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Repertoires: The Making and Unmaking of Epistemic Diversity

Sabina Leonelli

(with Rachel Ankeny, University of Adelaide)

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Historicizing epistemic diversity

- What makes specific types of research different from each other, and how can such difference be identified and analysed?
  - What are the units of analysis for epistemic diversity?
- How do different ‘ways of knowing’ become entrenched, and with which consequences?

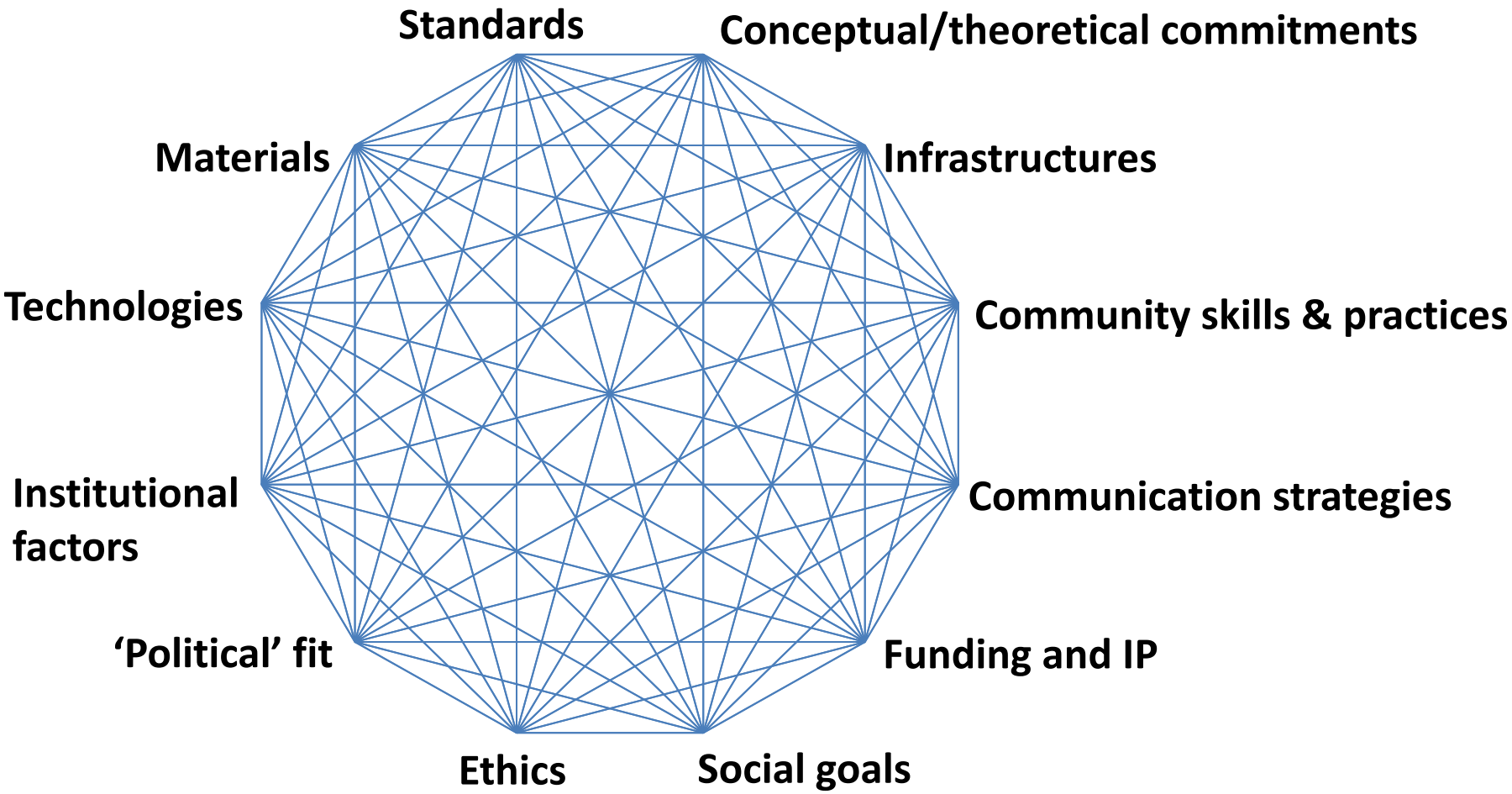
Beyond the Kuhnian response

- Shift away from conceptual history: abandoning paradigm shifts (or similar) as the main or sole drivers of theoretical changes/developments
- Including institutions: social, political, and economic factors are critical to the development and outcomes of scientific research practices (lessons from STS)
- Capturing performance: science seen as a set of epistemic activities, rather than a static sequence of decisions and strategies
- Research communities as plastic, flexible, overlapping (Fleck)

So what are repertoires?

"well-aligned assemblages of the skills, behaviors, and material, social, and epistemic components that groups may use to practice and manage certain kinds of science and train newcomers, and whose enactment affects the methods and results of research" (Ankeny & Leonelli 2016)

- Blueprints for specific ways of *doing science* that can be quickly adopted and reproduced by others
- Proposal arises out of historical, philosophical, and sociological analysis of scientific practices (descriptive) as well as reflection on when science 'works well' (normative)


Standards
Conceptual/theoretical commitments
Materials
Infrastructures
Technologies
Community skills & practices
Institutional factors
Communication strategies
'Political' fit
Funding and IP
Ethics
Social goals

Background

- *Répertoire*, from the Latin *repertorium*
  - Etymology: “listing, catalogue, inventories” that help to find items without having been involved in collecting the relevant materials
  - Adopted by performing artists (theatre, music) in 19th c. Italy and France
  - OED: “body of items that are regularly performed” and “stock of skills or types of behavior that a person habitually uses”
- Thus term refers simultaneously to
  - the work performed
