Solving Complex Problems at YCCSA

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today's schedule

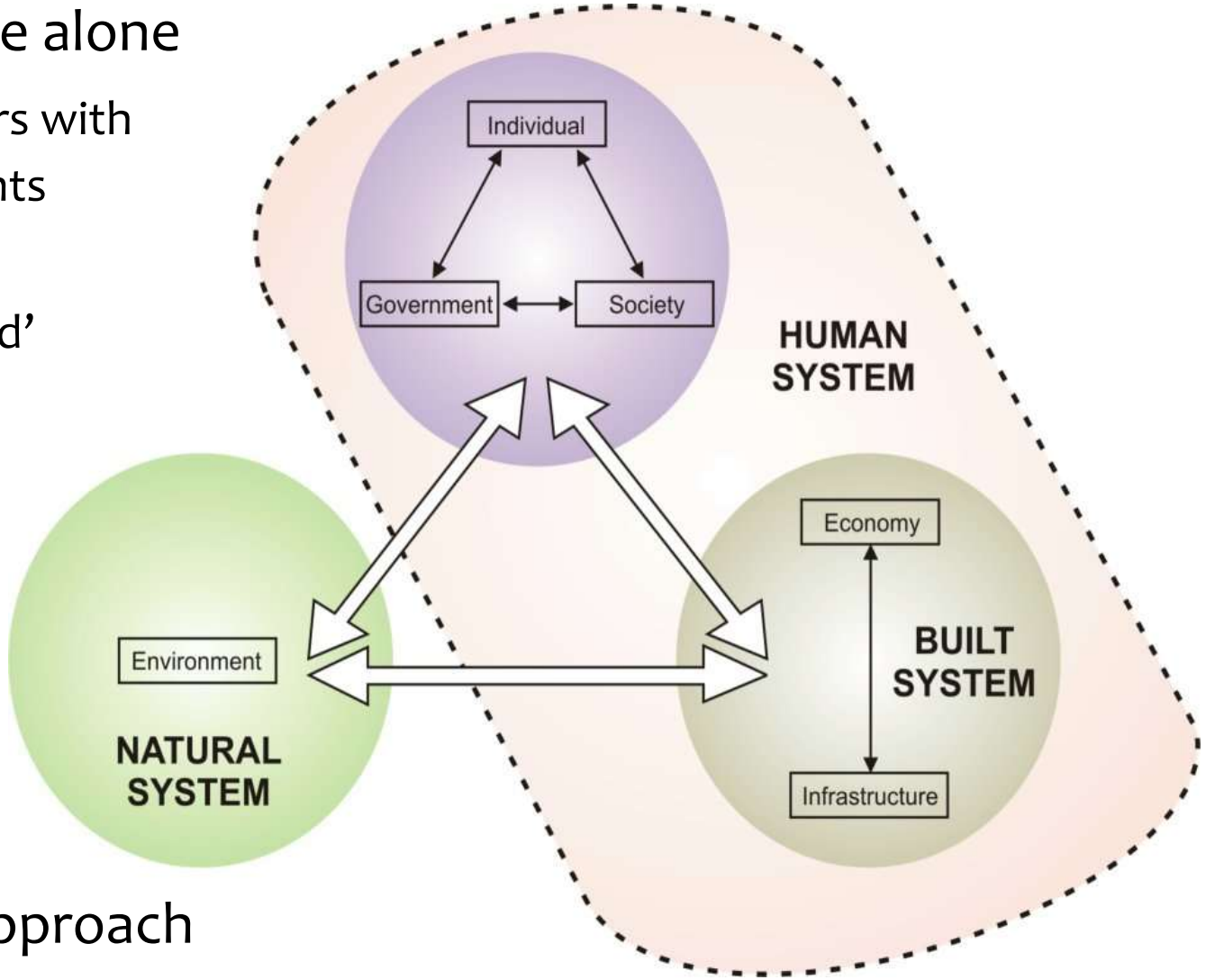
- 10:40–12:15 YCCSA case studies
  - Introduction to YCCSA
  - Using maths to attack viruses
  - How killer whales use Facebook
  - How to vaccinate a robot
- 12:15–13:00 Keynote address
  - Heather Dunlop-Jones, IBM Chief Technology Officer, and Distinguished Engineer
- 13:00–14:00 Lunch
- 14:00–16:00 YCCSA Exhibition
  - posters ; demonstrations ; 3Sixty exhibition ; Robot Lab tours
  - Research Innovation Office

