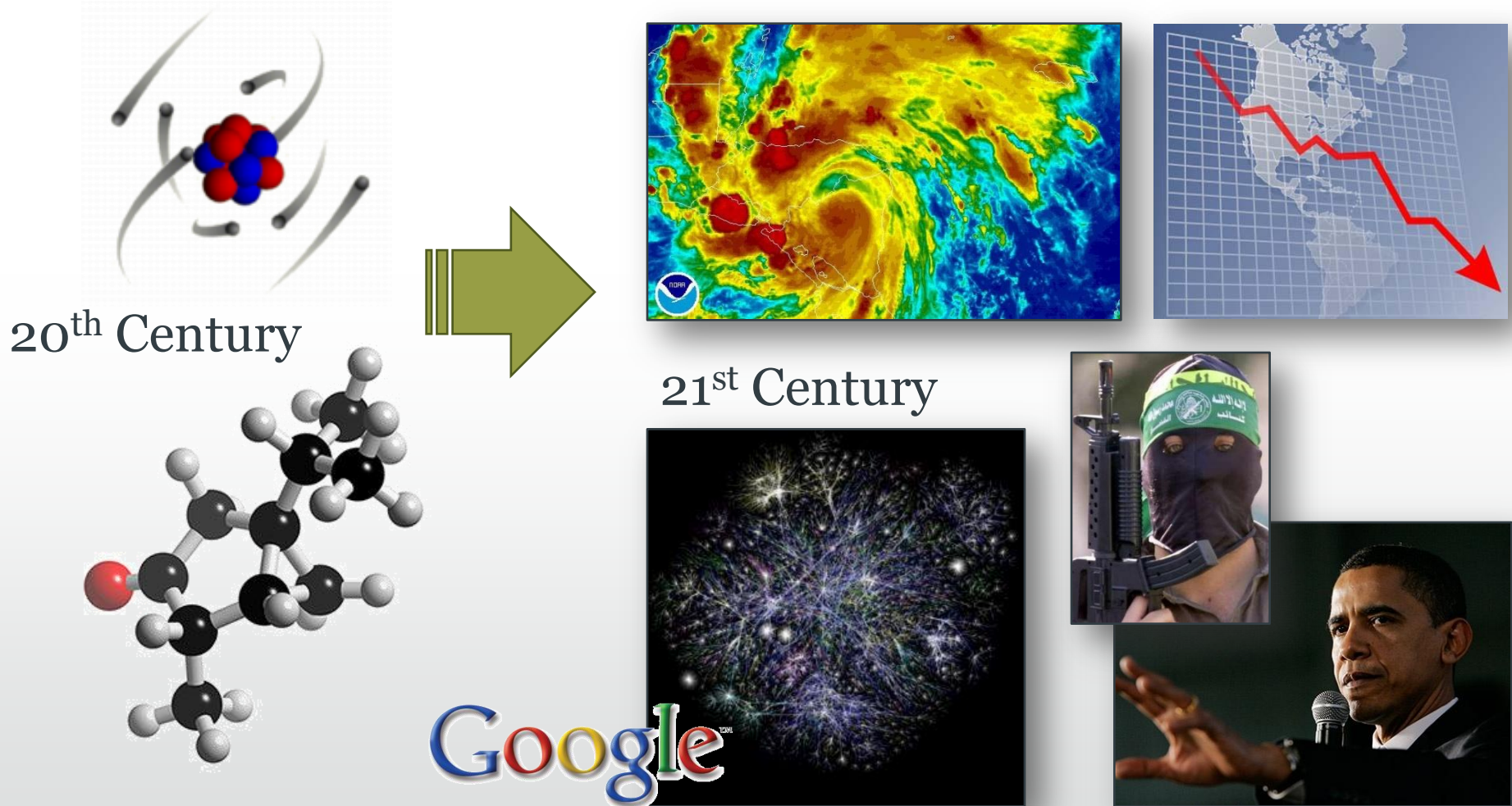
Institute for Complex Systems Simulation