  - the ways in which it can be transmitted and reproduced
  - the unique characteristics of specific enactments of the work

Characteristics of repertoires

- Strong resonance with usage in non-scientific, performative fields: enacted through individual or group performances; each instantiation typically results in new variations (see Becker on jazz)
- Can be abstracted from their specific performances, providing a 'blueprint' for assemblage of skills, concepts, instruments, materials, strategies, and structures required to enact particular projects
- Thus repertoires are assemblages of knowledge, social structures, methods, and tools which include epistemological, technological, and institutional elements (cf. Gilbert/Mulkay's intepretation of repertoires as about discourse)

Relation to other ways of analysing epistemic diversity

- **Socio-technical regimes / systems** (Pestre, Bjiker, Hilgartner)
- **Epistemic communities** (Knorr-Cetina)
- **Platforms** (Keating and Cambrosio)
- **Experimental systems** (Rheinberger)

Example 1: From experimental organisms to model organisms

Model Organisms for Biomedical Research

NATIONAL INSTITUTES OF HEALTH

Mammalian Models:


- Mouse
- Rat

Non-Mammalian Models:









- *S. cerevisiae* (budding yeast)
- *S. pombe (fission yeast)*
- Neurospora (filamentous fungus)
- *D. discoideum* (social amoebae)
- *C. elegans* (round worm)
- *Daphnia (water flea)*
- *D. melanogaster* (fruit fly)
- *D. rerio* (zebrafish)
- *Xenopus* (frog)
- *Gallus (chicken)*

Other Model Organisms:

- *Arabidopsis*

Other:

- Reports
- Funding Opportunities
- Process for Considering Support

- NIH Policy on Sharing of Model Organisms for Biomedical Research
- A User's Guide to the Human Genome
- Opportunity to Propose New Organisms for Sequencing
- Bacterial Artificial Chromosome (BAC) Resource Network
- Rate Setting Manual *for Animal Research Facilities*
- Final NIH Statement on Sharing Research Data
- Resource Sharing Guidelines
- What's New

We hope this web site provides you with information about national and international activities and major resources that are being developed to facilitate biomedical research using the animal models listed here. For organisms not listed, web pages may be developed in the future.

If you have suggestions as to how we can enhance the information provided, please send a message to Bettie Graham at bettie_graham@nih.gov.