Systems, and Complex Systems

- system
  - *a **set** of **interacting components** and **relationships**, forming an **integrated whole***
  - *has both **structure** and **behaviour***
- complex system : a system exhibiting properties such as:
  - self-organisation
  - growth and evolution
  - heterogeneous mix of networks and hierarchies
  - local interactions resulting in global behaviour
  - emergence and innovation
  - “edge of chaos”
  - …

Interdisciplinary Research

- a ***complex problem*** cannot be tackled by a single discipline alone
  - multiple stakeholders with differing requirements and goals
  - 'soft' social and 'hard' technical issues
  - issues from multiple natural and engineered domains
- it requires an ***interdisciplinary***, ***complex systems*** approach



Interdisciplinary Research

- the big problems facing us today are all complex
  - climate change – pandemics – food and water security …
- and so are most of the interesting "smaller" problems
  - socio-technical systems – global supply chains – drug design – smart infrastructure – ecosystem management – exploiting big data – managing system change – designing in resilience and adaptability …

YCCSA

- York Centre for Complex Systems Analysis
  - 2004: established as a virtual collaboration
  - 2005: accommodation for ~30 researchers
  - 2008: £370k "Bridging the Gaps" TRANSIT funding
  - 2010: expanded accommodation for ~70 researchers
  - 2013: currently holding ~£6M research funding

I have never seen any scientific group working so well together and where communication is flowing so effortlessly across disciplines. What you have is truly remarkable.

— Dr Paolo Dini, Senior Research Fellow,
Dept Media and Communications,
London School of Economics

YCCSA

- we focus on complex interdisciplinary problems

- "***The world has problems while universities have disciplines***"