An EPSRC Doctoral Training Centre

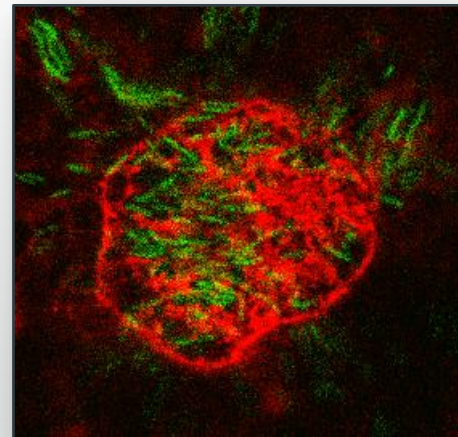
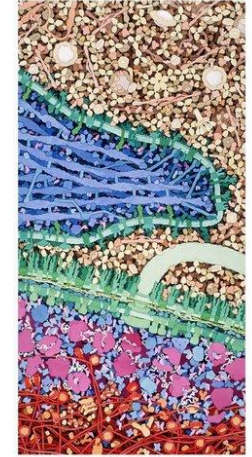
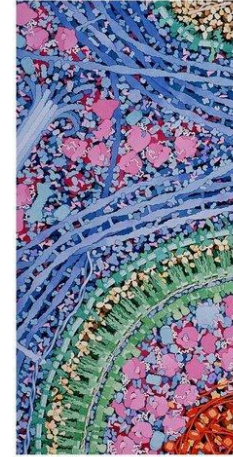
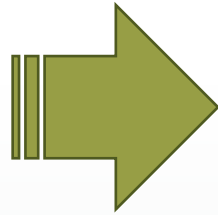
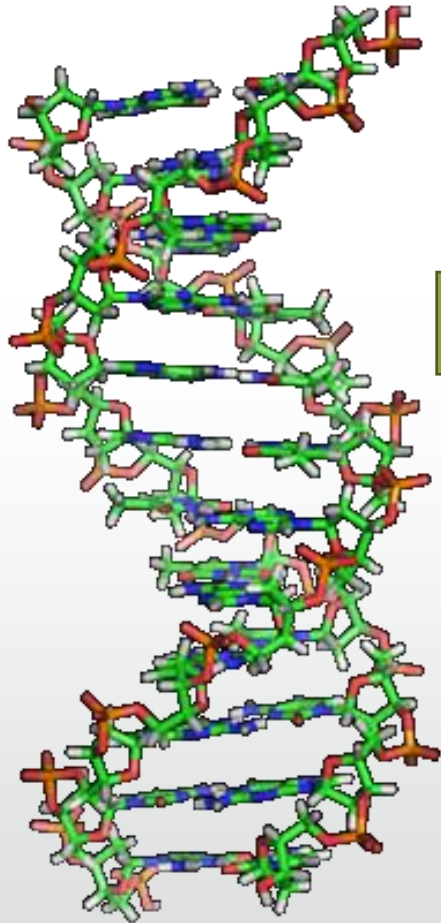
Seth Bullock
March 18th 2009

Institute for Complex
Systems Simulation 

A Systemic Century



E.g., Systems Biology



Complex Systems Science

“I think the next century will be the
century of complexity”
– Stephen Hawkins.

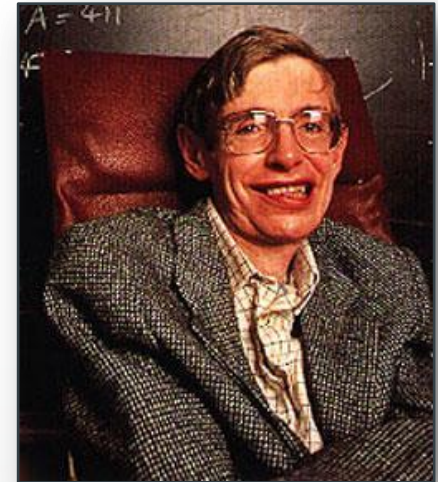
The Orthodoxy: Reductionism...