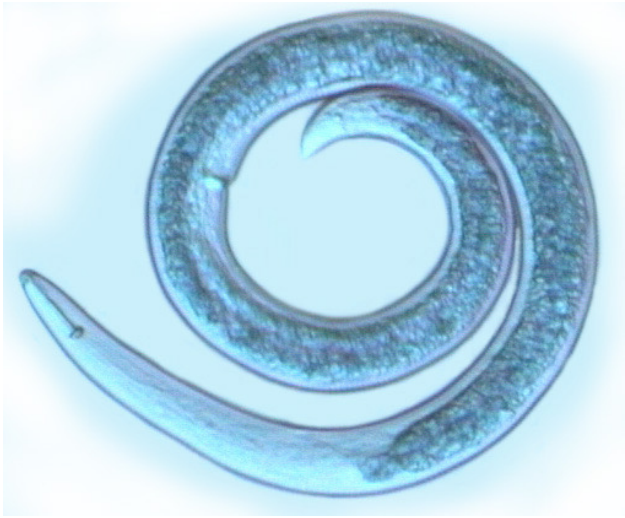
Thank you for visiting our web site.

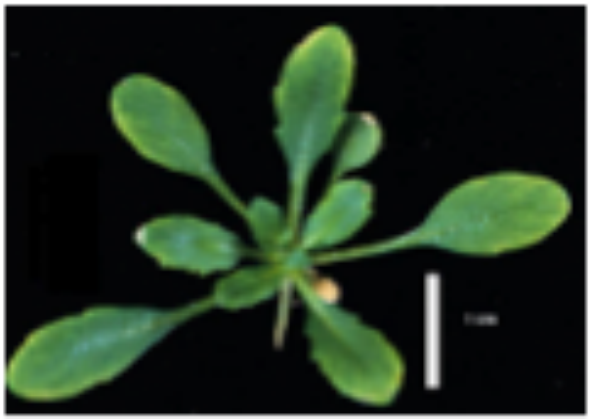
Francis S. Collins, MD, Ph.D.
Director, National Institutes of Health

C. elegans (nematode) and *Arabidopsis* (thale cress)

Repertoire that allowed research community to persist beyond the completion of a specific project:

- production, use, and dissemination of standardized strains
- relevant know-how, expertise, protocols, instrumentation and (critically) large-scale data collections
- an ethos of sharing data and techniques prior to publication
- establishment of infrastructures including databases and stock centres
- the concept of a 'model organism' as reference for other species
- long-term, blue-skies funding (via the HGP)





Components of MO repertoire (1)

CHARACTERISTICS OF THE ORGANISM	**Natural or intrinsic**	Tractability in the lab Length of life cycle Fertility rates and ease of breeding Size of organism Ease of storage Size of genome Physical accessibility of features of interest
	Induced/uncovered through experimental interaction and transfer to lab	Mutability of specimens Response to lab environment (food, light, temperature, cages, routine) Availability of standardised strains
	Attributed to or projected onto the organism by researchers	Representational scope (how extensively the results of research with the organism can be projected onto a wider group of organisms) Representational target (number of phenomena that can be explored via the organism) Power as genetic tools Ability to serve as the basis for comparisons to other organisms Multi-disciplinary usefulness (capacity to fit different research domains, e.g. genomics, development, and physiology) leading to cross-level integration

Components of MO repertoire (2)

CHARACTERISTICS OF THE COMMUNITY	**Conceptual commitments**	Evolutionary conservation Holistic, inter-level approach to organisms Focus on organisms in isolation from environment
	Available technologies	Well-developed community databases Fit with available instruments and tools (e.g., sequencing techniques)
	Shared skills and practices	Commitment to free exchange of materials, data, and knowledge Ability to move across biological subfields (and related instruments, terminologies, and standards) Public relations skills in attracting funding and attention from outside the scientific community
	Institutional organization	Charismatic leaders with strong organisational and scientific skills Efficient and accessible stock centres Common communication venues and institutions (e.g., steering committees, journals, community databases, organism-focused conferences)
	Dependable funding sources	Long-term support from governmental funding Strategies to secure that funding

