the cell project
modelling and simulation of stem cells between art and science

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CELL Team

- Mark d’Inverno, agent-based systems, formal modelling
- Jane Prophet, visual artist
- Neil These, liver pathologist, stem cell research
- Pete Ride, curator
- Rob Saunders, A-life programmer

background to our project

- interdisciplinary project
- stem cells
- new experimental findings
- Theise’s (now others) paradigm shift
- process-based research
  - no goals; money to exchange ideas
  - all come together first and then …

different outputs

- art outputs and exhibitions
- research papers
  - medical, cs, mathematical biology, cross-disc
- mathematical model
  - express current and new theories
- agent-based simulation that’s strongly linked to model
  - functional programming language (erlang)
- new project to build a software tool
  - researchers, students, general public

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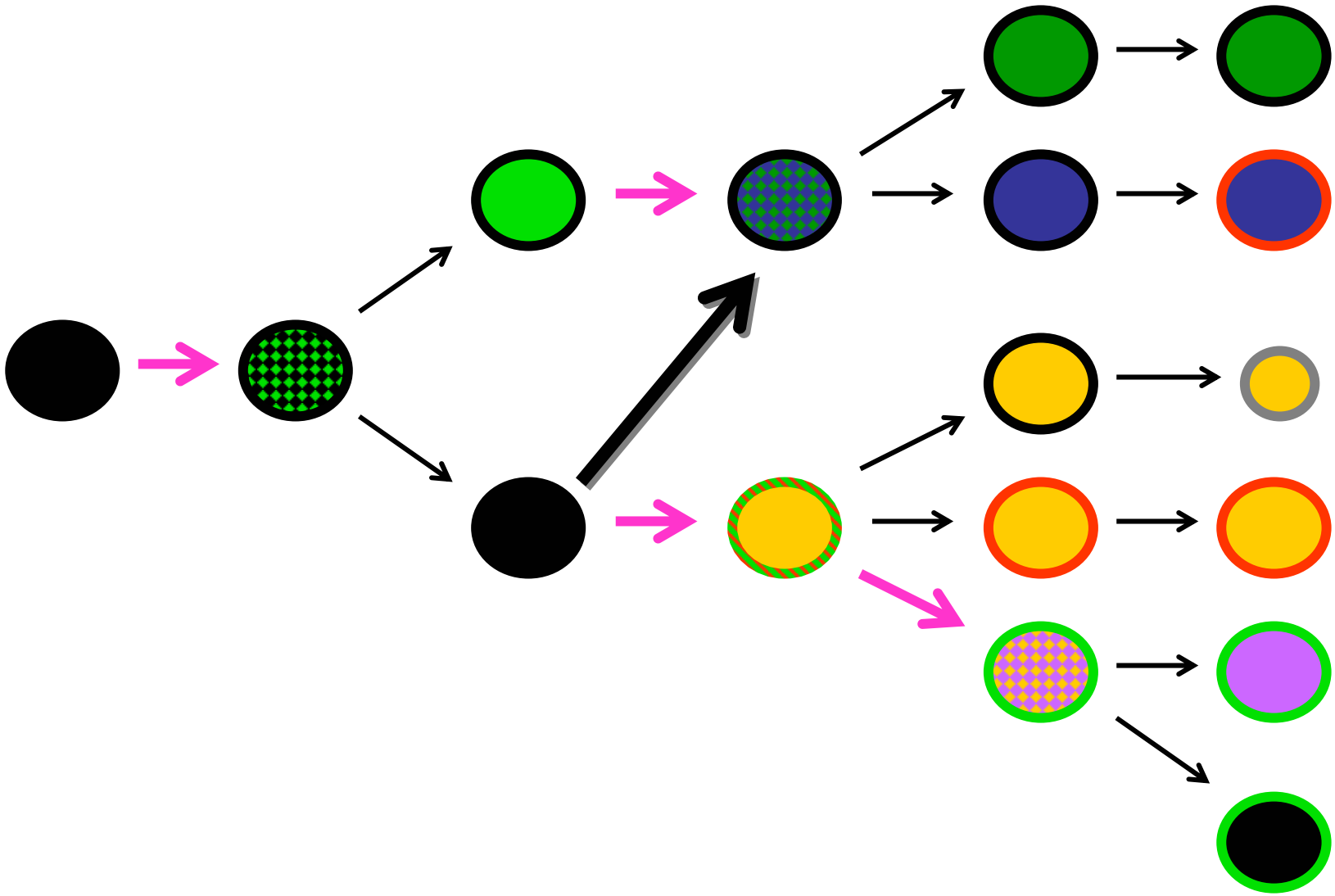