- 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”

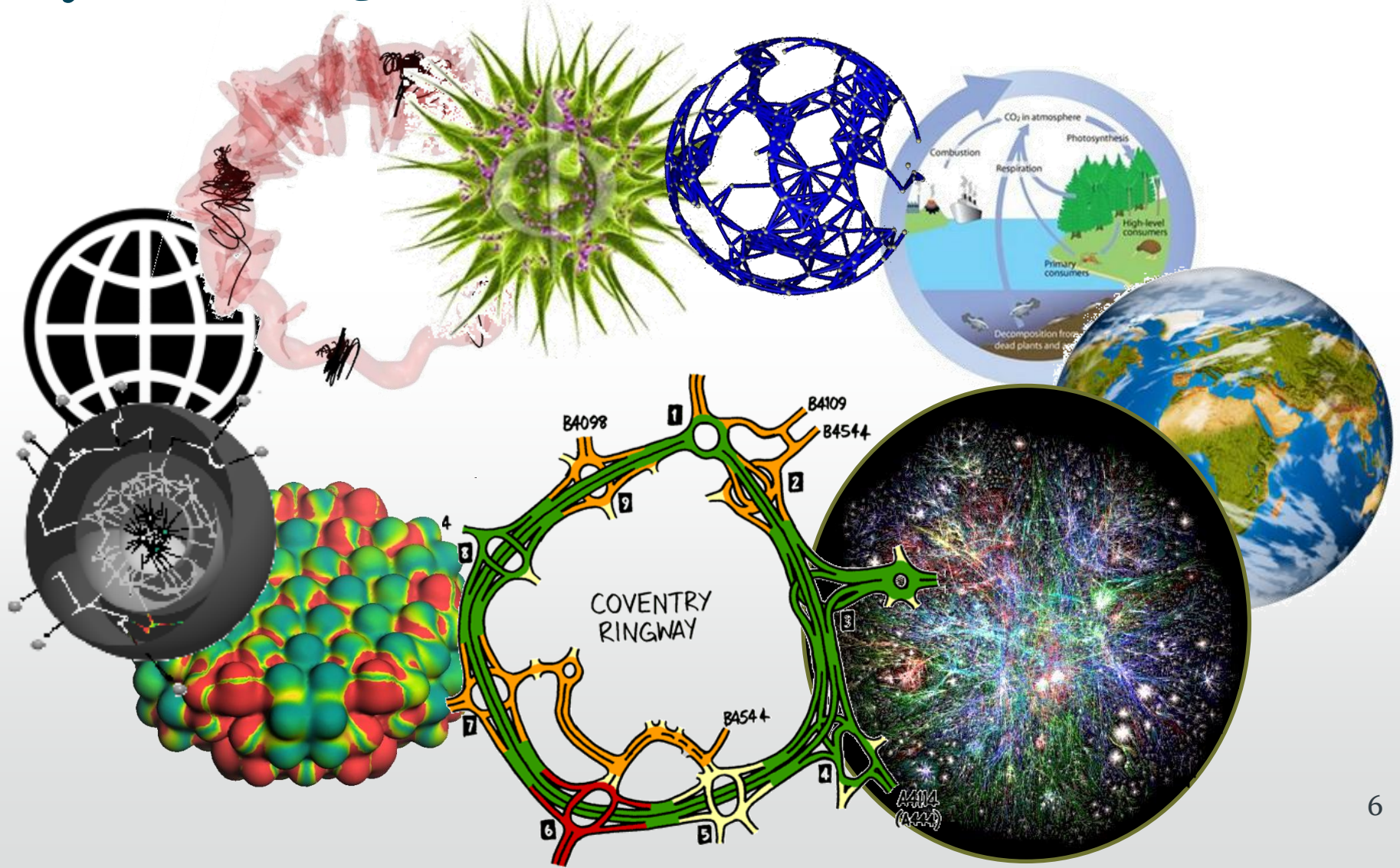
Target: *understanding system organisation*