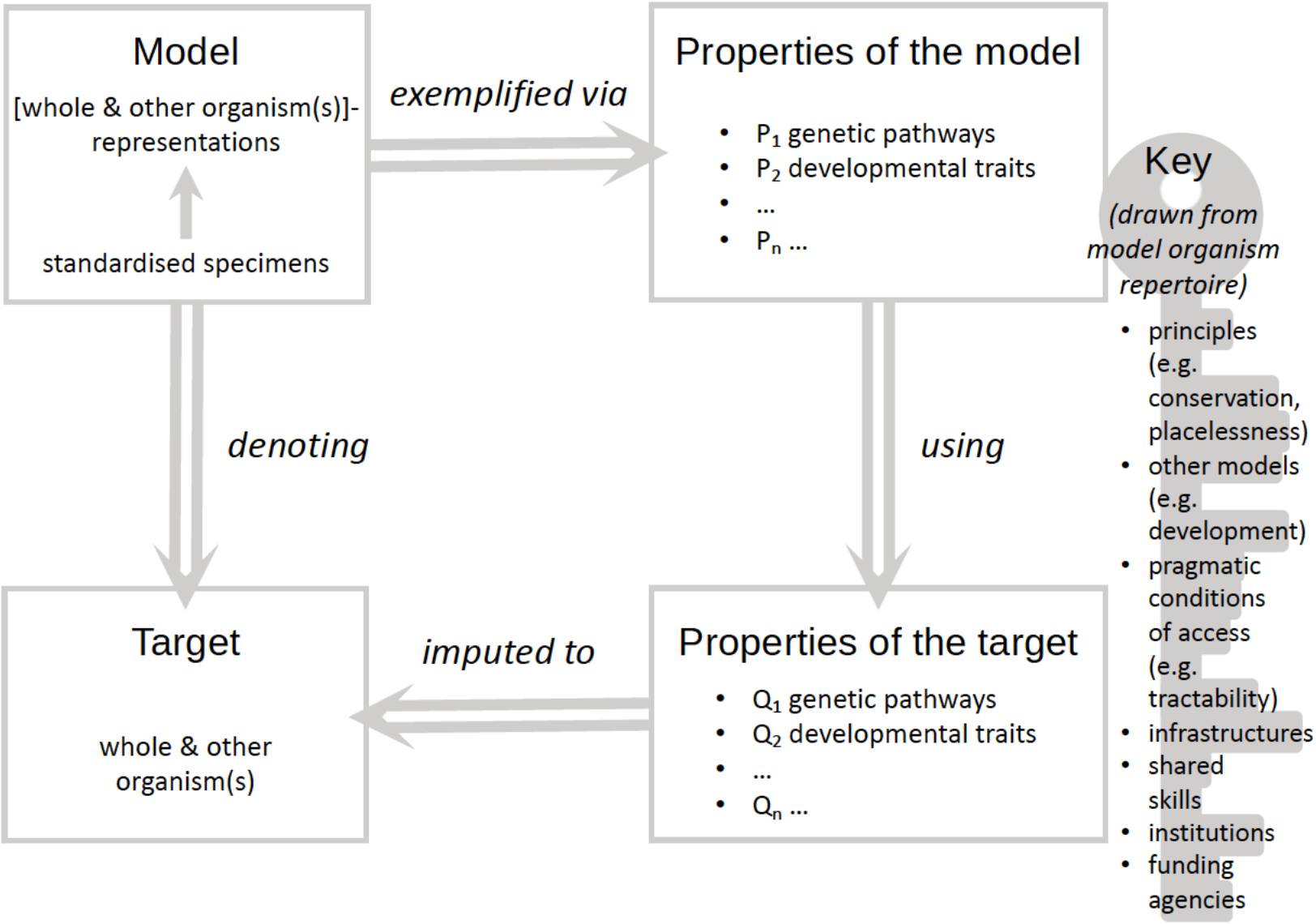
Components of MO repertoire (3)