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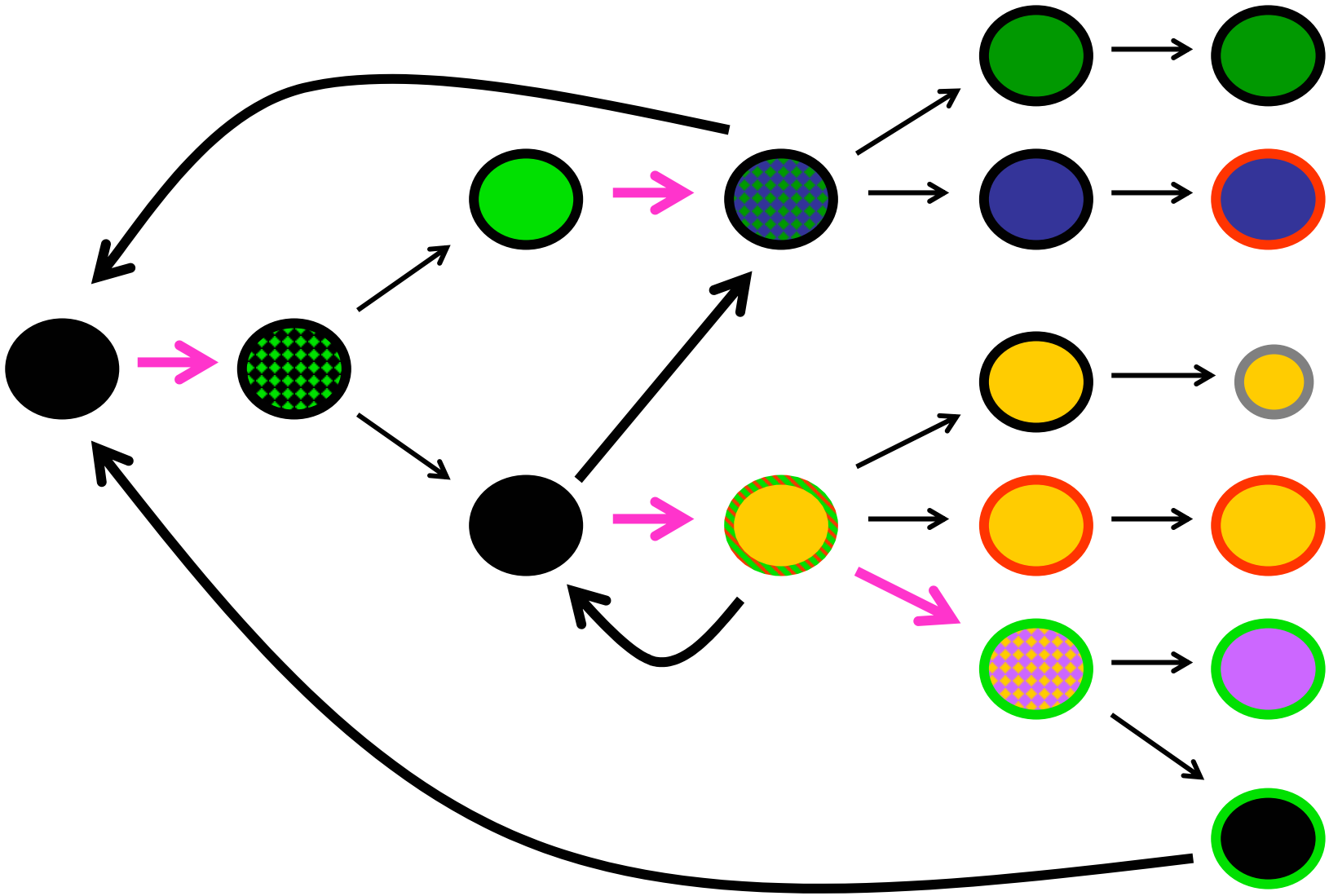

