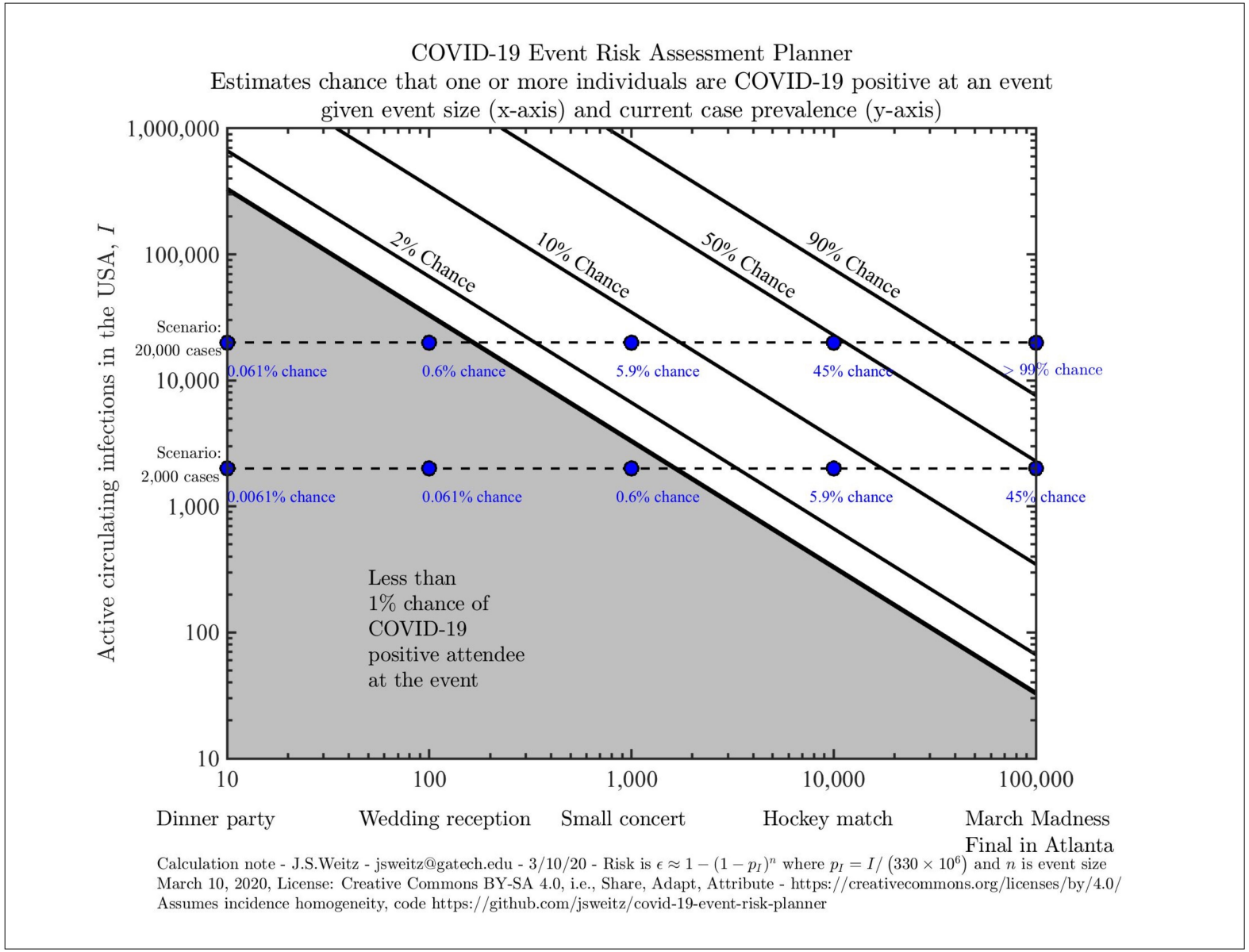
Exactly two tips on slide/figure design

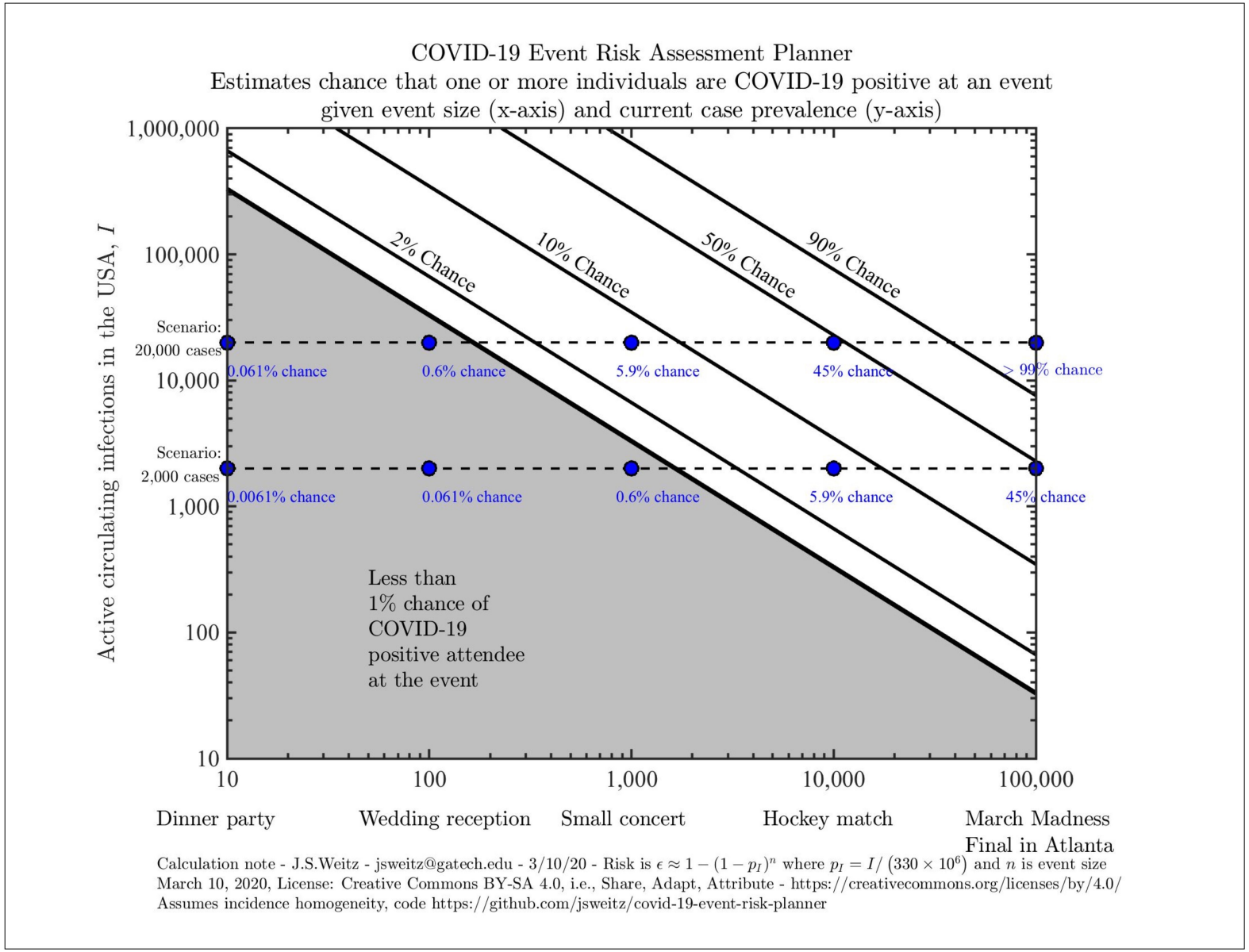
1. Your figures/data/diagrams

What do you see?



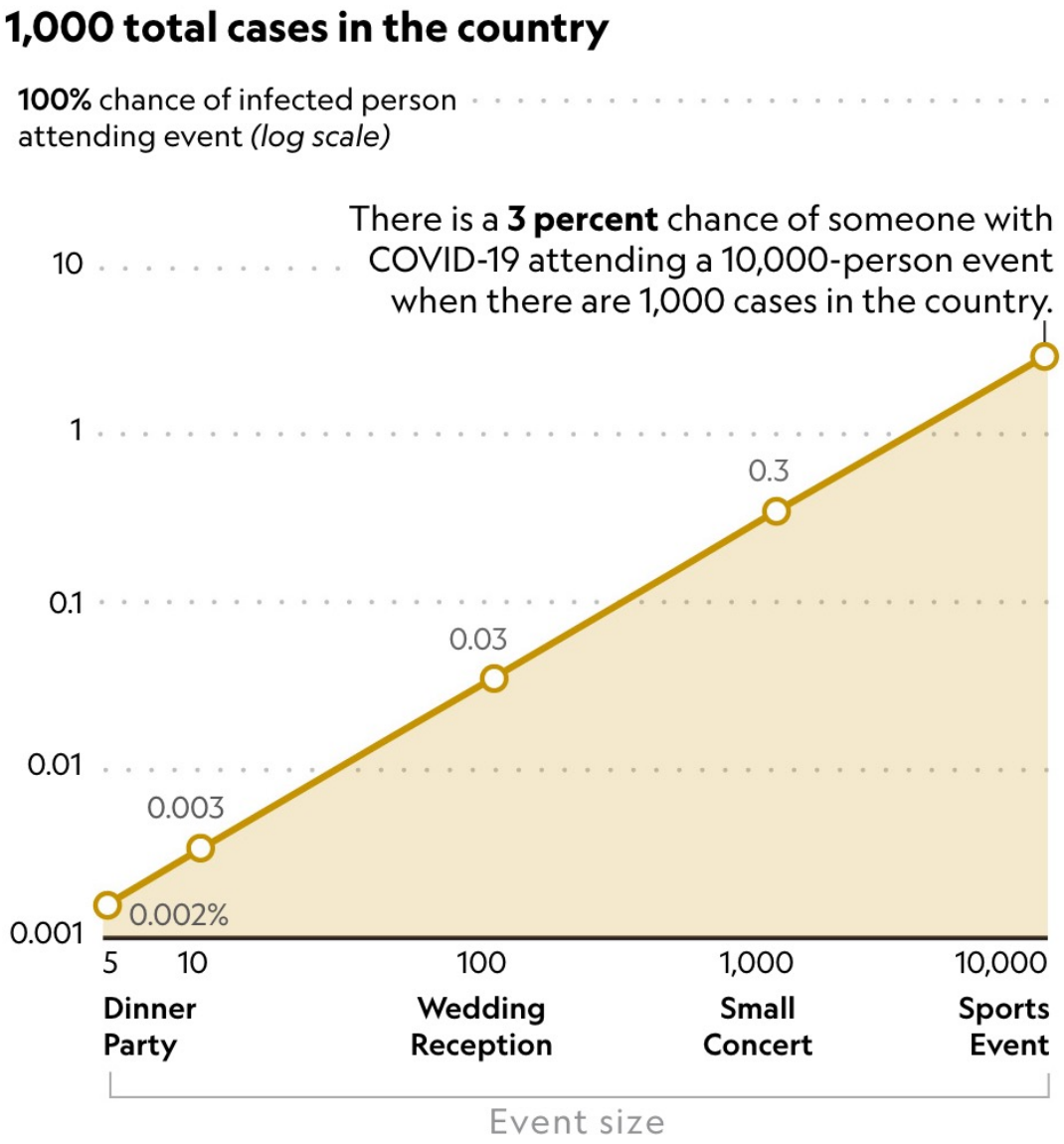
twitter.com (X!?)

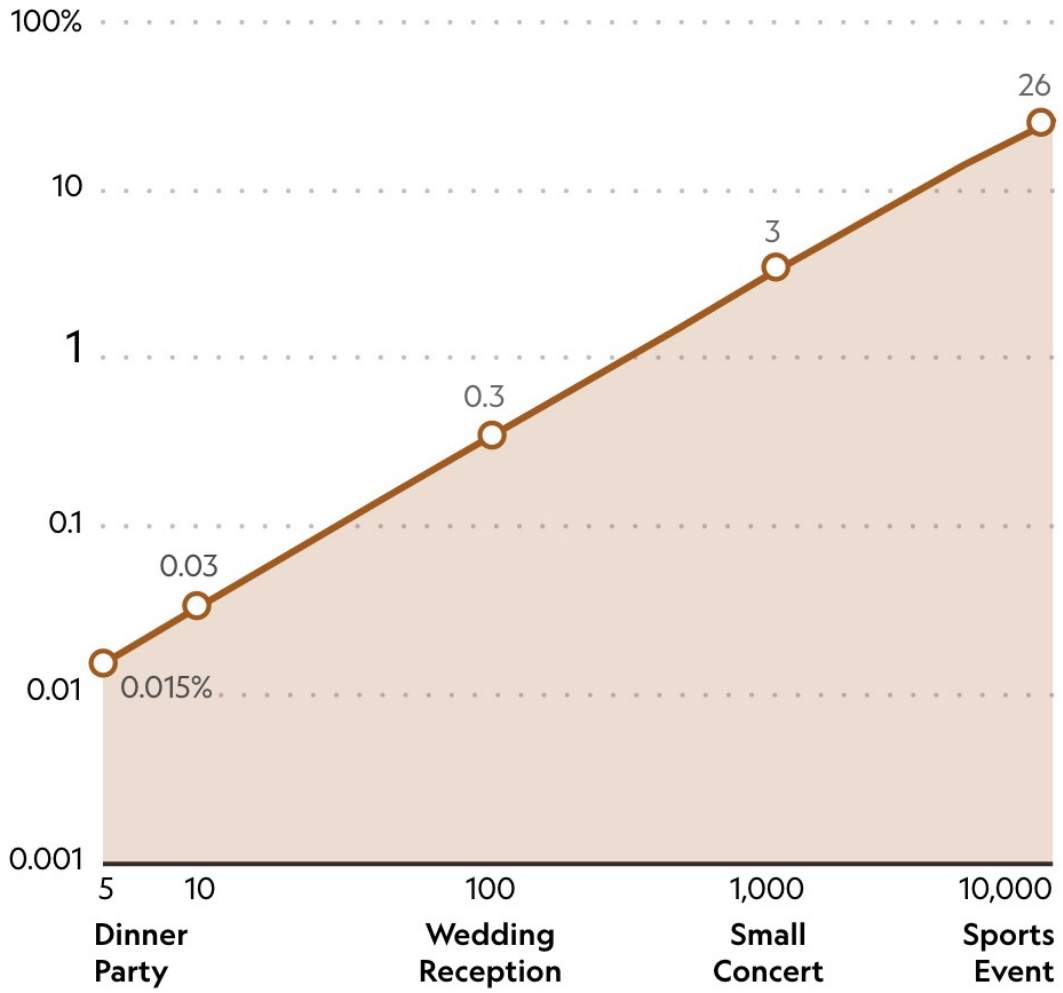
How would you improve it?



twitter.com (Xiz)

What do you see?