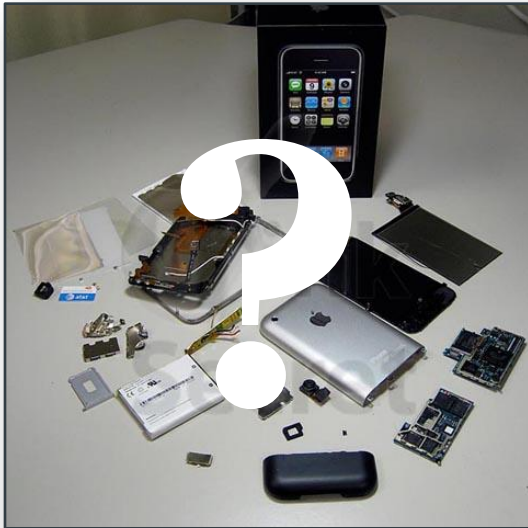
Complex Systems Science



Systemic Questions



The Synthetic Method



...perhaps inside a computer.



“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...**

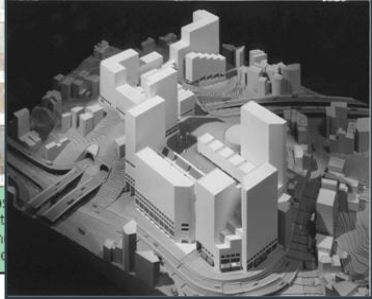



Should we trust them? How can we guard against *hubris*?


Models, models...





The Phillip as "a Heat before ren being criti














It is to be shown that A^*, P^* defined in (4) is a solution to the ESS conditions (3). The first order condition for the male maximization is

$$-w[P^*(a), v(a, q)] = P^{**}(a)w[P^*(a), v(a, q)] + v_1(a, q)w_1[P^*(a), v(a, q)] = 0.$$

posituting $Q(a)$ for q defined by $Q[A^*(q)] = q$, we obtain

$$P^{**}(a)w_1[P^*(a), Q(a)] + v_1[a, Q(a)]w_1[P^*(a), v(a, Q(a))] = 0$$

$\forall a: Q(a) \in [q_{min}, q_{max}]$.

Now substituting for P^{**} in terms of Q' , using $v_1(a, Q(a)) = P^{**}(a)$, provides us with the differential equation for $Q(a)$ given in (4). $Q'(a_{max}) = q_{min}$, according to Appendix 1. It is easily verified that the solutions for A^*, P^* given in (4) solve this first order equation for males.

To tackle the second order condition, we follow the method of Appendix 2, by substituting into the marginal value of advertizing using the formula for P^{**} . After dividing by $w_1[P^*(a), v(a, q)]$, which is positive, we see that the marginal value of advertizing has the same sign as

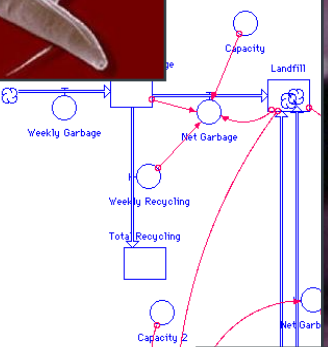
$$\frac{v_1(a, q)w_1[P^*(a), v(a, q)]}{w_1[P^*(a), v(a, q)]} - \frac{v_1[a, Q(a)]w_1[P^*(a), v(a, Q(a))]}{w_1[P^*(a), v(a, q)]}$$


If the left hand quotient is an increasing function of q , then the marginal value of advertizing is negative for $q < Q(a)$, and positive for $q > Q(a)$. As $Q(a)$ is increasing, the inverse function A^* is also increasing. This implies that the marginal value of advertizing is positive for $a < A^*(q)$, and negative for $a > A^*(q)$. If the left hand quotient is globally increasing in q , then $A^*(q)$ is a globally best strategy, while if it is increasing only local to $q = Q(a)$, then we can conclude only that $A^*(q)$ is locally best. Hence the $A(q)$ is globally stable if