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levels of agency

inhabits an environment

- it can act so as to change this environment
- the environment affects what it does
- might perceive, possibly to notice this change

weaker view

- reflexive – environment dictates
- state – environment and internal agent state
- goal – implicit, ascribed

stronger view

- goal – it's now symbolic, proactive, selects perception
- intentional – sophisticated symbolic representation & manipulation

social view

- can't have a single agent system
- models others, cooperation, communication, social rules and laws

complex adaptive systems

- we require (emergence of?) global behaviour
  - dynamic equilibriums
  - constant number of cells
  - constant production of differentiated cells of different types
  - can recover from massive perturbation (disease or injury)
  - how can we

- agents
  - what can they perceive?
  - what is there state?
  - what are there goals/strategy?
  - intention? can they signal it?
  - how can they interact?
  - what are there rules?
  - (non-deterministic) selection over competing rules

encompassing model and simulation

Journal of mathematical biology, 2003, Augur at el.

constants:
n1 time taken for a differentiated cell to leave niche.
n2 represents cycling phase of a stem cell
n3 stem cell to divide

cells (extrinsic and intrinsic)
state (a counter)
perceptual capabilities (local population)

Rule 1 for determined cells
Rule 2 for stem cells
Rule 3 for ``wholes'' which state when a new stem cell come come into existence

how can we achieve a shared understanding of a model?

language insufficient for understanding model

- common conceptual framework
  - ``getting everyone on the same page'' (KB)
- used a formal accessible mathematical model
  - link to simulation
- precise definitions of concepts, structures, state and operation
- immediate prototyping helps reflexivity
- process of simulation catalyses shared model
  - agent rules and behaviour
  - communication, interaction possibilities
  - modelling the environment
  - physics, motion, cell-division, time and space

Can and should we simulate the human body?

1. ethical (embryonic stem cells)

2. failings of the experimental

- difficult to identify cells in adult body
- even if you could you would only ever see one possible behaviour
- mechanical forces can affect behaviour
- need to kill cells to look at them
- images are heavily stained and magnified
- looking at slides in 2D