NatGeo

What do you see?

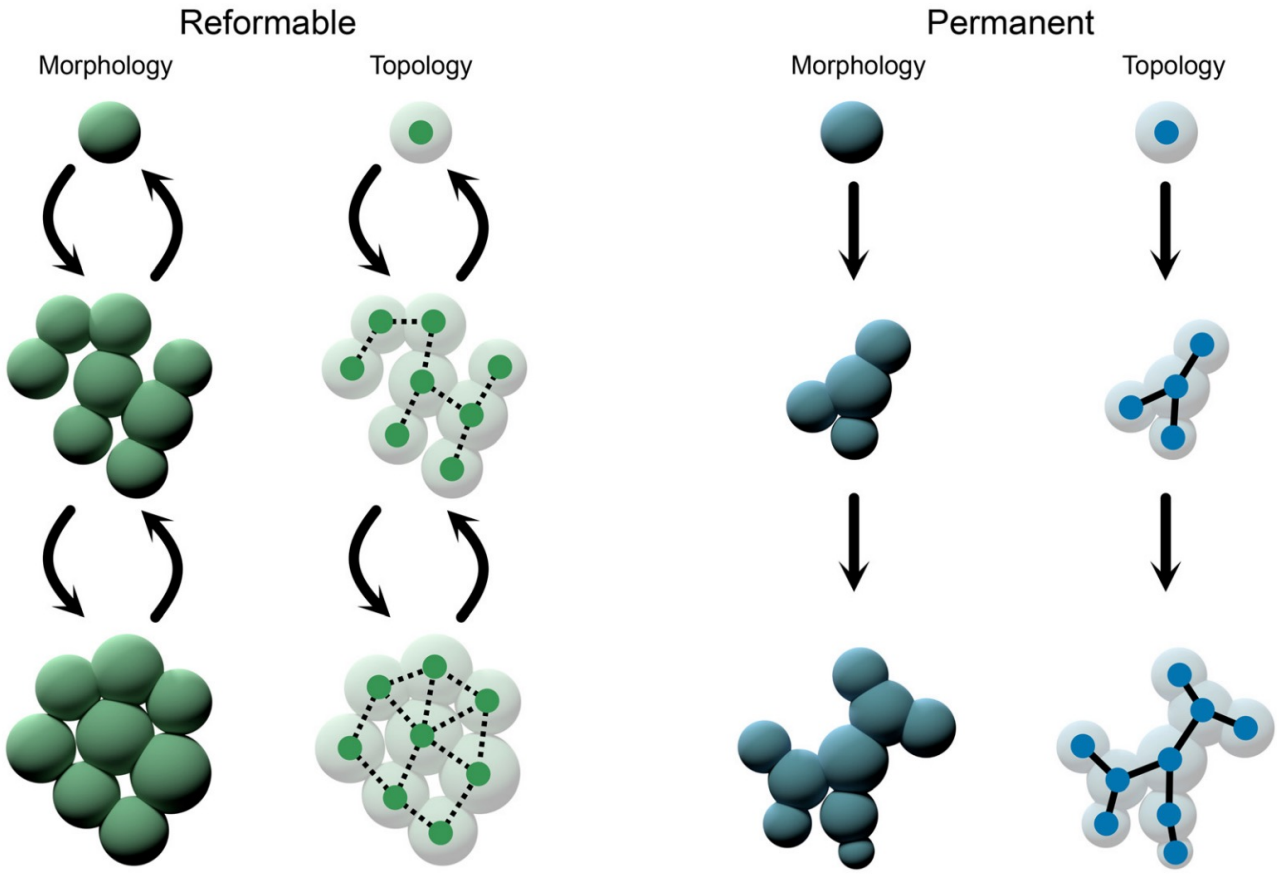


FIG. 1. The two main classes of bonds, which form a multicellular organism. Reformable bonds allow for relative cellular rearrangements; permanent bonds do not. This topological constraint has many downstream effects.

cell separation, where cell cytoplasms may be disconnected, but the cell walls or membranes remain strongly adhered; syncytial growth, where a cylinder of cell wall material is partitioned via crosswalls; and

incomplete cell separation process that are broadly shared. For one, the rate of bond formation is intertwined with the rate of cell division, since the division process creates these bonds. Ultimately, this

What do you see?

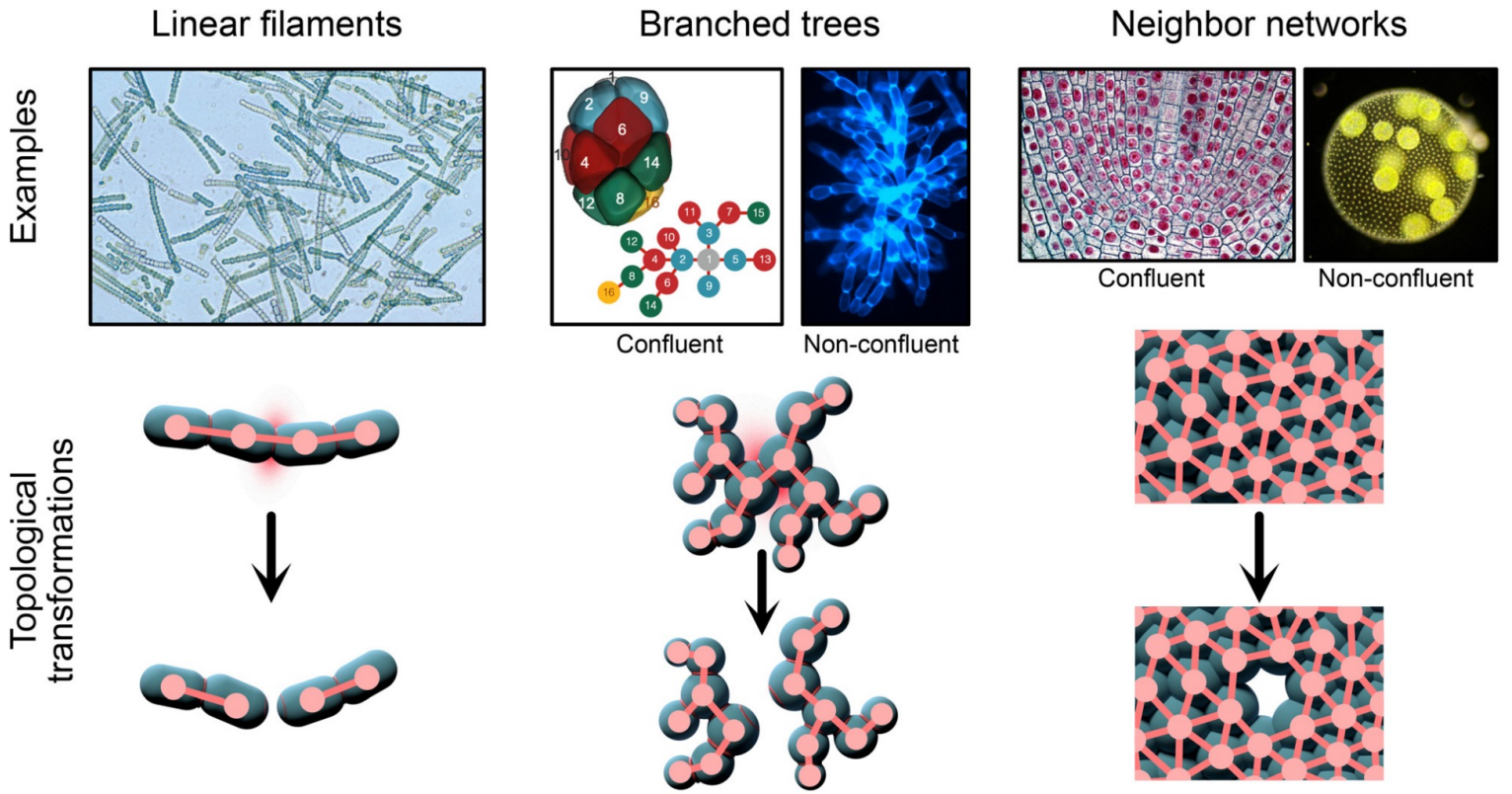
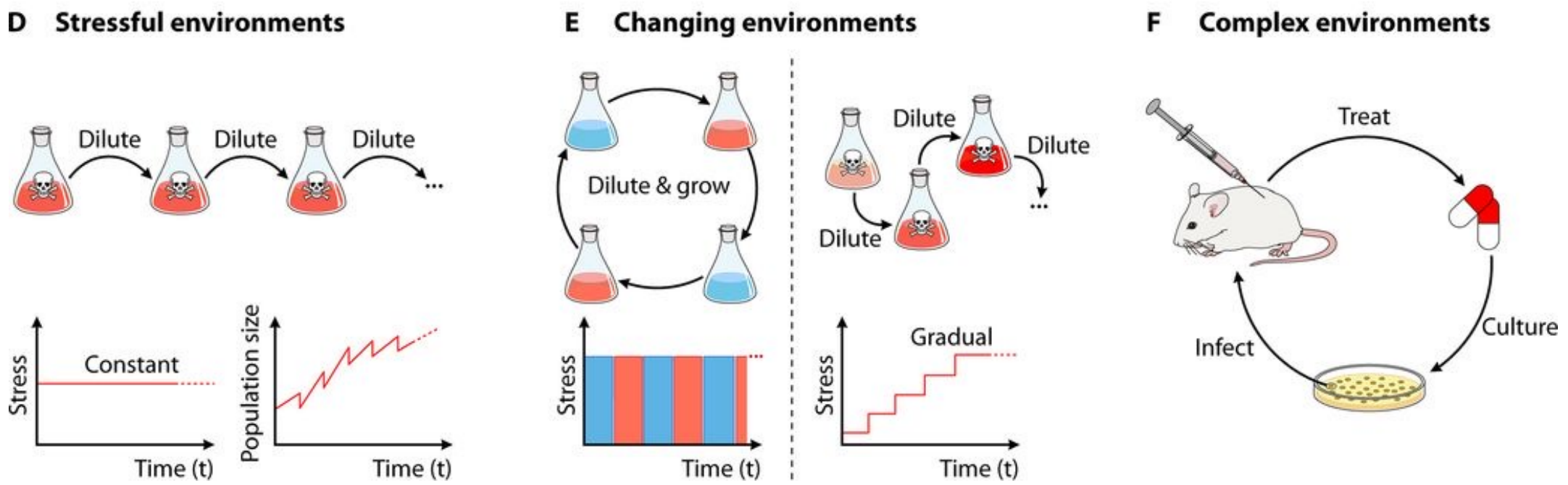


FIG. 3. Multicellular groups are formed with linear filament and branched tree bond topologies' fragment into two pieces when any one bond is broken. Neighbor-network topologies do not share this property: multiple bonds must be removed to extract any piece of the organism. Experimental images shown left to right are as follows: (i) linear filaments of the cyanobacteria *Cylindrospermum sp.* courtesy of CSIRO; (ii) membrane-based 3D volume from confocal microscopy of a *Drosophila melanogaster* embryo, courtesy of Dr. Jasmin Alsous, Flatiron Institute; (iii) branching "snowflakes" of the yeast *S. cerevisiae*, adapted from Bozdag *et al.*, bioRxiv: 2021.08.03.454982 (2021). Copyright 2021 Author(s), licensed under a Creative Commons Attribution (CC BY 4.0) License; (iv) the apical meristem in an onion root tip; (v) the entire green algae organism *V. carteri*, adapted from Day *et al.*, eLife **11**, e72707 (2022). Copyright 2022 Author(s), licensed under a Creative Commons Attribution (CC BY 4.0) License.