$$\frac{v_1(a, q)w_1[P^*(a), v(a, q)]}{w_1[P^*(a), v(a, q)]}$$

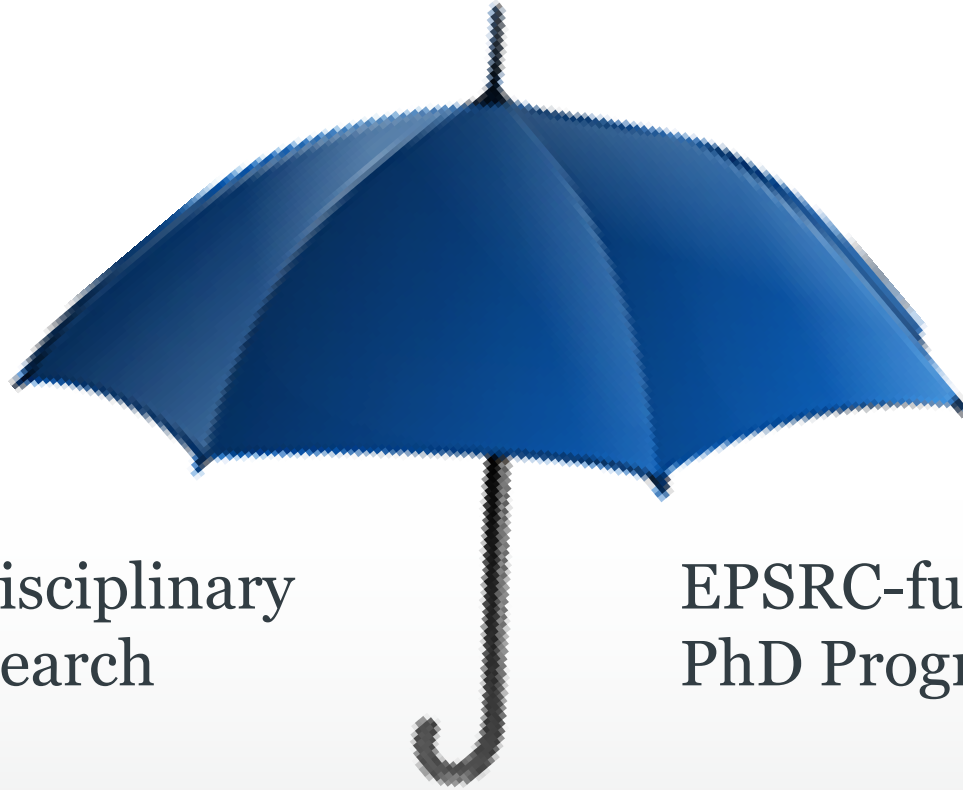
is increasing in q . Strict local stability holds if it is strictly increasing in q near the path $a = A(q)$.

As in Appendix 2 the stability concerns the monotonicity with respect to true quality of (minus) the expression for P^{**} with general arguments. Again its