CHARACTERISTICS OF THE BROADER LANDSCAPE	**Fit with political and social goals**	Vision of basic molecular research as grounding innovation in medicine and agriculture
	Intellectual property regime	Free or otherwise well-regulated exchange of materials, techniques, and data

Thus model organism research is an excellent example of a repertoire, including:

- specific material, social, and epistemic conditions under which individuals joined together to perform projects and achieve common goals, in a robust way over time despite changes in the broader landscape
- adoption and increasing entrenchment of specific theoretical commitments, such as the assumption of evolutionary conservation and emphasis on integrative, cross-level accounts

How do repertoires ground the plausibility of model organisms as models?



Example 2: COVID research and emergency science

- Imaginaries of data use during first year of pandemic closely matched existing repertoire of facing epidemiological research
- .. To the detriment of other sources of insights / research practices that could have proved decisive
- Exemplary of problem with ‘emergency science’ mode relying on, instead of challenging, existing repertoires

COVID-19 crisis: Imaginaries of data use

(in order of public prominence)

1. Population surveillance
2. Predictive modelling
3. Causal explanation
4. Evaluation of logistical decisions
5. Identifying social and environmental need

Imaginaries of data use 1: population surveillance

- Surveillance is key data ideology: seemingly “perfect fit” with epidemiological advice on tracing and tracking

- Problems:
  - Surveillance measures outlast the emergency
  - Governmental centralization of power is worrisome in many national contexts
  - Basic sources of bias and inequity across digital footprint are ignored or papered over
  - Tracing not flanked by medical capacity to support
  - Testing is prone to mistakes and extremely difficult to obtain for most nations, which makes this a dangerous exercise
  - What relations between industry, public agencies and citizens?
  - What does transparency mean in this context?

Imaginaries of data use 2: predictive modelling

- Prediction is another key data ideology, reflecting the Big Data trend of the last decade as mere 'input' for AI and ML

- Assumptions:
  - Data as powerful, neutral, indisputable 'facts'
  - Modelling as univocal and unambiguous

- Problems:
  - Data do NOT speak for themselves
  - Data are very diverse and hard to compare
    - Differences in what and who counts as 'dead', what and who counts as 'tested', medical and social organization, political priorities
  - Tests are not [fully] reliable and not easily available
    - Which makes a big difference at this scale
  - Overarching trends less relevant than local scenarios

Imaginaries of data use 3: causal explanation

- Understanding variety and interrelations of factors underpinning contagion and severity of disease
  - Mechanisms of contagion, social/environmental triggers (e.g. pollution), economic conditions for spread & slowdown

- Crucially, this requires integration of quantitative measurements and qualitative observations
  - E.g. data from GPs and clinics – inefficient sharing..
    - E.g. oxygen levels measurements as crucial to avoid 'silent' pneumonia

- Contextualising data is crucial to understanding why effects are observed, and how to intervene

Imaginaries of data use 4: evaluation of logistical decisions

- Thinking about the digital structures required for post-covid world, and implications of alternative paths here

- Data science underpinning logistical and organizational demands
  - Crucial both to medical and social services, and to arrangements post-lockdown

- Data management decisions taken now will also outlast the emergency
  - E.g. using Amazon web services for data storage or Zoom for communications in schools, hospitals, social services; whether or not to trust Facebook (again)
  - E.g. expansion of data sharing across governmental and private agencies

Imaginaries of data use 5: identifying social and environmental need

- Visualising the other(s) – to enable respect, understanding, compassion
  - E.g. death tolls of frontline workers and minorities
- Data-based solidarity: what does this look like, what enables it? How do data worlds relate to physical and social worlds?
  - 'syndemic': "a set of closely intertwined and mutual enhancing health problems that significantly affect the overall health status of a population within the context of a perpetuating configuration of noxious social conditions" (Bambra et al 2020)
- Antidote to shrinking, increasingly monolithic public discourse; and nationalist and exceptionalist narratives