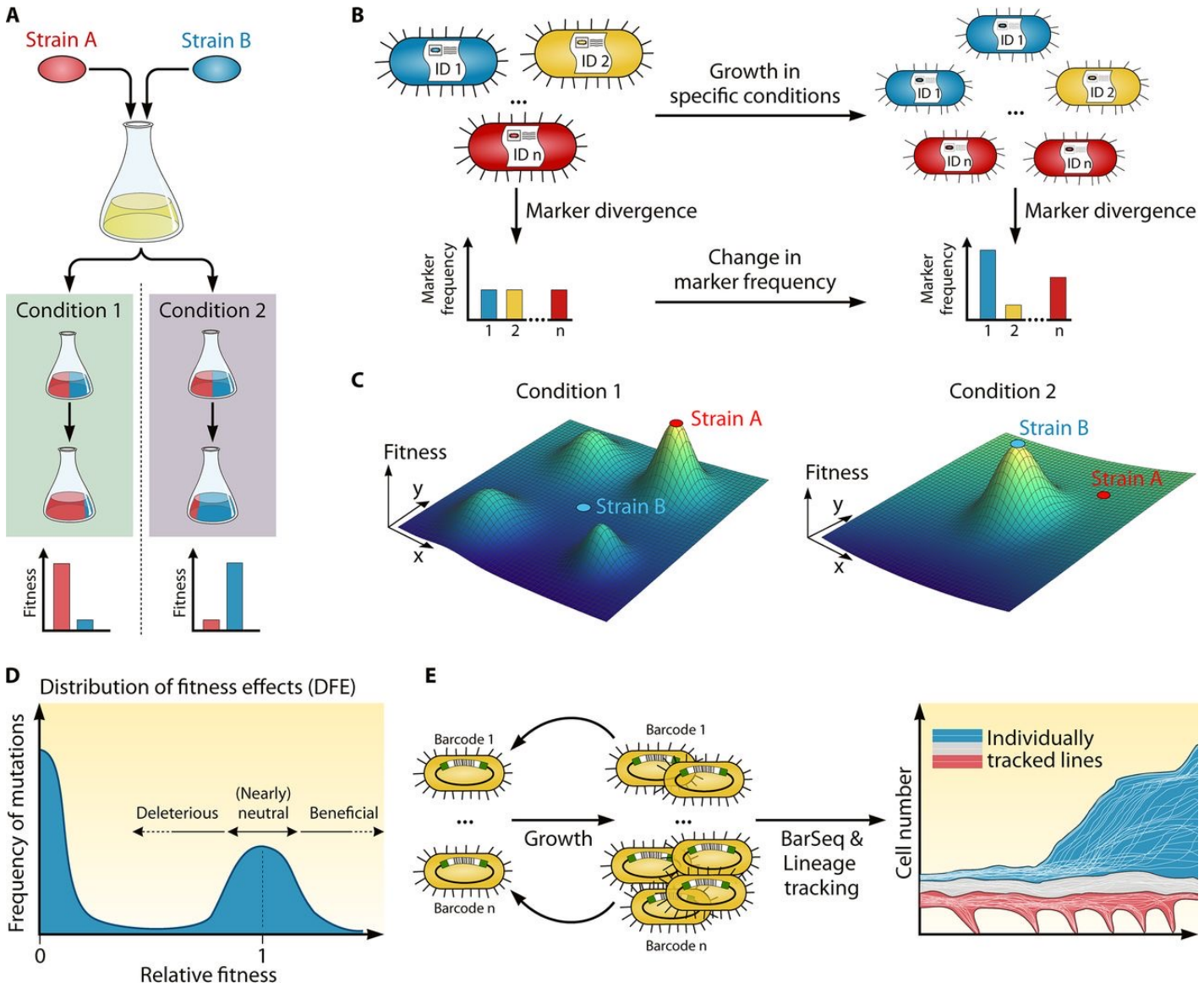
possibly choanoflagellate rosettes.[58] In these cases, there can be significant gaps between the individual cells where nutrients can pass. There are also many examples of confluent tissues in plant tissues, others with a neighbor network topology; tetrads are then bonded one to another in an unknown fashion. It is possible that each tetrad is bonded to the next tetrad at only one location, meaning that the bond

Complex experiments can be explained with diagrams



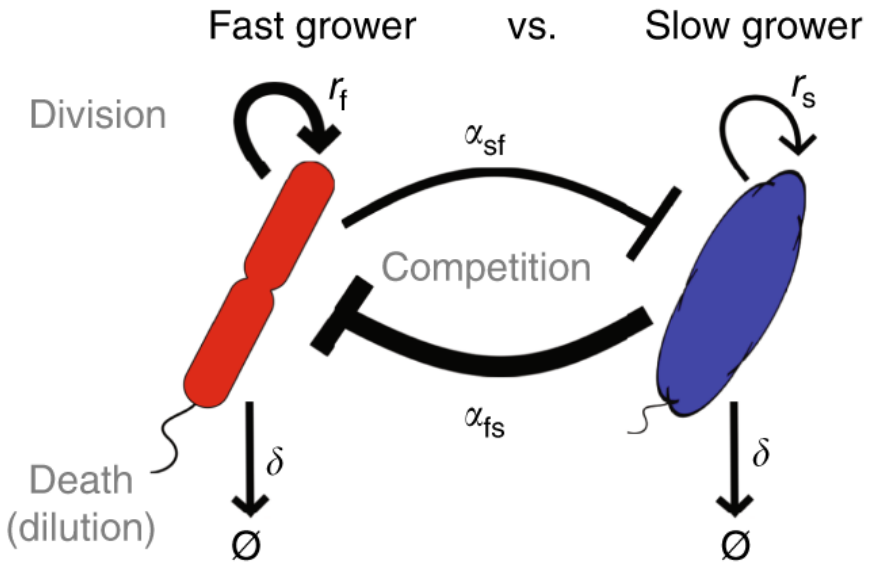
Van den Berg *et al.*, 2018

Complex experiments can be explained with diagrams



Van den Berg *et al.*, 2018

Even theory-heavy papers can have nice diagrams



Per capita growth | Maximal growth rate | Self-inhibition | Inhibition by competitor | Added death rate

$$\frac{\dot{N}_f}{N_f} = r_f\left(1 - N_f - \alpha_{fs} N_s\right) - \delta$$

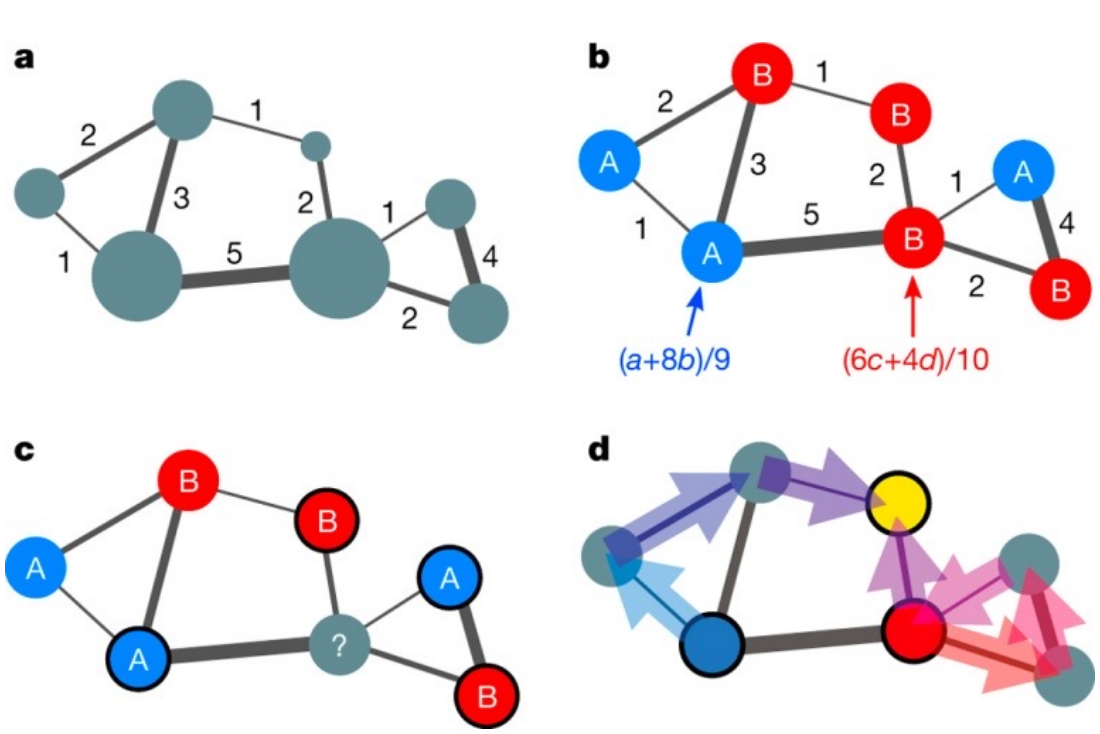
$$\frac{\dot{N}_s}{N_s} = r_s\left(1 - N_s - \alpha_{sf} N_f\right) - \delta$$

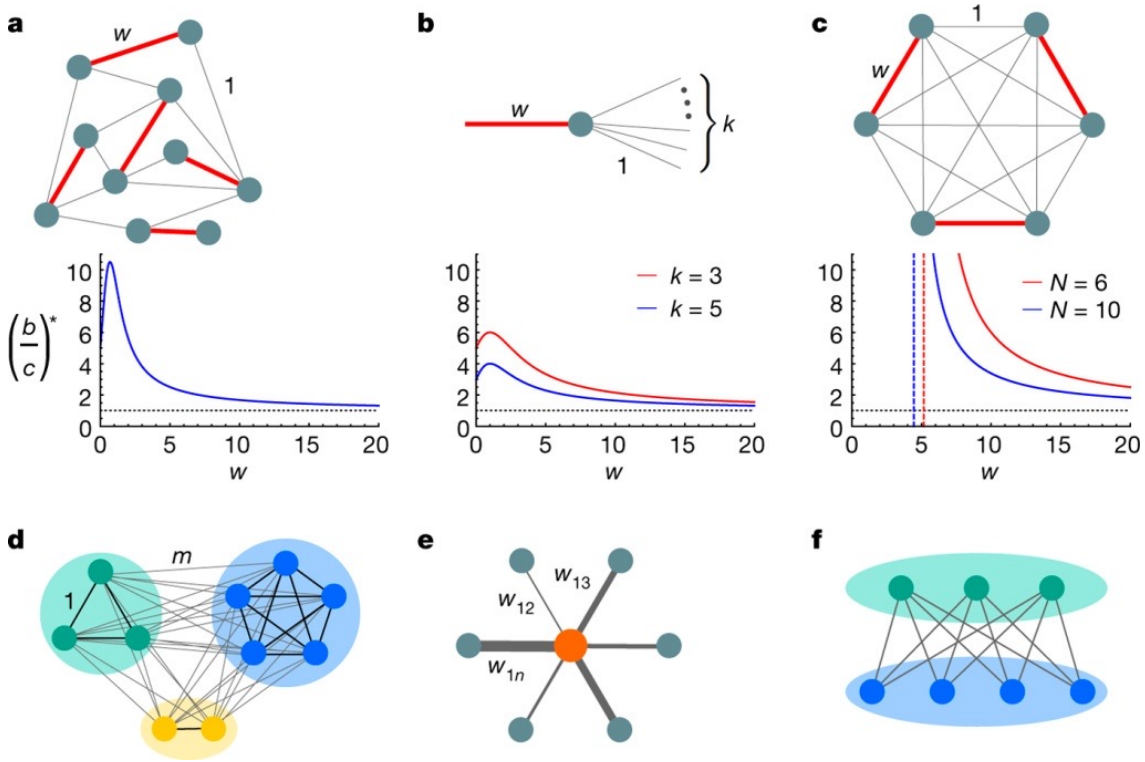
Re-parameterized competition coefficients

$$\tilde{\alpha}_{fs} = \alpha_{fs}\left(\frac{1 - \delta/r_s}{1 - \delta/r_f}\right)$$