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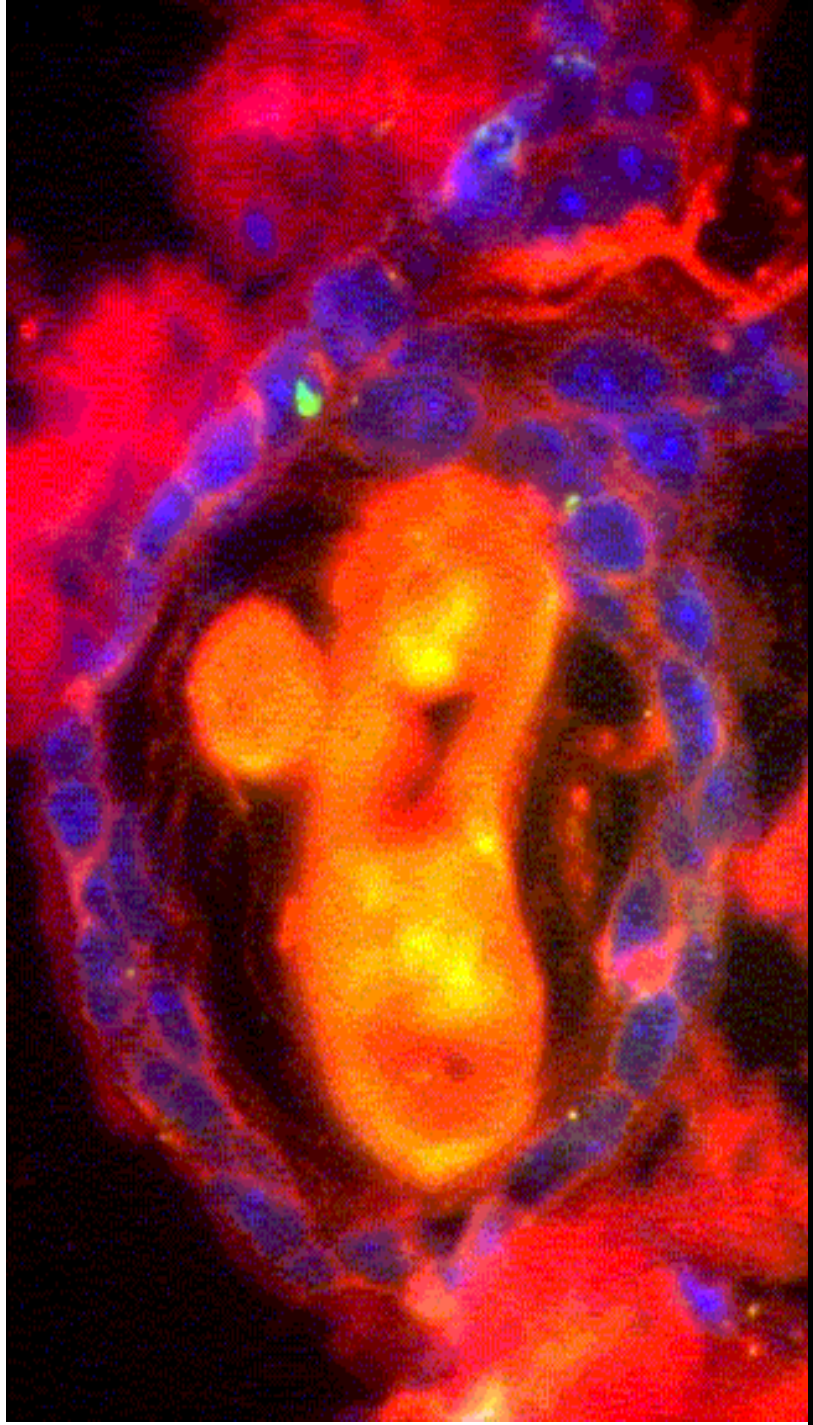