ICSS



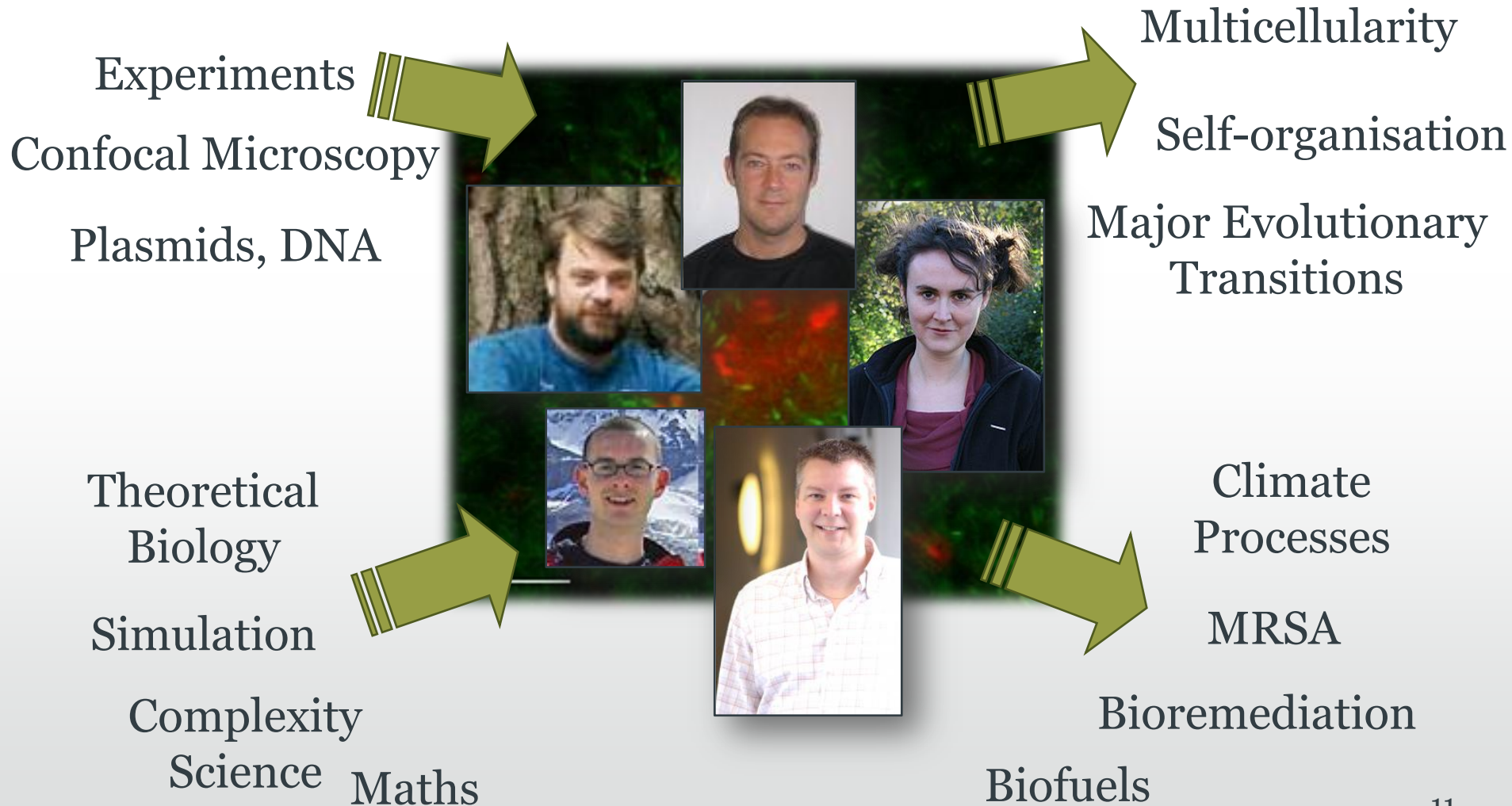
Interdisciplinary
Research

EPSRC-funded
PhD Programme

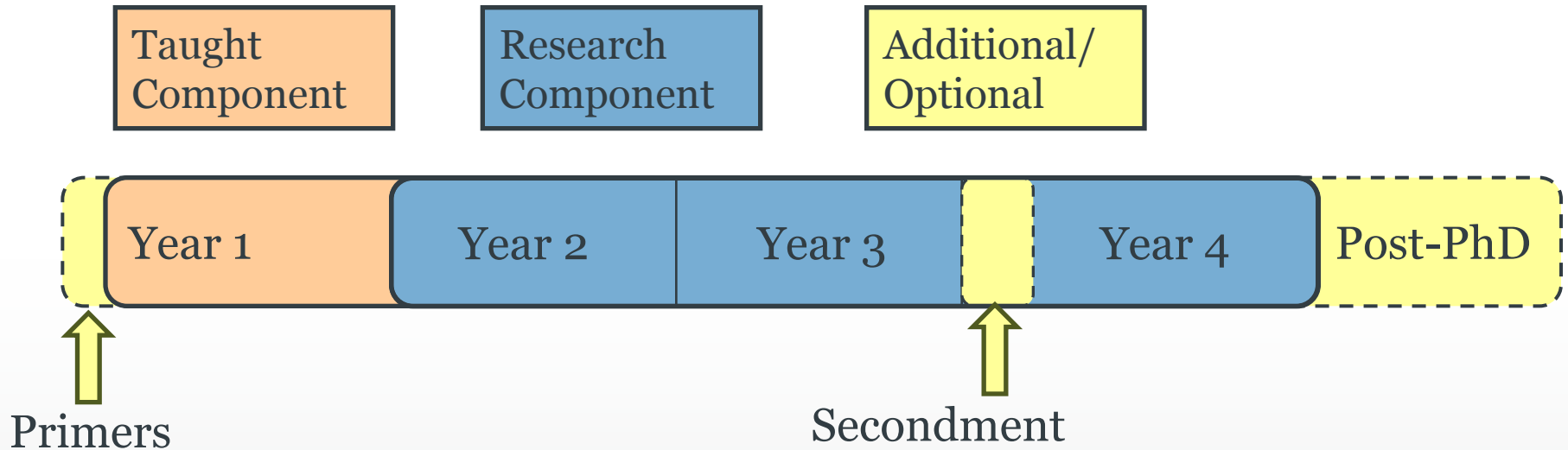
ECS, Engineering, Maths, Physics, Chemistry, Biology,
Geography, Earth Sciences, Medicine, Civil Engineering