Abreu *et al.*, 2019

Even theory-heavy papers can have nice diagrams





Allen *et al.*, 2017

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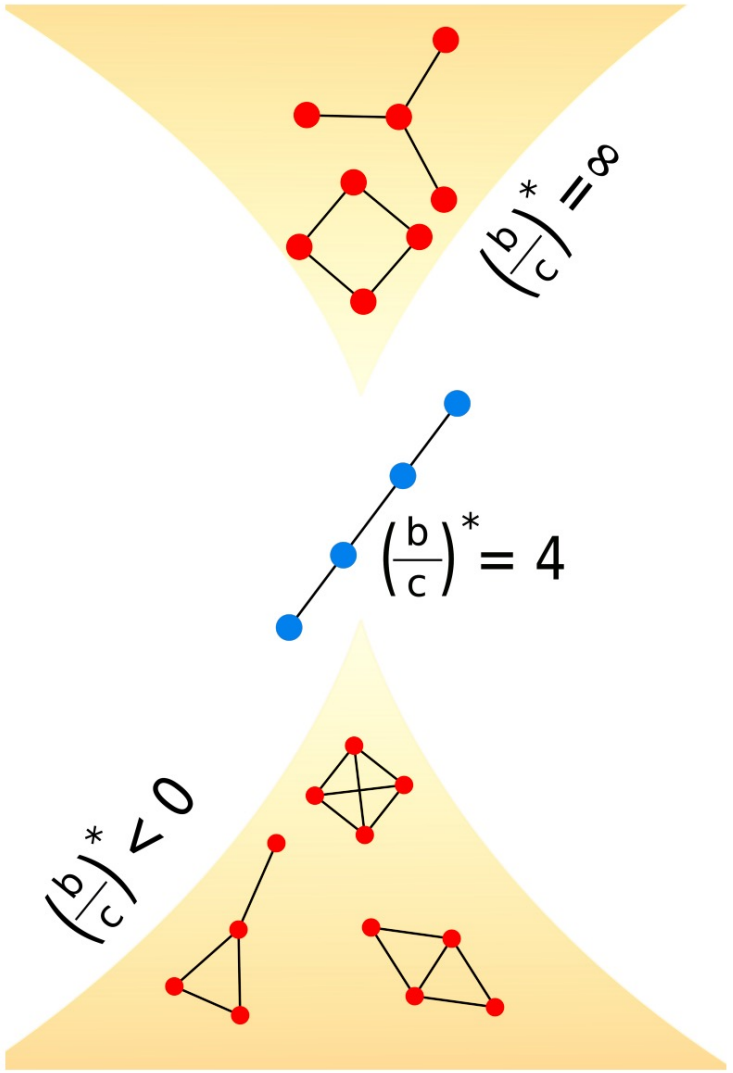
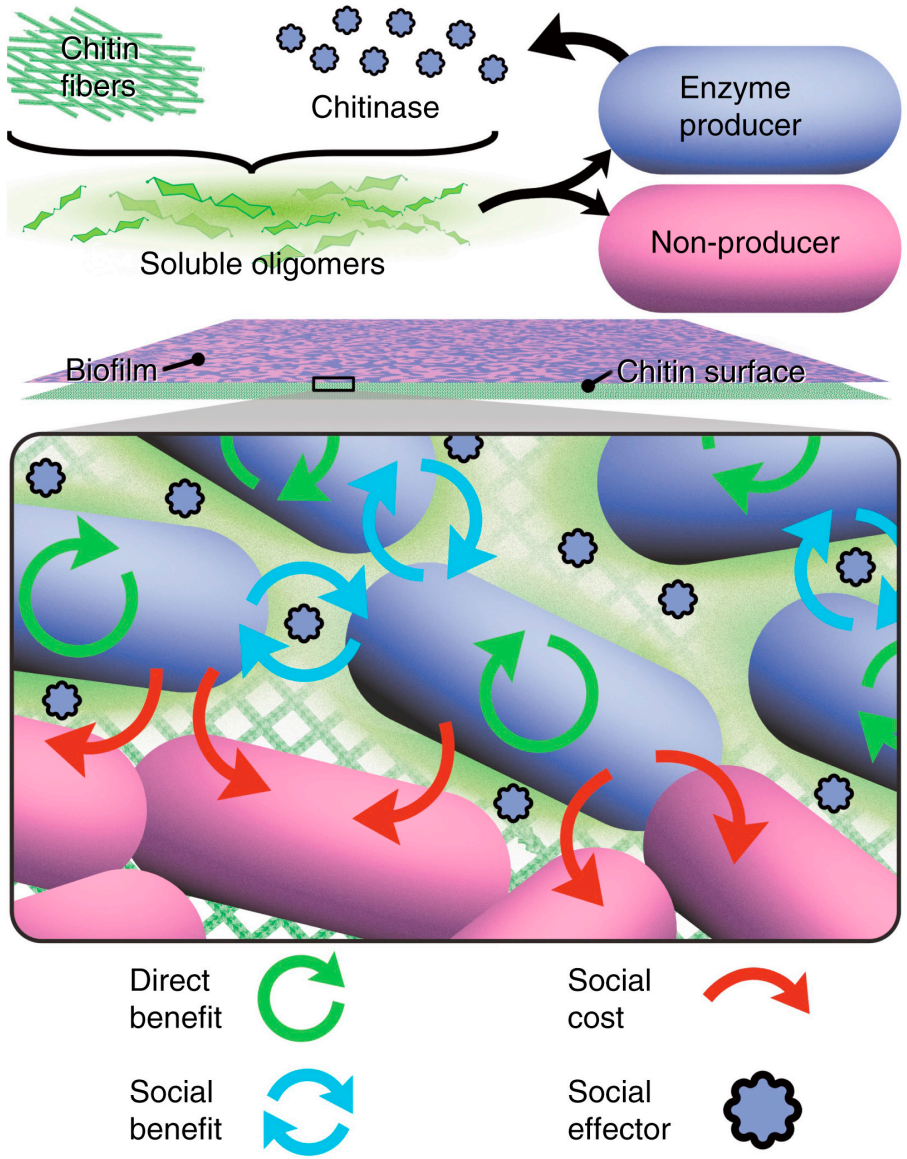
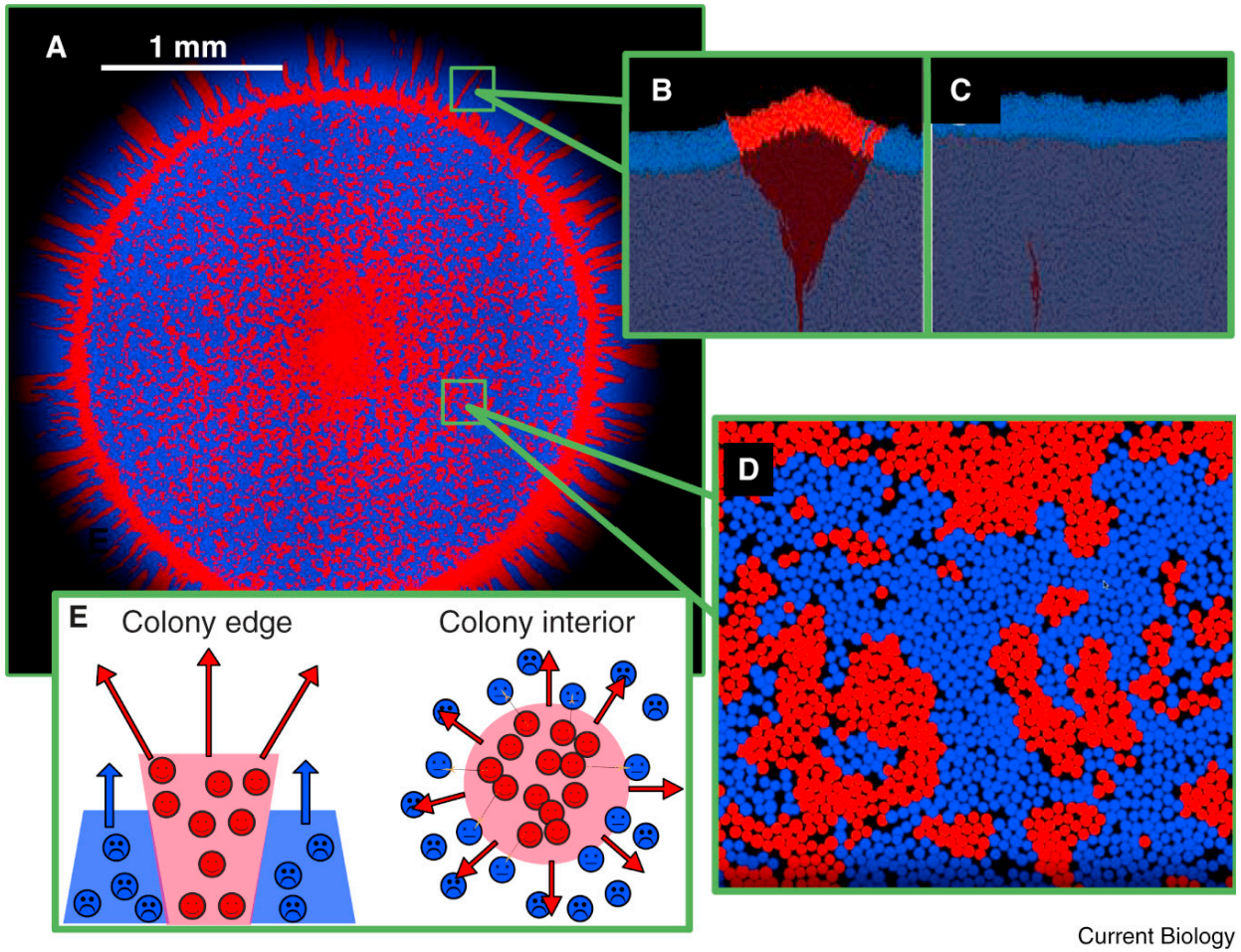


Allen *et al.*, 2017

What do you see?



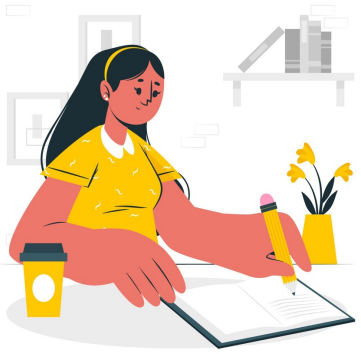


Yanni *et al.*, 2019

How do you achieve good figures?

Draft/think/thinker!

How do you achieve good figures?



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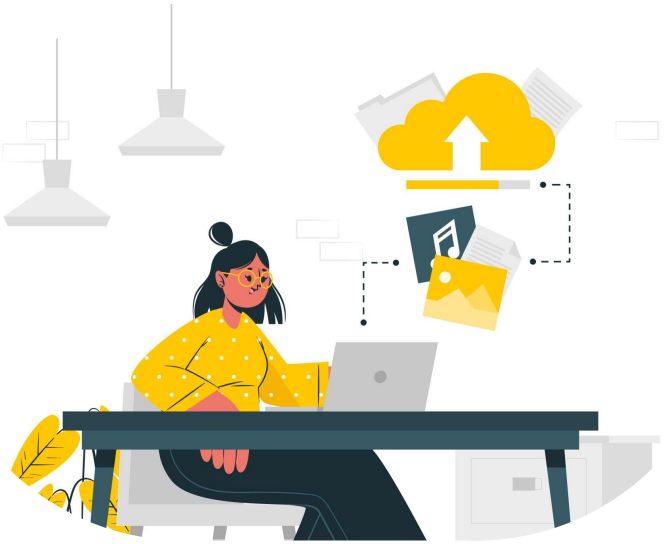
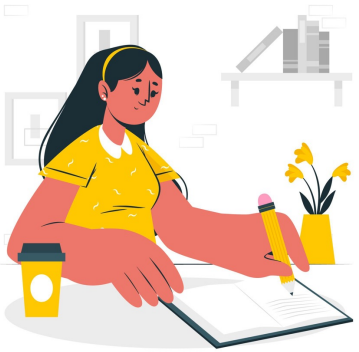


Implement

How do you achieve good figures?



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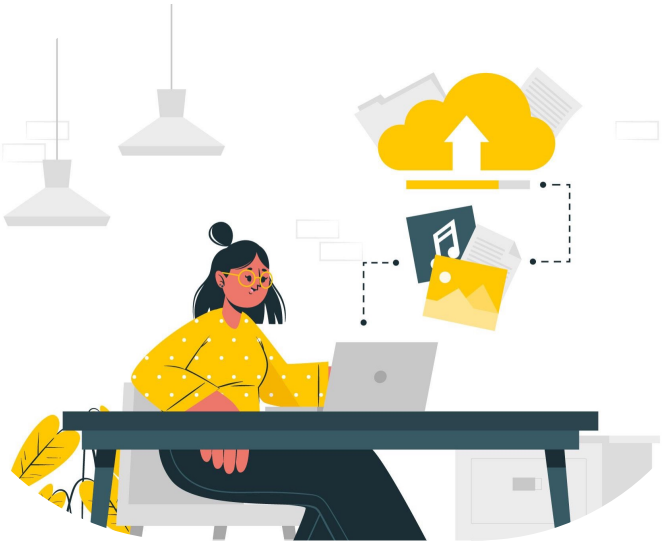
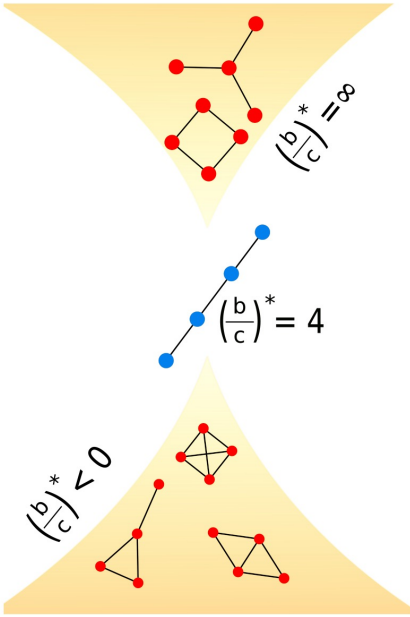
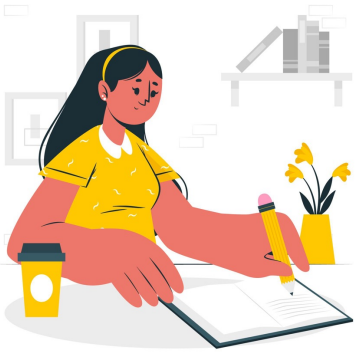


Implement

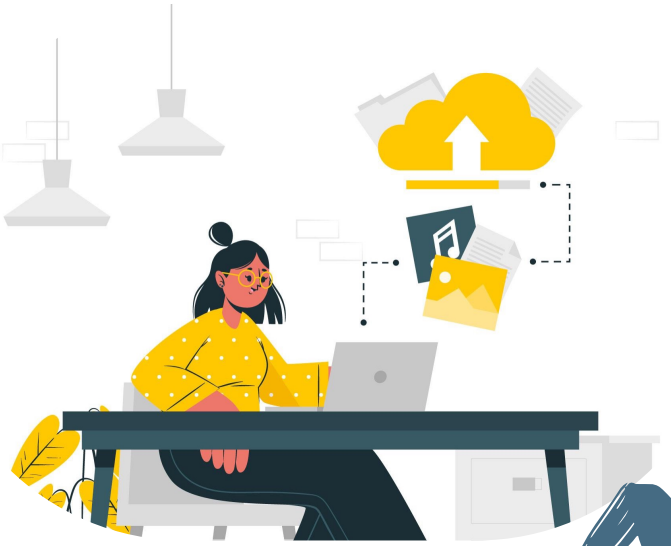


Enjoy!

How do you achieve good figures?

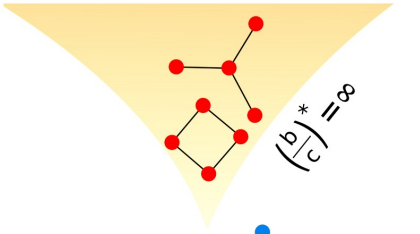


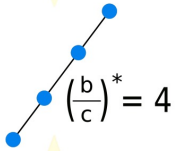
Draft/think/thinker!

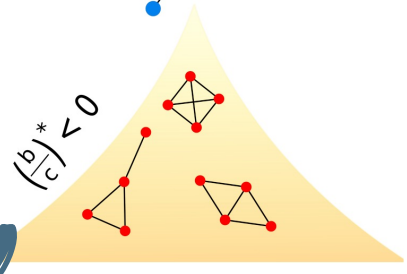


Implement

Revise if needed



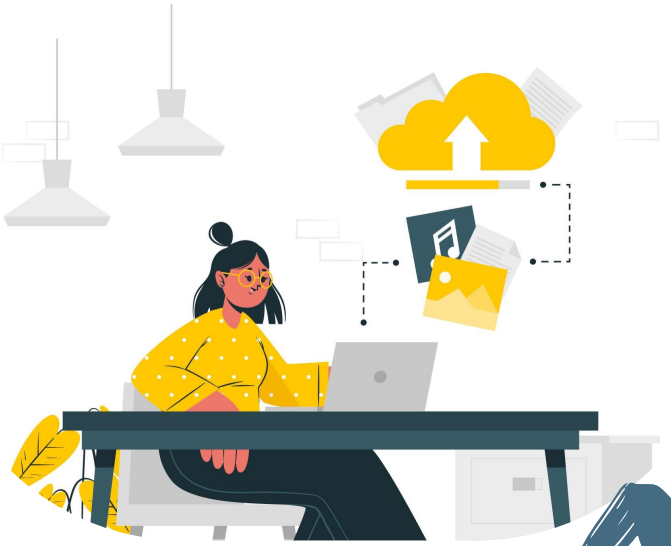




Enjoy!