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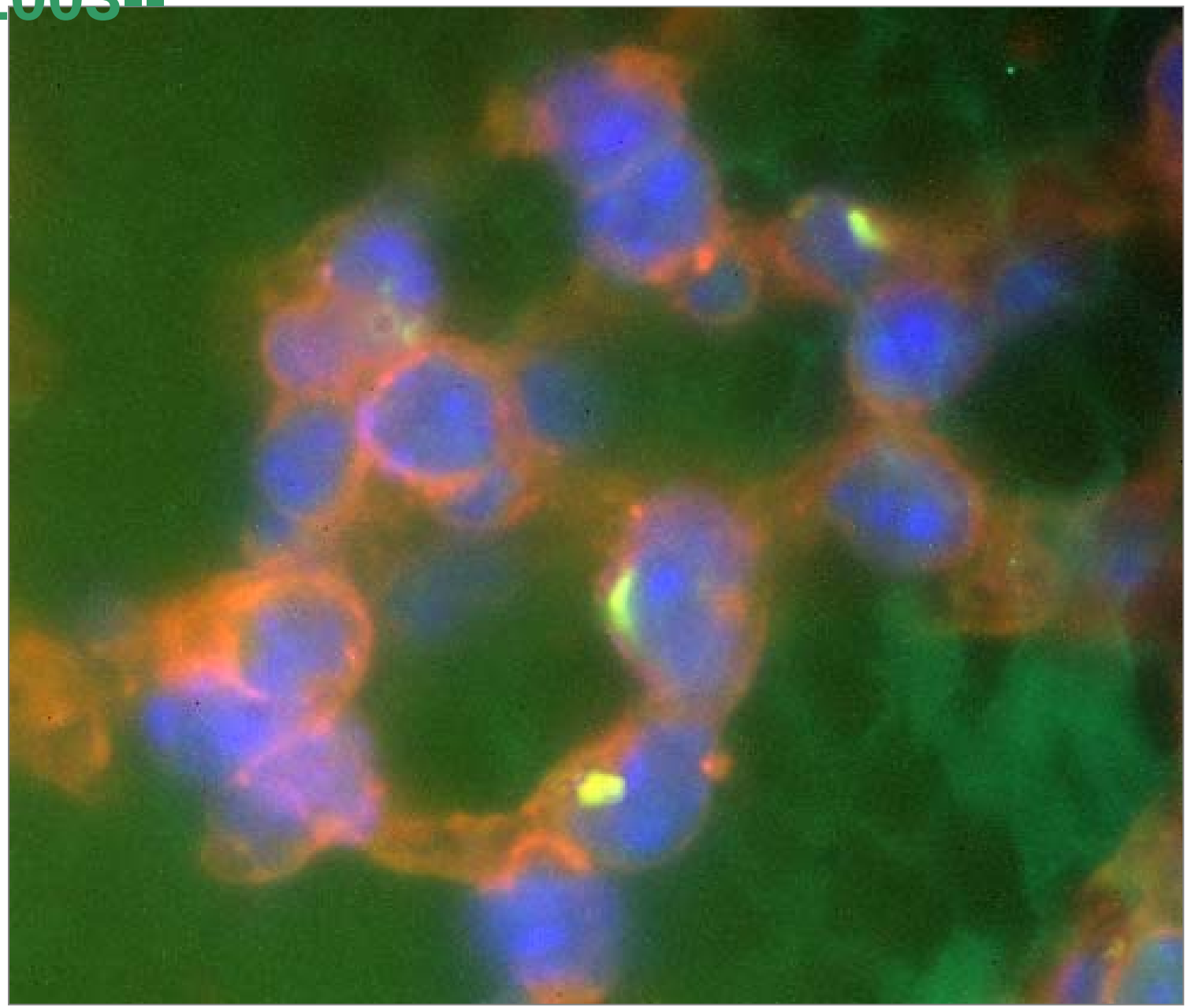