Fast data science need not be rushed

- Community engagement in collecting, analysing and interpreting data of relevance to the pandemic response – often perceived as a waste of time, a gigantic mistake
- Need to allow for interdisciplinary, multi-stakeholder consultations **especially** around results with significant public health implications and under emergency conditions
- Producing useful, reliable results requires speed of exchanges and collaborations, not haste to push onwards
- Key message for scientific and civic world, and especially government who needs to invest in initiatives, spaces and infrastructures to facilitate exchange

Some examples

- USA: “COVID for you” initiative
- International: RDA COVID-19 Working Group
- UK:
  - Open Data from UK Office for National Statistics
  - CHESS (Covid-19 Hospitalisation in England Surveillance System) adapted from the UK Severe Influenza Surveillance System by Public Health England
  - UK Biobank
- Existing activist networks around specific diseases
  - E.g. EULAR COVID-19 Database established to capture how rheumatology conditions and their treatment affected the risk of and severity of COVID-19

The role of repertoires

- Failure of preparation = failure of repertoires of reference to policy-makers
  - WHO focused on pandemic flu rather than other types of infection
  - Some governments focused on modelling rather than experience of local public health authorities, physicians, victims of “long COVID”
  - Importance of mixing different imaginaries of data use – with related repertoires - was underestimated in most countries
- Big challenge to (at least some) repertoires, or even to the very notion of repertoire:
  - How to challenge status quo in the midst of an emergency?
  - Which repertoires work best in relation to specific imaginaries of research?

Other cases

- Coral reef research (Ankeny & Leonelli 2019)
- Clinical trials and EBM
- Pre-clinical research (e.g., pharmacological *in vivo*)
- Freudian analysis
- ‘Big’ particle physics
- Oceanographic surveying
- Science in the making: synthetic biology, big data analytics

Transferability and variability of repertoires

Same investigator/group can employ a **variety of repertoires** at any one time, depending on projects

Analogy: Franchising

- Model for how given business can be established, organised, and enacted, and implemented widely
- But unique enactment at each site ('value added')
- Serious financial stakes: considerable investments in materials/technologies; technological lock-in; business models for publishing and patenting; public-private partnerships
- Power of franchise goes beyond economic value: epistemic, institutional, and affective aspects

Repertoires and groups (1)

- Research fields emerge when a given community adopts a certain repertoire in a stable and long-term manner
- Communities with successful repertoires share abilities to align components of their work which they control, with broader components over which they have much less control
- Disciplines typically encompass several repertoires (though the ethos, values, and general goals characterising a discipline will make some repertoires more appropriate than others)

Repertoires and groups (2)

- Importance of repertoires in instantiating, shaping, strengthening, and disrupting social relations within science
- Not all repertoires are associated with a stable/coherent research community (e.g., microbiome, often used as tool for funding without a shared ethos/identity)
- Existing repertoires can foster the emergence of a research community
- Research communities can also emerge in association with the birth of a repertoire (e.g., model organism communities)
- Research communities can have indirect or one-to-many relationship to repertoires (e.g., synthetic biology 'community' and the variety of repertoires therein)

When do they fail?

- Failure/success are evaluated with respect to epistemic as well as ethical and social goals
  - Example: mice researchers tried and failed to adopt model organism repertoire because in conflict with highly commercialised, proprietary biomedical regime of knowledge production
- Collaborative projects do not often result in substantial shifts in researchers' habits (or repertoires)
- Failure to establish a repertoire typically results from lack of alignment among (and/or knowledge and reflection about) components of a repertoire and accompanying boundaries and constraints
- Alignment is not only difficult to generate, but also maintain
- Repertoires are not easy to export, and not just a matter of technology

Success and diversity

- Repertoires can allow acquisition of funding swiftly and efficiently
- But also impose serious constraints such as potential conservatism, discrimination and hesitance to pursue original, alternative paths (similar to Kuhn's 'normal science')
- They can create or strengthen prejudice, blind spots and canalisation
- Many creative and innovative scientific initiatives grow at the margins of, or in outright opposition to, the most long-lived repertoires
- Repertoires have significant consequences in terms of reputation, visibility, and resources

When repertoires clash and reconfigure: data science

- Technical expertise is crucial: maths, stats, programming, engineering, biology, epidemiology, biomedicine…

- Yet just as crucial to understand the context and social significance of data: social and behavioural sciences, ethics and responsibility, environmental science, data curation and Open Science infrastructures, consultations around such themes

- Multidisciplinary teams are indispensable..