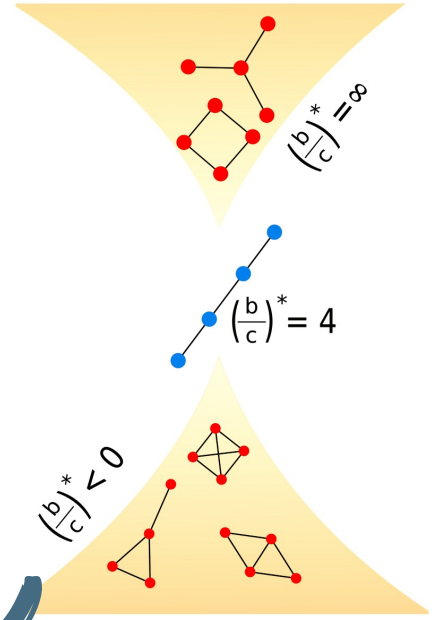
How do you achieve good figures?

Draft/think/thinker!



Implement

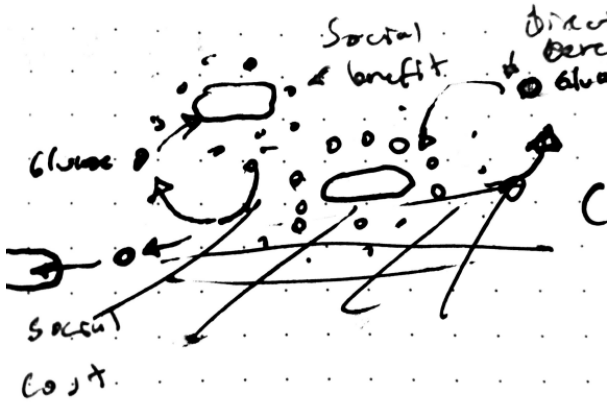
Revise if needed



Enjoy!

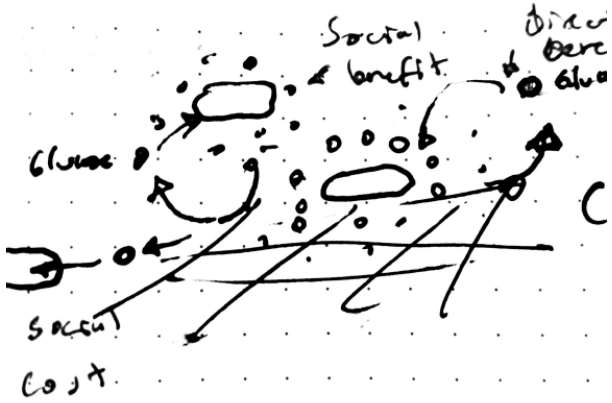
Rethink if needed

How do you achieve good figures?



Draft/think/thinker!

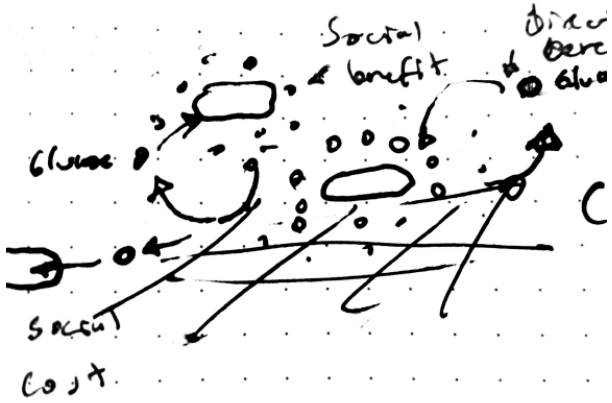
Method in action 1



Draft/think/thinker!

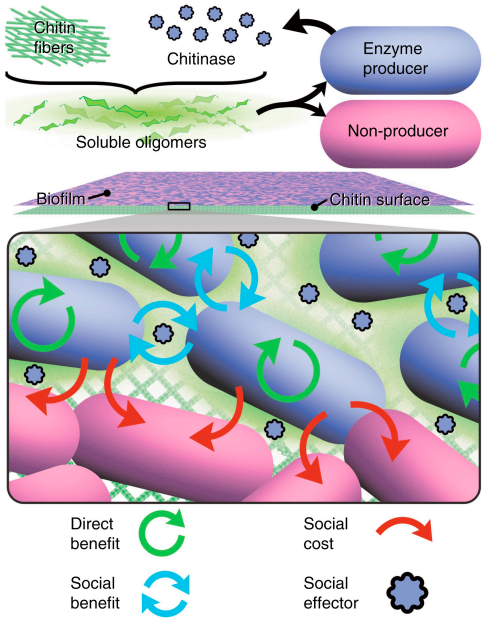
Implement

Method in action 1



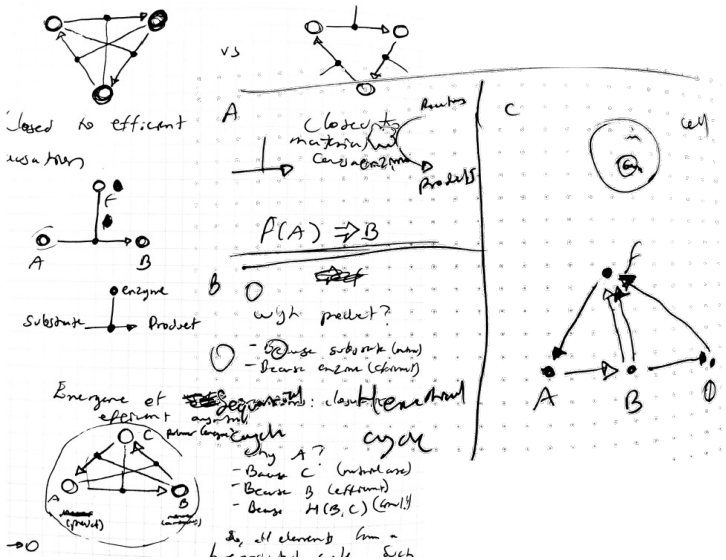
Draft/think/thinker!

Implement



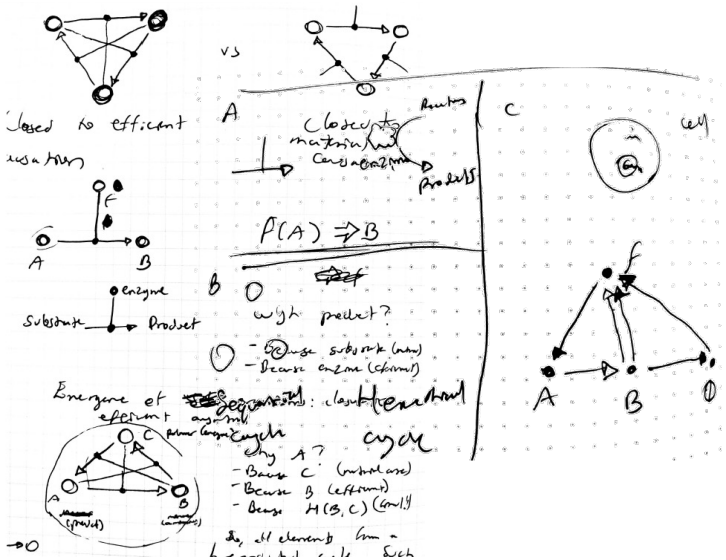
Enjoy!

Method in action 2

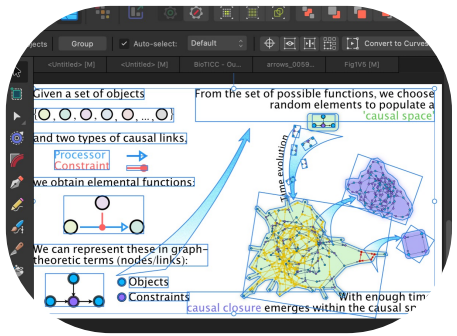


Draft/think/thinker!

Method in action 2

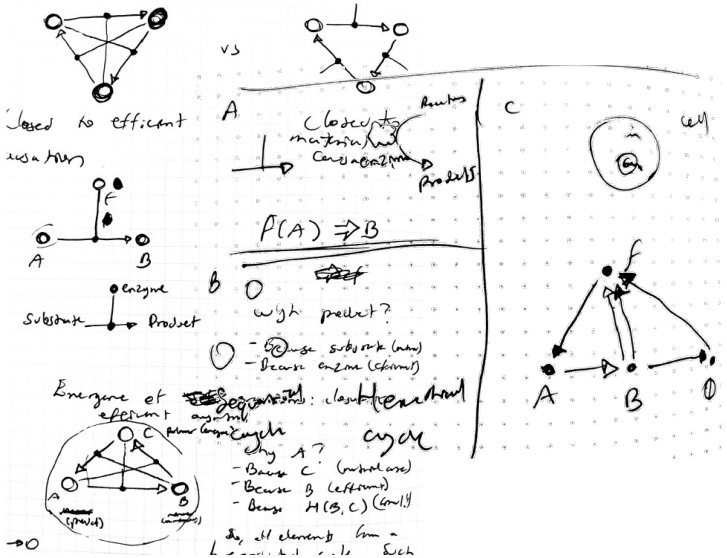


Draft/think/thinker!

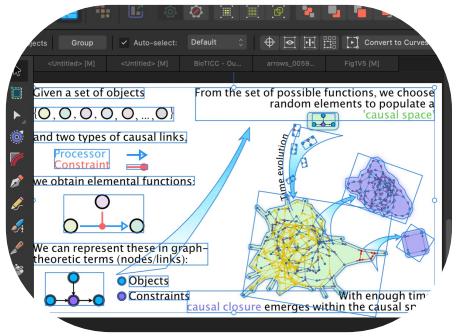


Implement

Method in action 2



Draft/think/thinker!



Implement

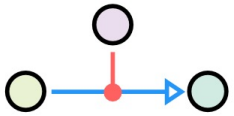
Given a set of objects

$\{O, O, O, O, O, \ldots, O\}$

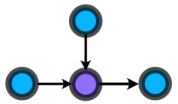
and two types of causal links,

Processor
Constraint

we obtain elemental functions:

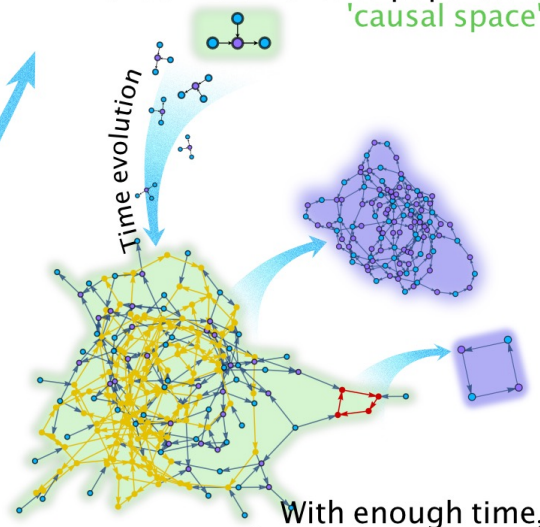


We can represent these in graph-theoretic terms (nodes/links):



Objects
Constraints

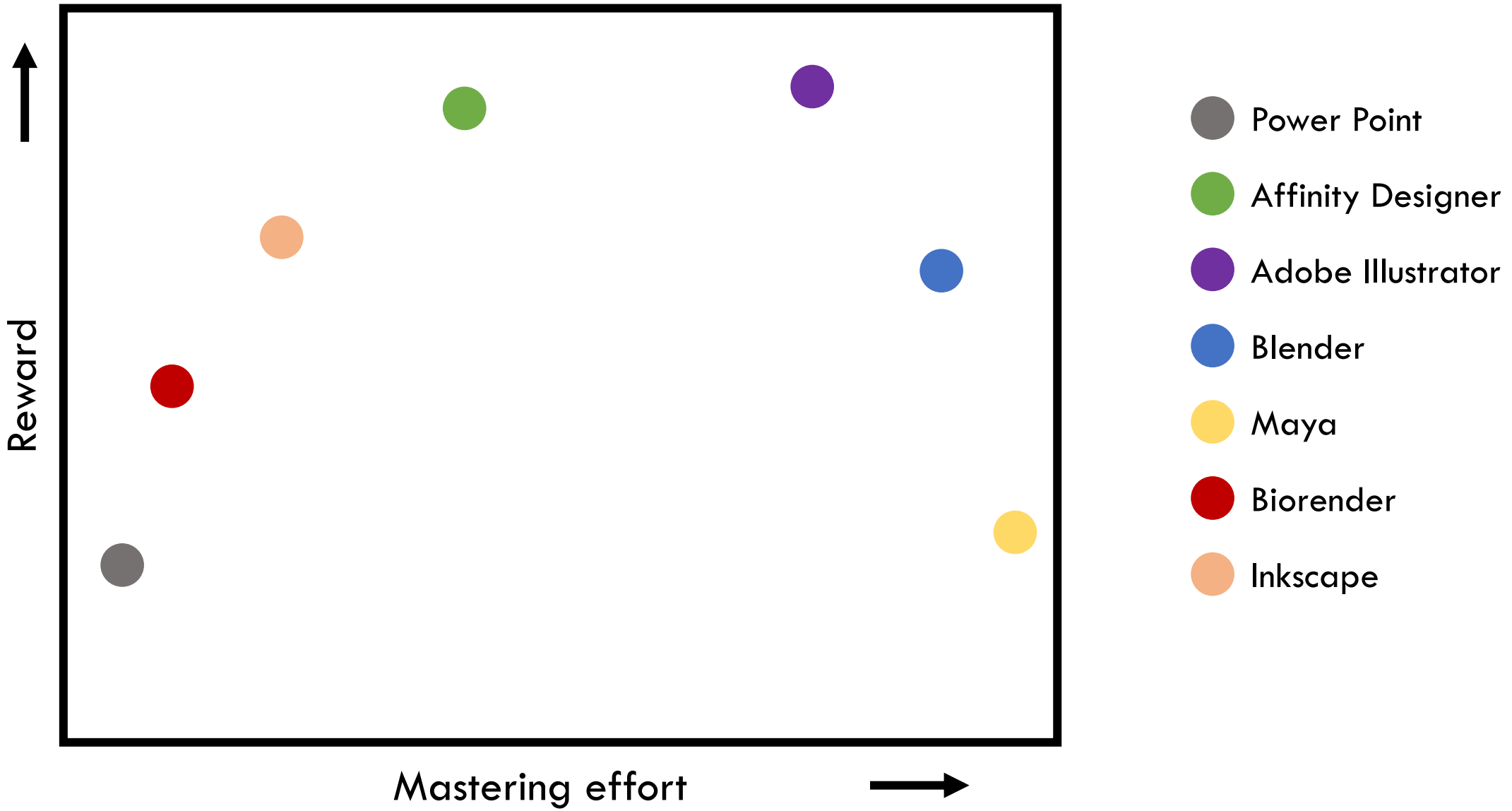
From the set of possible functions, we choose random elements to populate a 'causal space'