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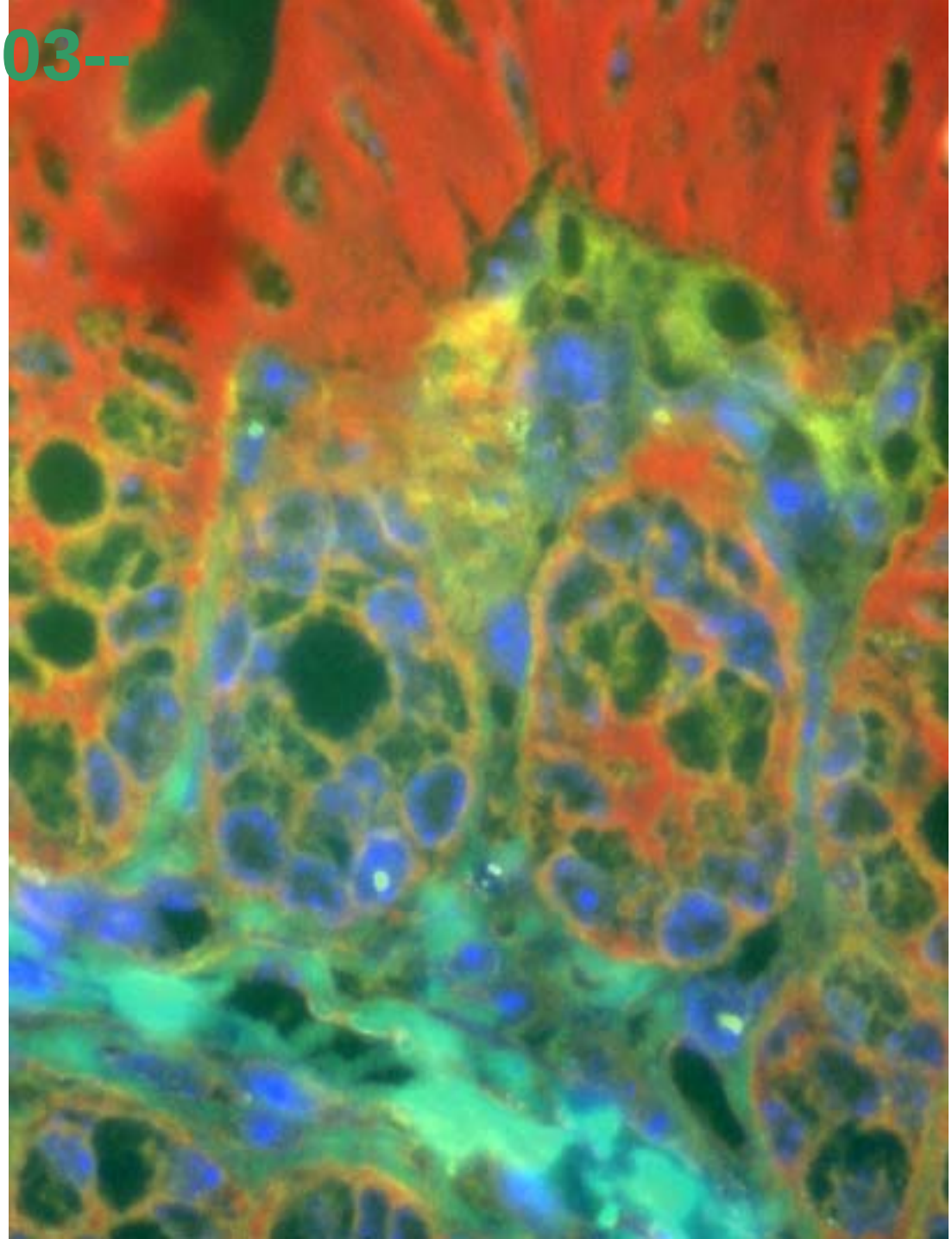

can and should we simulate the human body? part 2

3. simulation lets us see things we cannot in the laboratory (DW)

- can study wholeness of dynamic system
- theoretical simplifications key to understanding fundamental properties
- insights into emergent/global phenomenon
  - how macro behaviour arise from individual behaviours and interactions
- suggests reasons for disease
- suggests medical experiments
- run lots of experiments
- fundamentally challenge current thinking
  - no such thing as stem cells, all cells are more or less likely to exhibit stemcell-like properties

how can we meaningfully express the scale of the unseen?

- if simulation suggest experiments then it has meaning
- meaning is related to emergence (it only happens at the macro-level; observable experimental results)
- photographs of microscopic phenomenon are shown at A4 size representing microscopic structures in pathology
  - are these simulations?
  - artificially coloured, stained, doctored
  - aesthetics counts in medical publication!

What are the limitations and failures of simulation?

simulation

- do not often understand the theoretical framework that is behind it
  - how do you know what seeing?
- simplifying assumptions are never expressed (NG)

visualisation

- Clearly address what kind of thing do you want your audience to take away?
- JP – every image has multiple contested meanings
  - scientists needs to recognise this

Staining Space Jane Prophet

- Staining Space
  - underlying issues of nature of simulation
  - trying to get close to things by modelling
  - always trying to slice. to approximate.
  - dynamic vs. still images (different truth values)
  - reveals extraordinary, humbling gulf between real and model/simulation

please see janeprophet.com

and finally

work with artists to look at visualisation, sonification (BP), user-interface

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Intelligent responsive sound