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

Collaborative Research: Biofilms



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

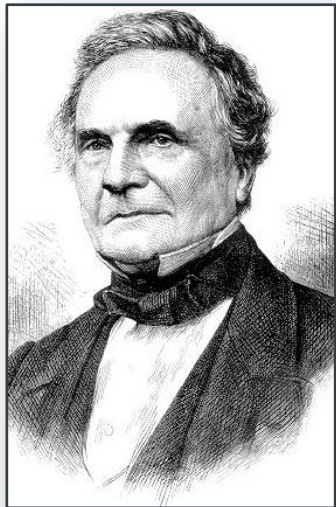
Environmental Systems: Climate, Transport, Ecosystems

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

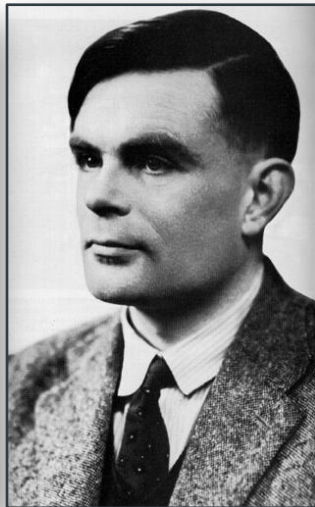
Depth

- 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.

From Toys to Tools



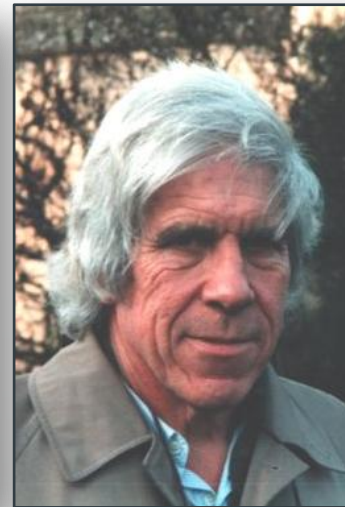
Babbage
(1791-1871)



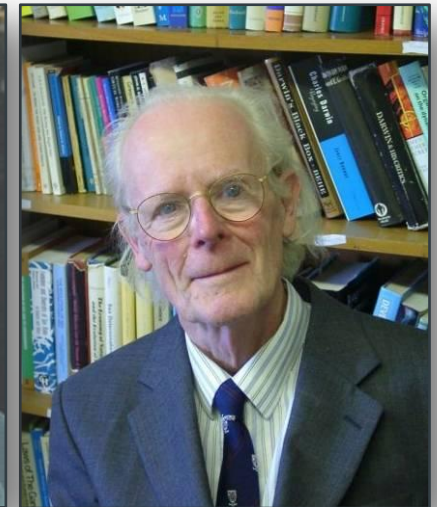
Turing
(1912-1954)



Von Neumann
(1903-1957)



Hamilton
(1936-2000)



Maynard Smith
(1920-2004)

Thankyou

ICSS The logo consists of four black corner brackets arranged in a square pattern, with the top-left and bottom-right corners pointing outwards, and the top-right and bottom-left corners pointing inwards.