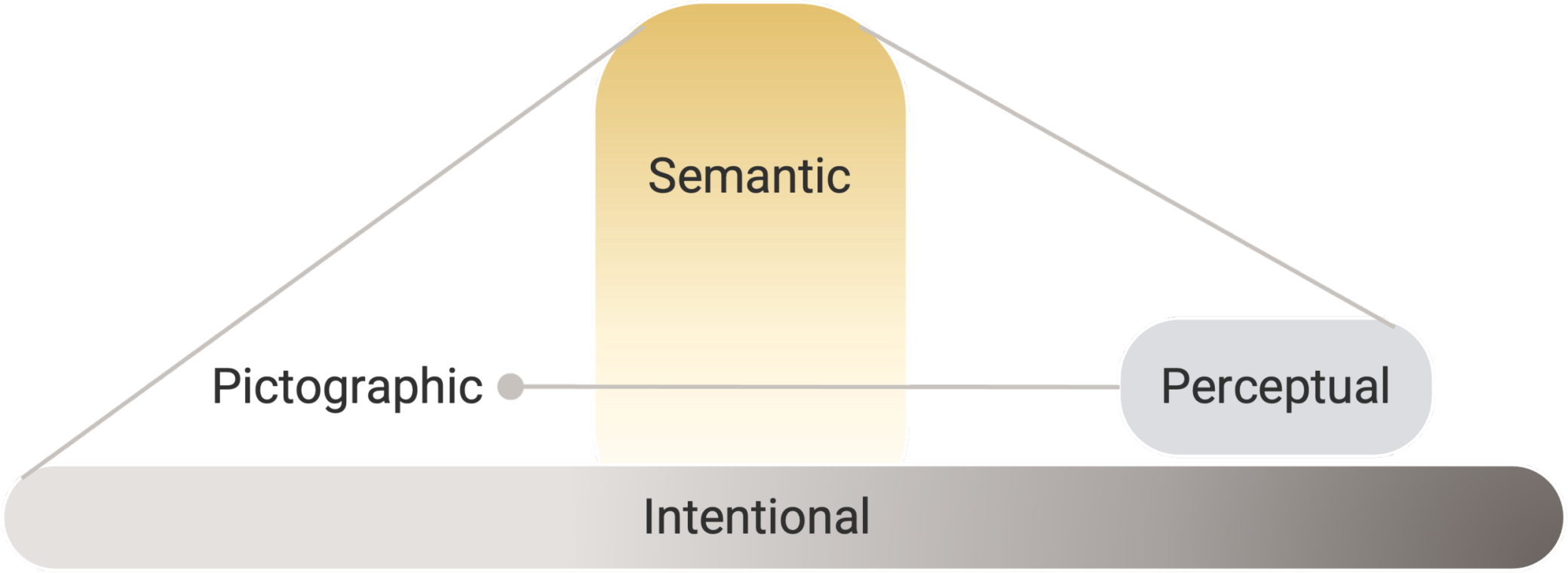
With enough time, causal closure emerges within the causal space

Enjoy!

Which tools to use?



What do you see?



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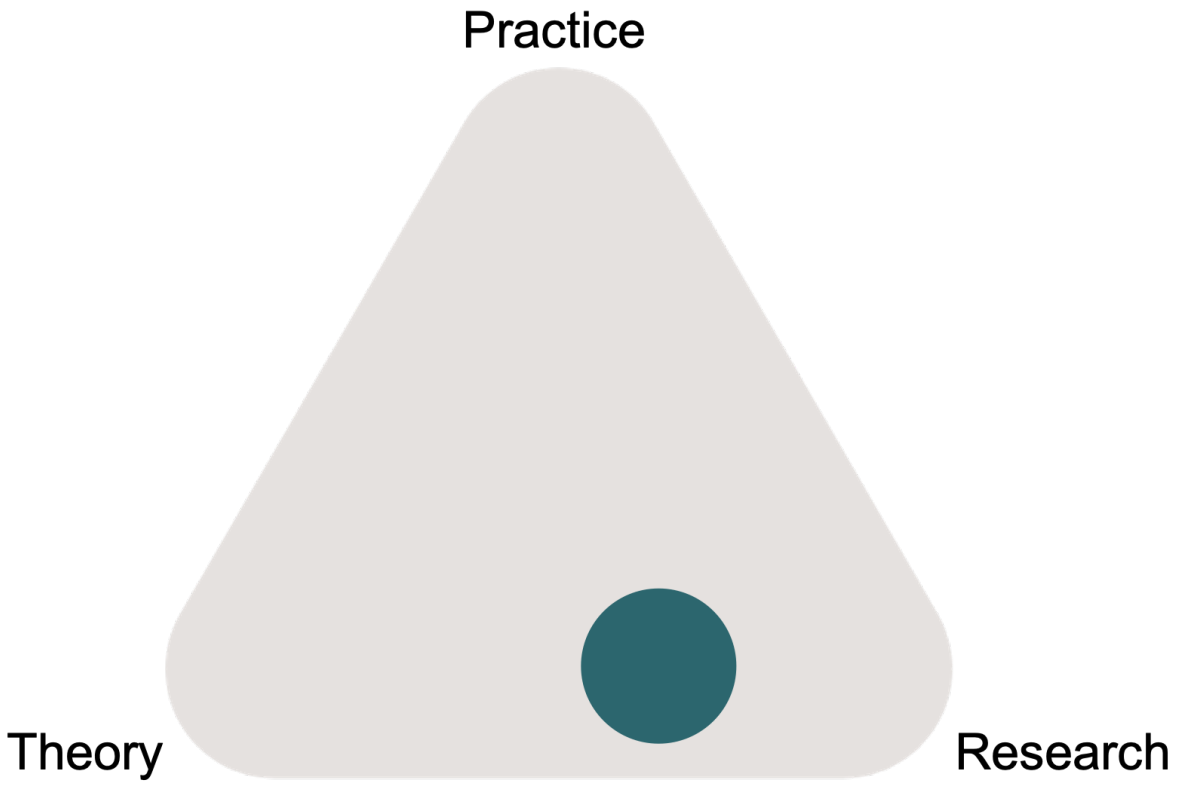

What do you see?

Perception

Semantics

Intent

Putting it all together

2. What’s your story?

Ask yourself

- *Why* is this important?

Ask yourself

- *Why* is this important?
- *What's* the gap in the knowledge?

Ask yourself

- *Why* is this important?
- *What's* the gap in the knowledge?
- *What* did you do/plan to fill the gap?

Ask yourself

- *Why* is this important?
- *What's* the gap in the knowledge?
- *What* did you do/plan to fill the gap?
- *What* are the implications of your results/proposal?

Ask yourself

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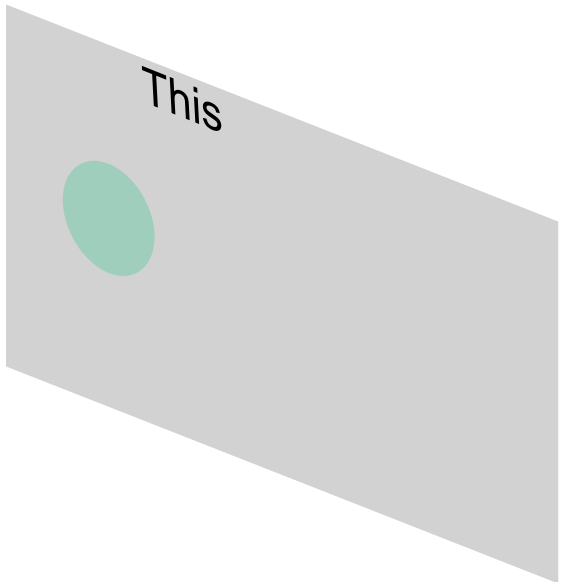
- *What* are the implications of your results/proposal?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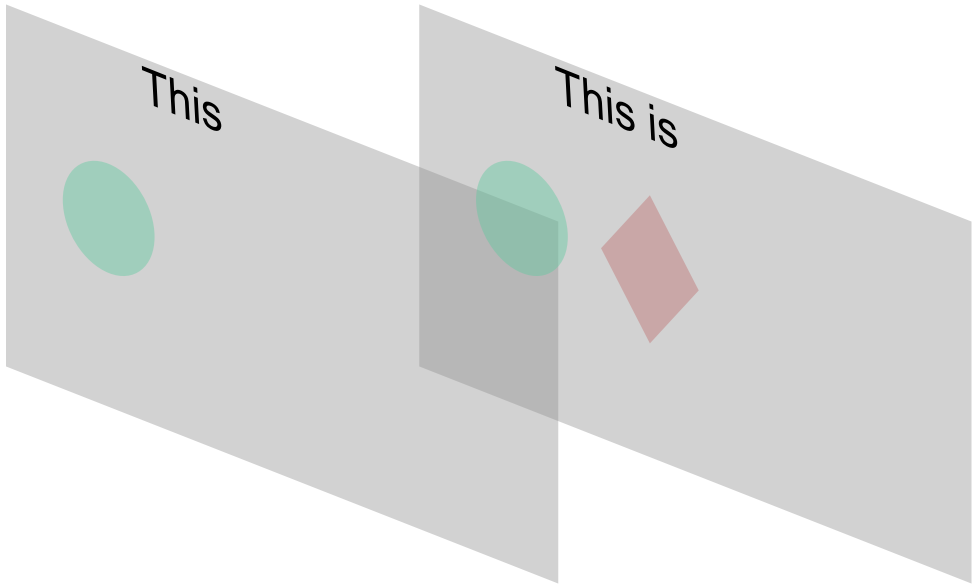
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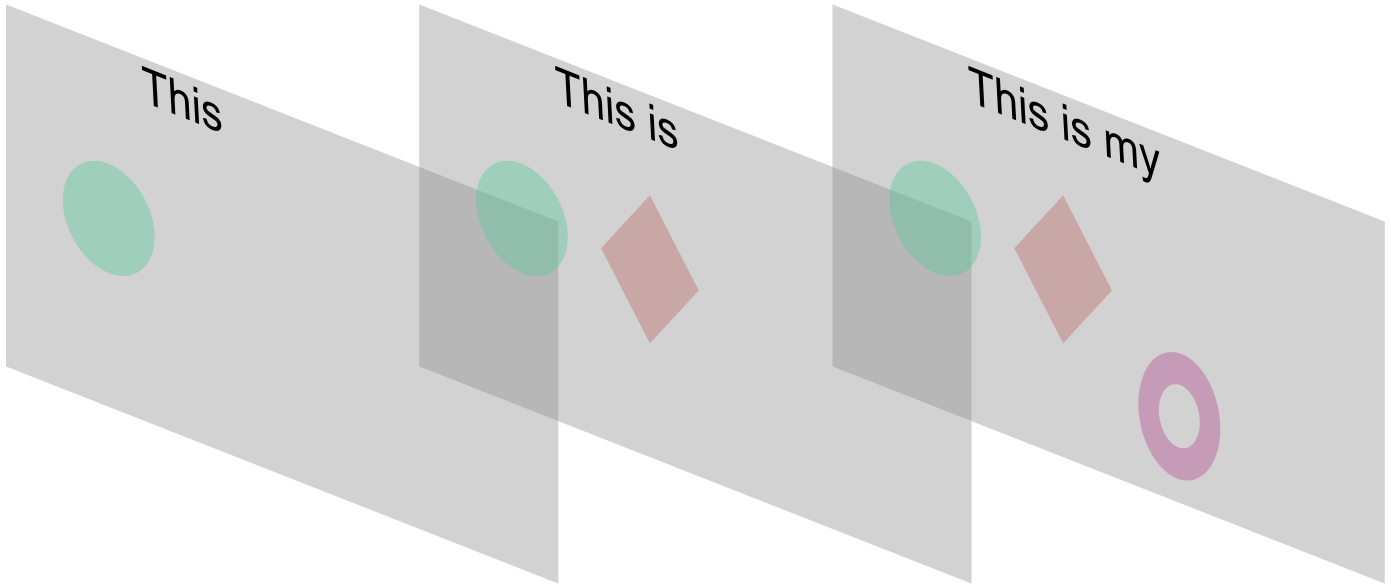
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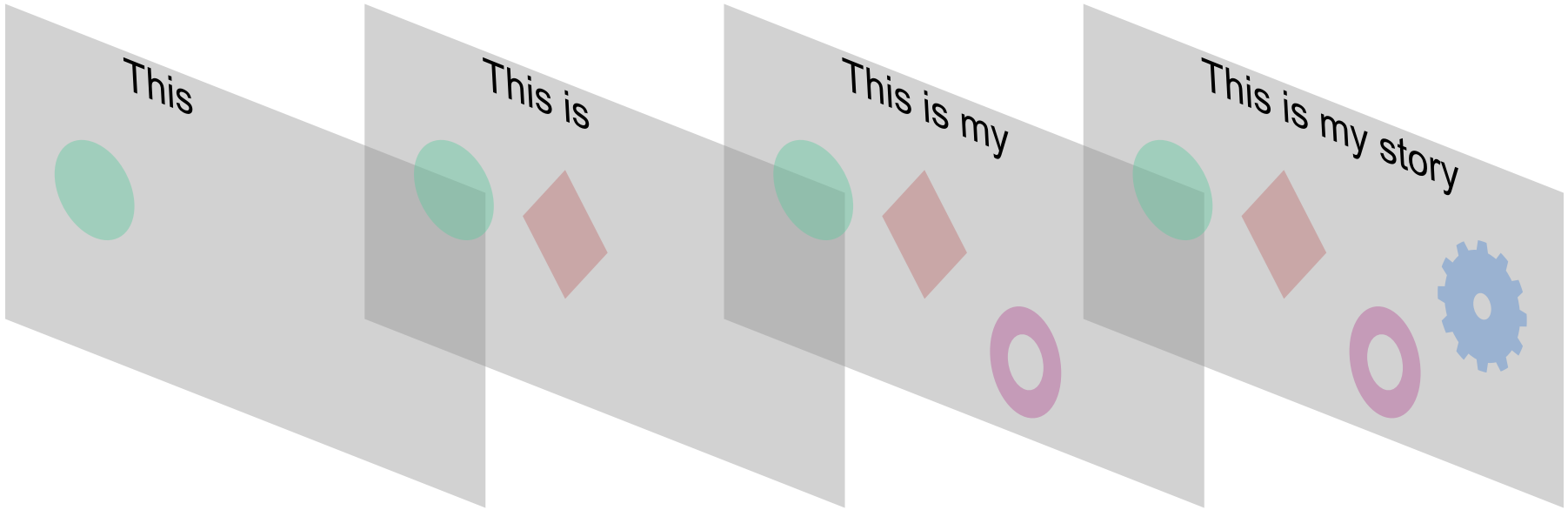
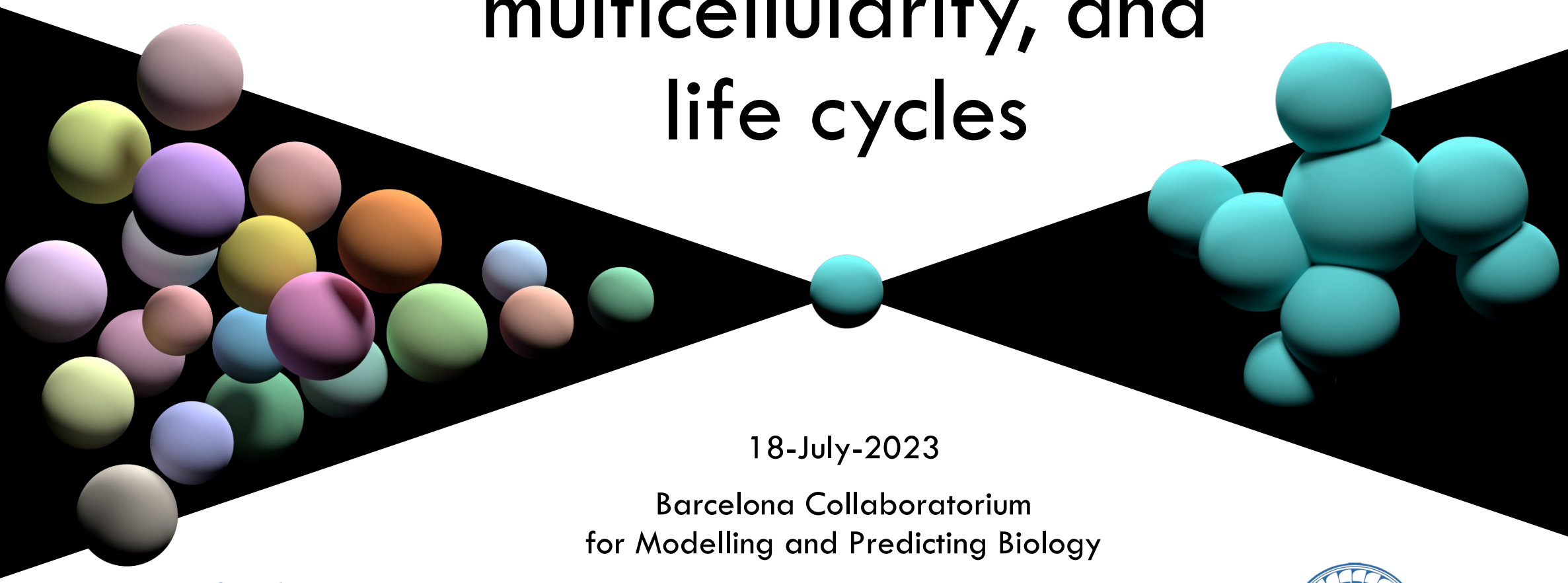