When repertoires clash and reconfigure: data science

- .. As well as the ability to engage beyond professional research
  - Consultation and participation of multiple perspectives is essential to scientific efforts and decisions around what such efforts mean in terms of social interventions
    - Collaboration between companies, public agencies, researchers from different backgrounds, social services
  - Expertise beyond disciplines: community engagement
    - Adds precious data
    - Diversifies perspectives
    - Adds robustness to existing data and helps to contextualize and validate their interpretation
    - Makes scientific knowledge more reliable and provides tools to counter disinformation
- Repertoire in the making?
  - Is this a good thing?
  - Are we supporting/creating repertoires in STS, esp. when teaching?

Acknowledgments

Funding: associated with research on the repertoires concept has been received via the Australian Research Council Discovery Project (DP160102989) "Organisms and Us: How Living Things Help Us to Understand Our World" (2016-20) and the European Research Council Project "The Epistemology of Data-Intensive Science" (2014-2019)

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Thank you! and questions

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Variation on success stories: Drosophila (fruit-fly)

- Arguably the Morgan group built a shared repertoire which allowed focused research to persist beyond their specific goals
  - production, use, and dissemination of standardized strains
  - the know-how, expertise, protocols, and instrumentation
  - establishment of communication and other infrastructures such as newsletters
- Repertoire was not immediately expanded, but rather remained within (parts of) genetics until its adoption in developmental biology in 1960s

Thus note that details of what makes a 'repertoire' are highly historically and contextually contingent

General criteria for organism choice

Type of concern	Criteria
Access	(1) Ease of Supply (2) Phenomenal Access (3) Ethical Considerations
Tractability	(4) Standardization (5) Viability and Durability (6) Responsiveness (7) Availability of Methods and Techniques (8) Researcher Risks
Resourcing	(9) Previous Use (10) Epistemic Resources (11) Training Requirements (12) Informational Resources
Economies	(13) Institutional Support (14) Financial Considerations (15) Community Support (16) Affective and Cultural Attributes
Promise	(17) Commercial and Other Applications (18) Comparative Potential (19) Translational Potential (20) Novelty

Dietrich, Ankeny, Crowe, Green & Leonelli 2019

Example 2: Microbiomes

earth microbiome project

american gut

Hospital Microbiome

Equine Microbiome Project

The microbiome repertoire

- Large governmental funding and related efficient publicity/PR
- Large scale (big data, big networks)
- International standardisation efforts for data and software repurposing of sequencing technologies for new intellectual goals
- Ecological conceptualisation of organisms and ecosystems as multispecies environments with unique microbial footprints
- Savvy use of social media and crowdsourcing

How? Practices and normativity

- Barnes: practices as "collective accomplishments of individuals concerned all the time to retain coordination and alignment with each other to bring them about" (2001:33)

- Rouse on normativity as essential to practice understood as a temporally extended, recurrent pattern of activity: "a practice is not a regularity underlying its constituent components, *but a pattern of interaction among them that expresses their mutual accountability"* (2007:48; see also Lewendon-Evans 2018)

- Repertoires encourage and stabilise a specific kind of normativity, which becomes the basis for communication and collaboration among scientific groups and associated stakeholders over an extended period of time

Why the concept of repertoires?

- To encourage those who study and practice science to reflect on a wide range of research practices and behaviours—including how and when these factors do (or do not) align—thus highlighting the significance of political economy for accounts of the epistemology of scientific practice
- To facilitate deeper and more accurate understanding of the relationship between individual research contributions and collective practices and norms
- To broaden existing view of what 'counts' as scientific work and workers (including administrators, technicians, funders, and other 'non-scientists') whose skills and expertise contribute significantly to the enactment of research repertoires