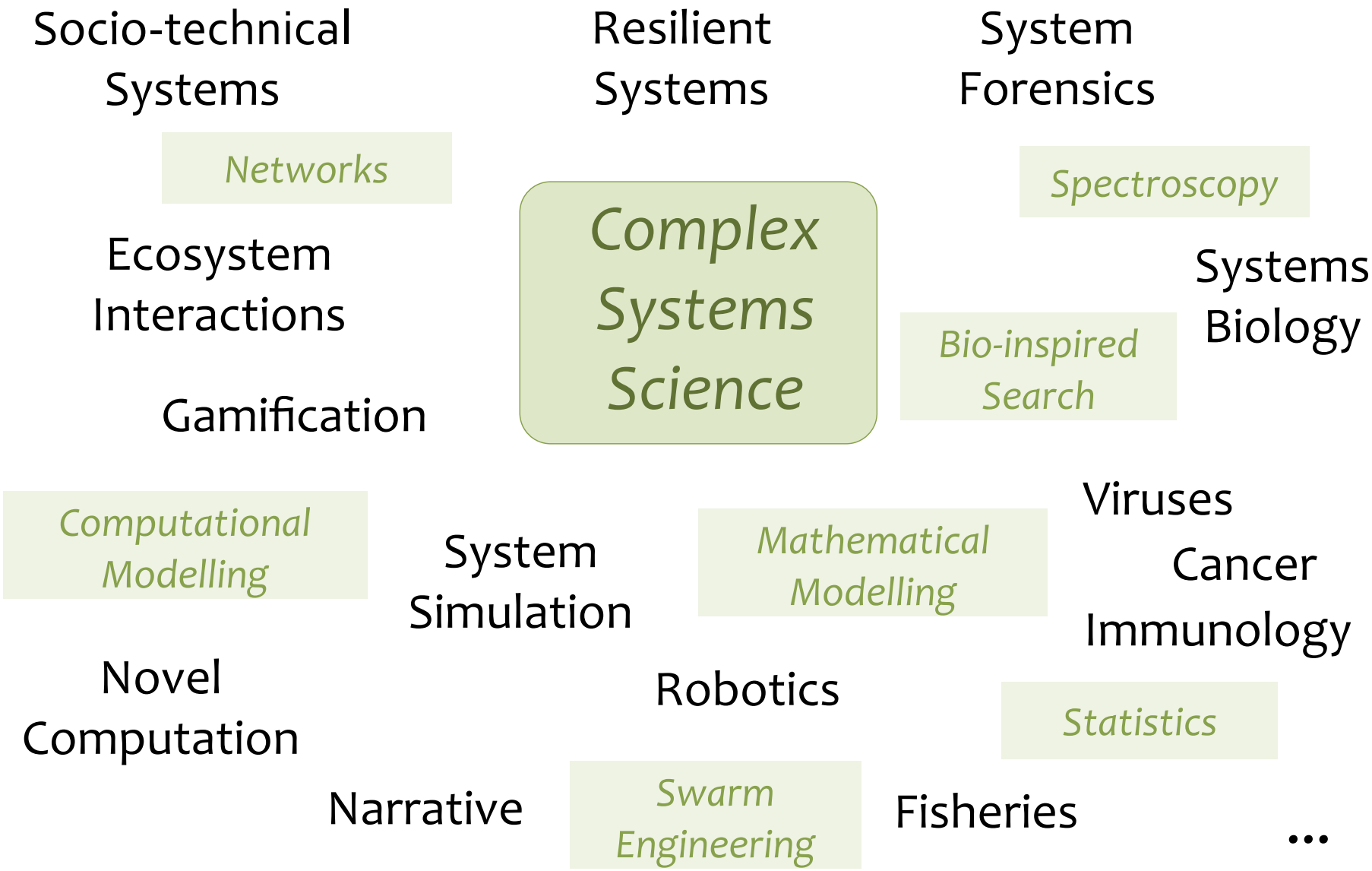
- we are an **interdisciplinary** team of 90+ researchers from a wide range of departments :
  - Biology – Chemistry – Computer Science – Electronics – English – Environment – History of Art – Management – Mathematics – Physics …

- we have associate members from other universities :
  - Birmingham – Cambridge – Durham – Madrid – Manchester – Oxford – Warwick …

YCCSA

- we have a range of industrial, government, and NGO partners

YCCSA problem domains, and tools



YCCSA's approach

- for YCCSA, ***interdisciplinarity is a way of life***
- our process for building trust and respect
  - **coming together**
    - learning each others' languages and culture
      - seminars, reading groups, workshops, …
  - **thinking together**
    - learning the system domain
    - pump priming feasibility studies
  - **working together**
    - delivering more than the sum of its parts
    - research projects
      - co-supervising students across disciplines
    - development projects

getting involved

- research summer school projects : 10 weeks
  - ~ 10 bright undergraduates from around UK and Europe
- Masters projects : 3–6 months
  - from Autonomous Robotics to Computational Biology
  - Interdisciplinary Science
- PhD projects : 3–4 years
  - CASE studentships
  - new EPSRC-funded Centre for Doctoral Training : "Intelligent Games & Game Intelligence" (IGGI)
- knowledge transfer partnerships (KTPs) : 1–3 years
- bespoke consultancy

exemplar projects

- Prof Reidun Twarock (Biology/Maths)
  - **Using maths to attack viruses**
    - using mathematical modelling and symmetry to identify weaknesses in viruses

- Dr Dan Franks (Biology/Computer Science)
  - **How killer whales use Facebook**
    - using network analysis and modelling to gain insight into animal societies

- Prof Jon Timmis (Electronics)
  - **How to vaccinate a robot**
    - taking inspiration from the immune system to develop anomaly detection and self-repairing systems