This
This is
This is my
This is my story

Evolutionary transitions, multicellularity, and life cycles



18-July-2023

Barcelona Collaboratorium
for Modelling and Predicting Biology

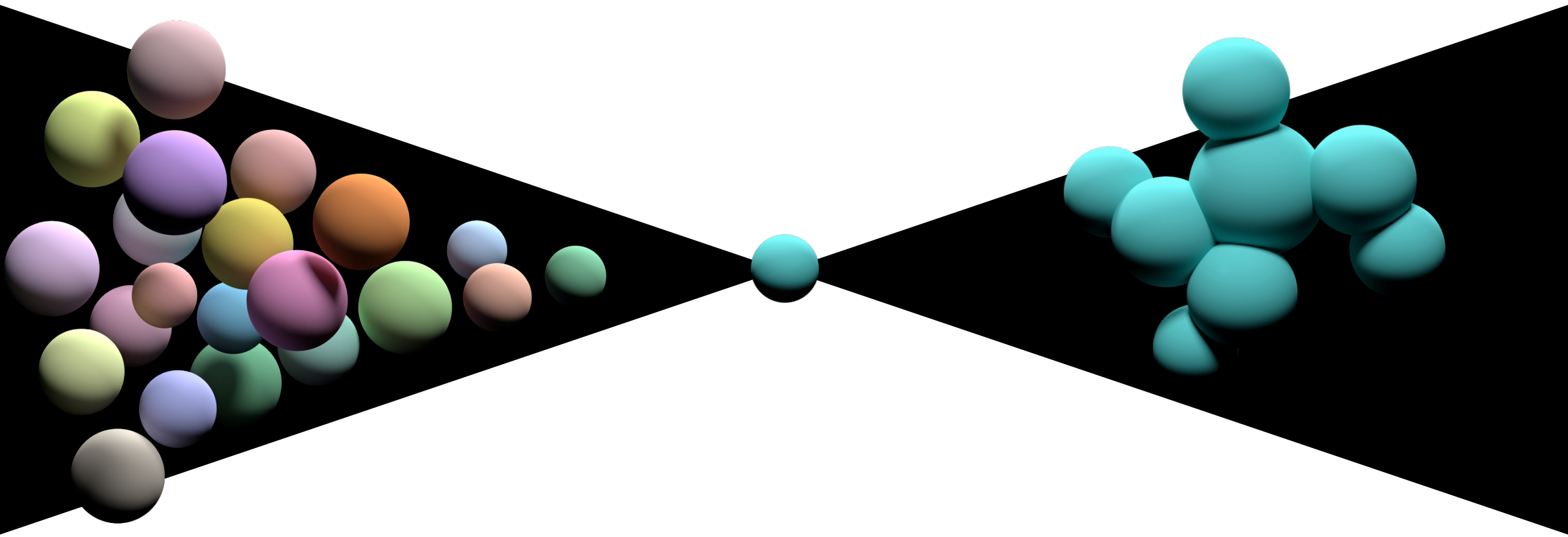
Pedro Márquez-Zacarías, PhD

Omidyar Complexity Fellow, Santa Fe Institute

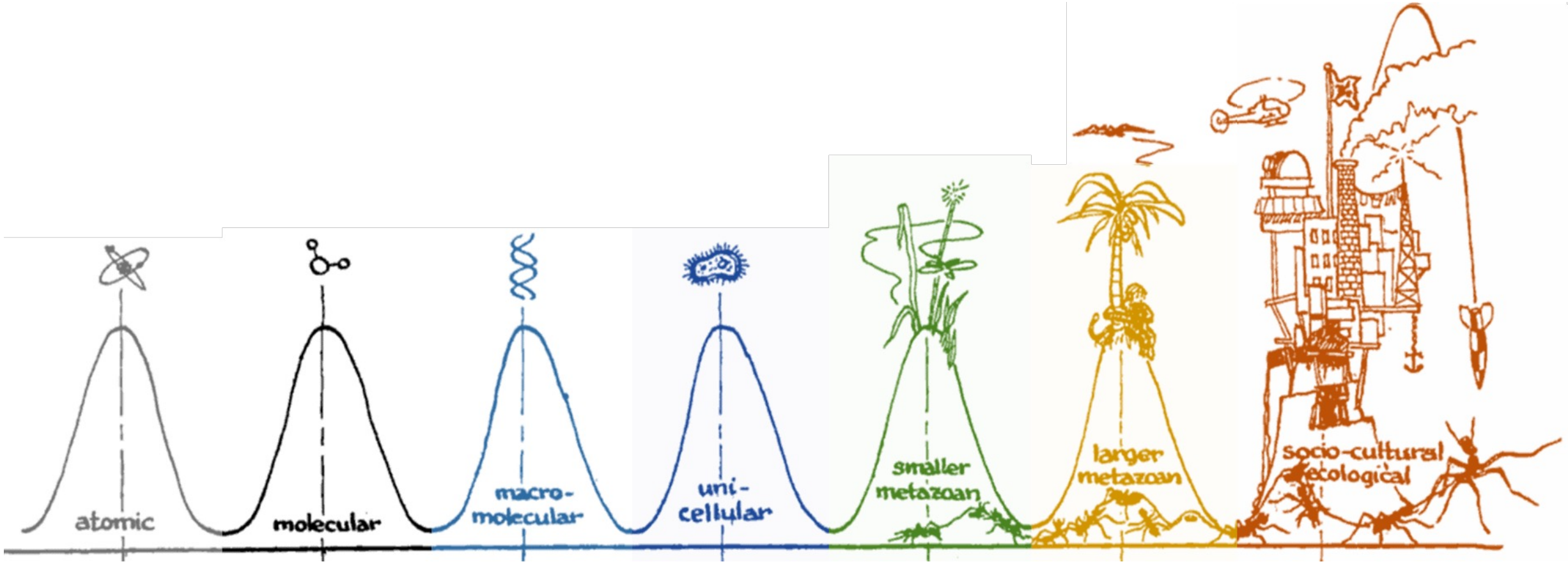
EMBL Barcelona Collaboratorium

CRG Centre for Genomic Regulation

SANTA FE INSTITUTE

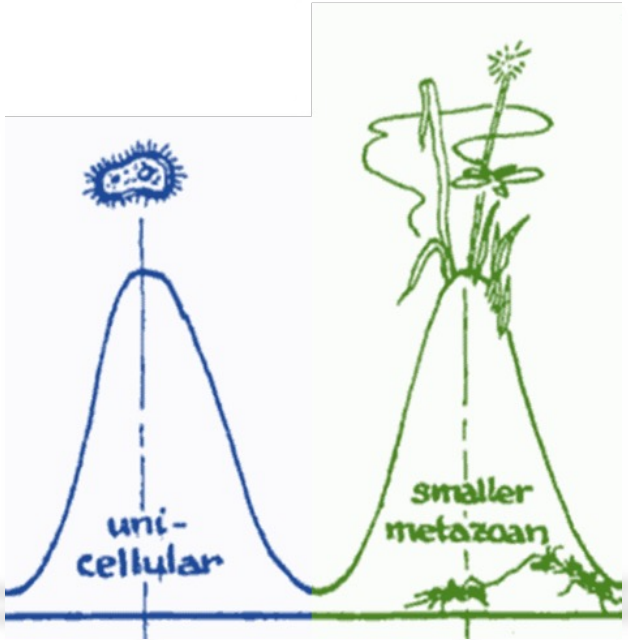


Life is organized hierarchically



Wimsatt (1978)

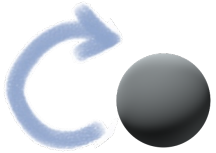
How did single-cells become multicellular organisms?



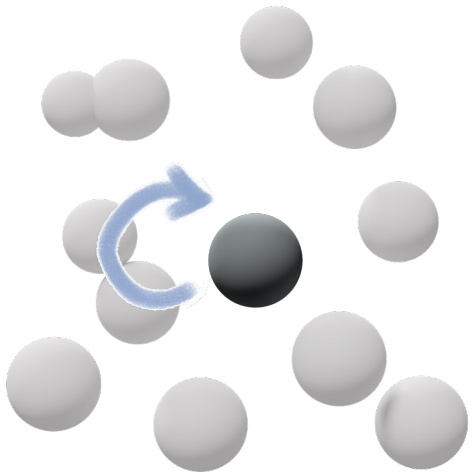
Wimsatt (1978)

Transition to multicellularity

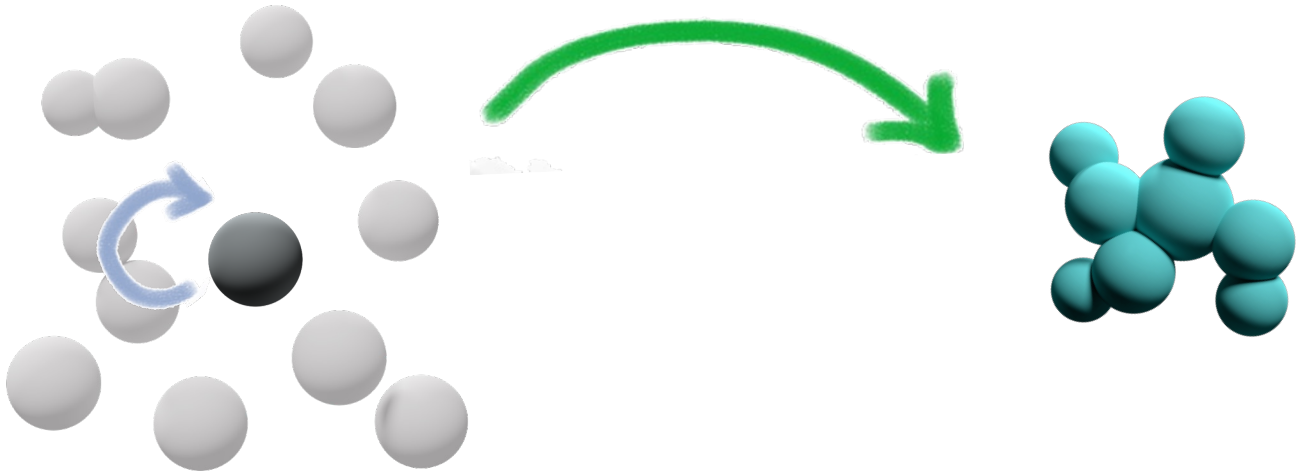
Transition to multicellularity



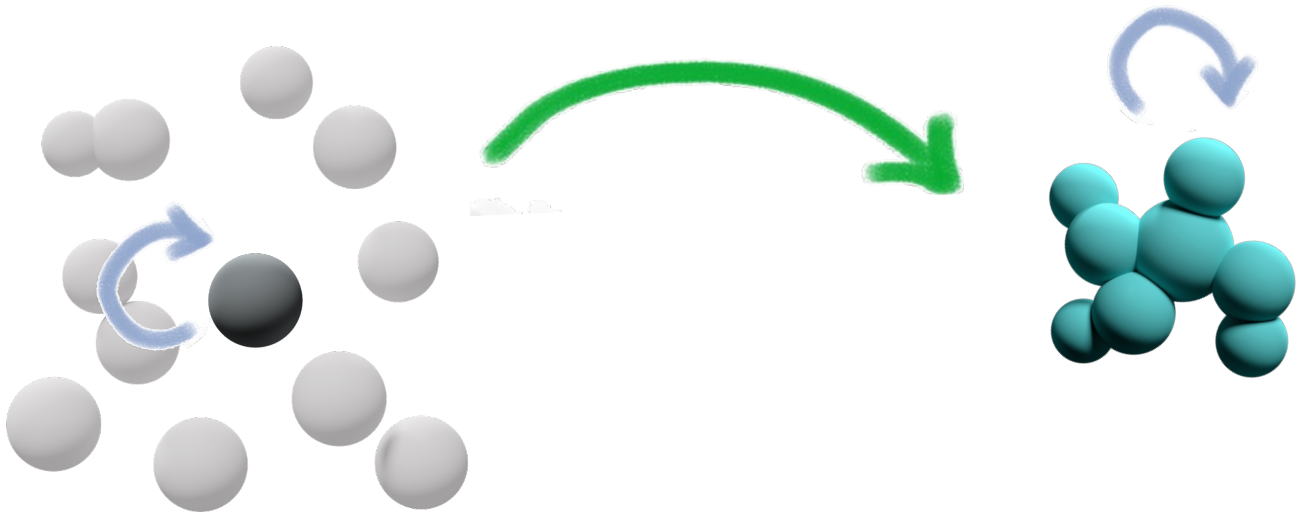
Transition to multicellularity



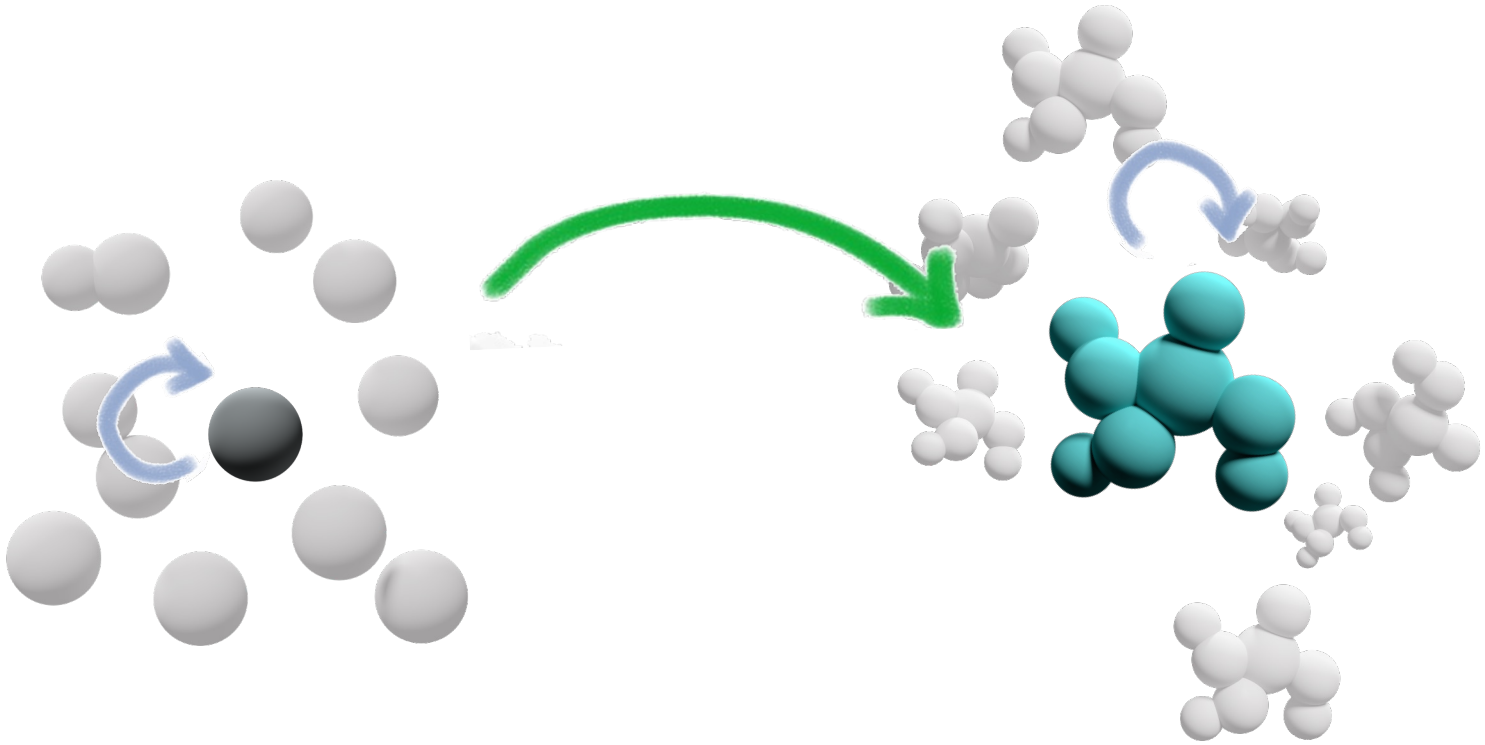
Transition to multicellularity



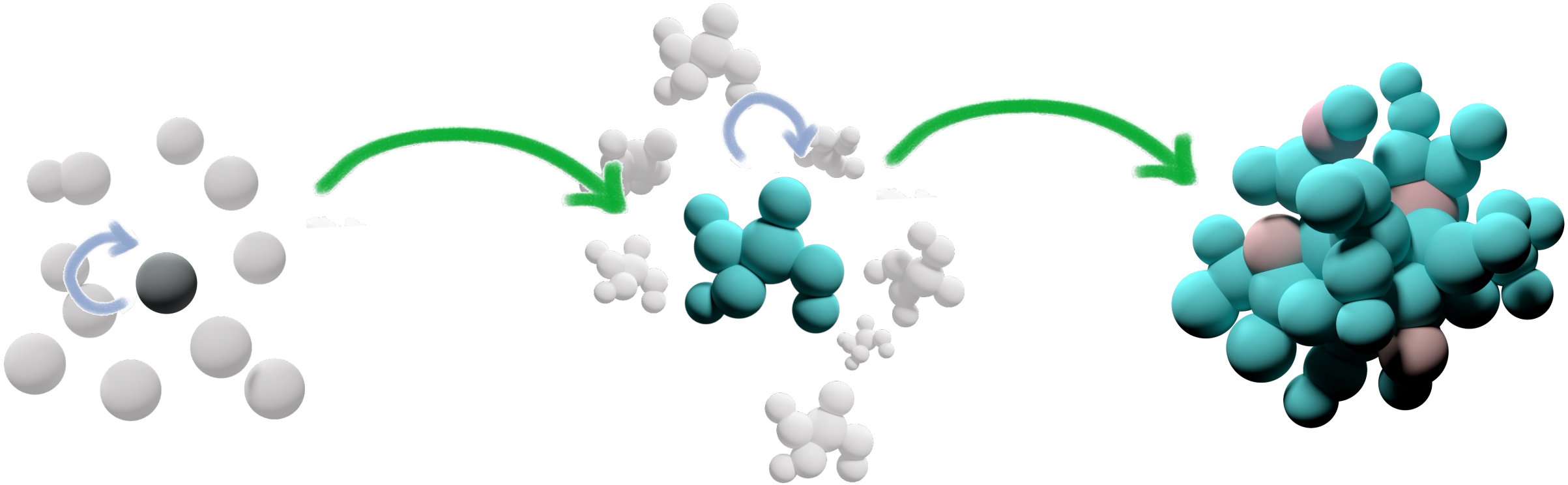
Transition to multicellularity



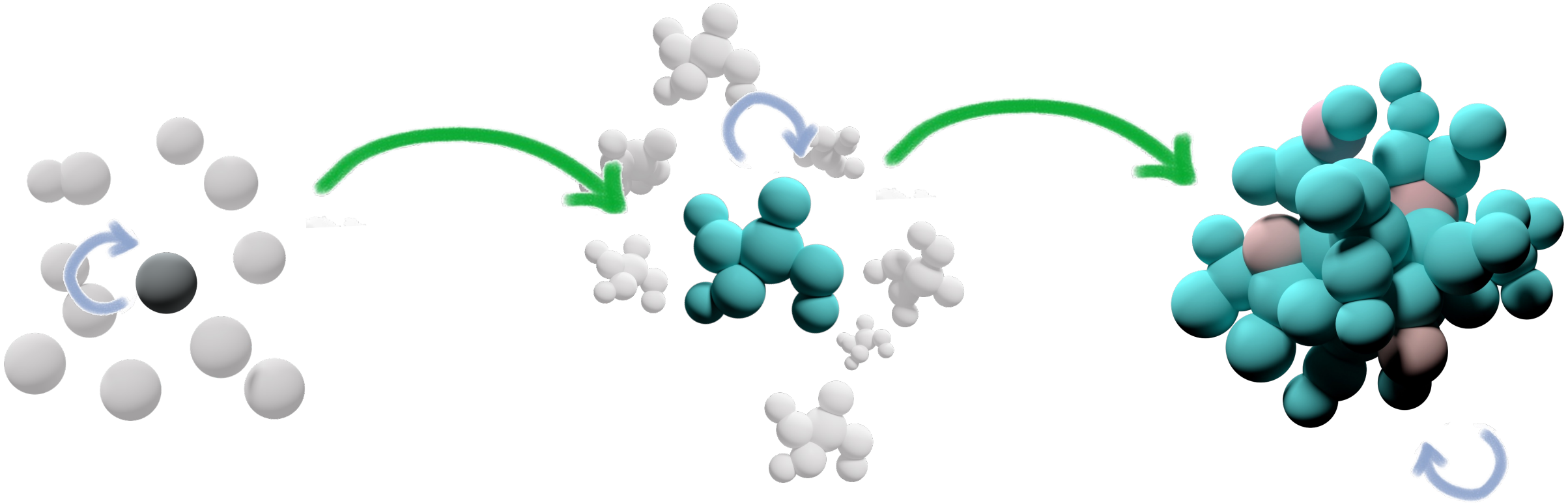
Transition to multicellularity



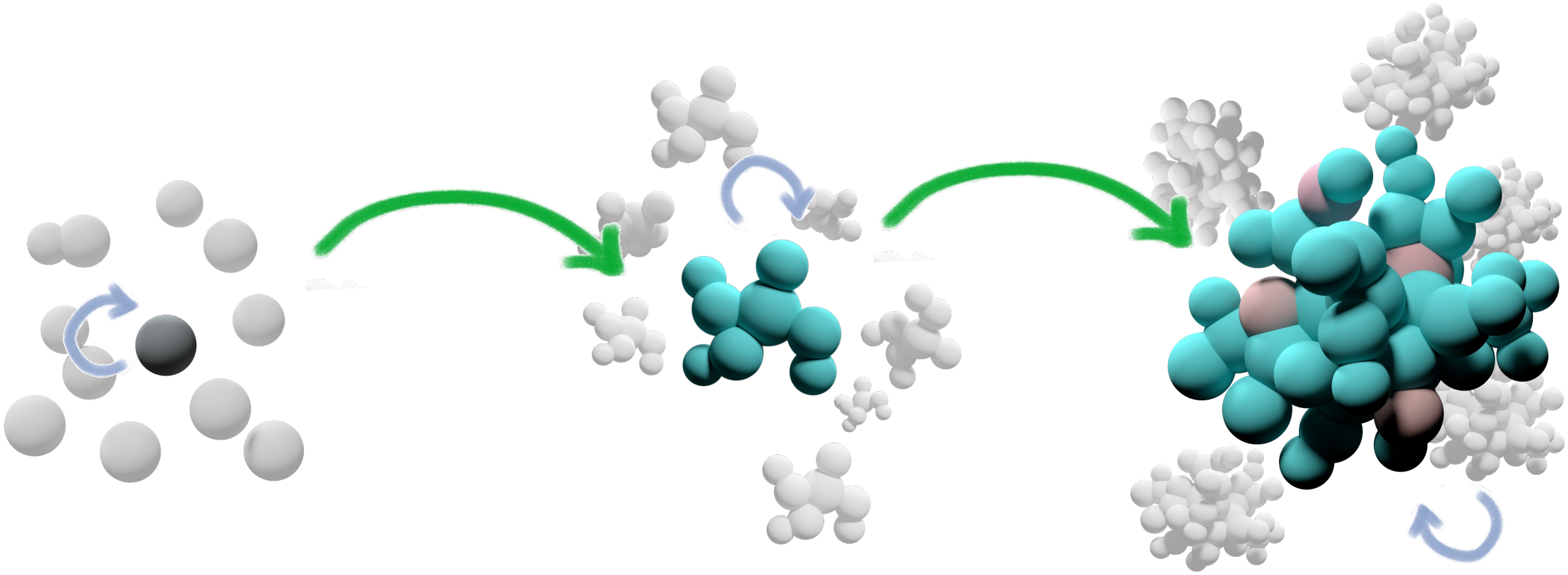
Transition to multicellularity



Transition to multicellularity

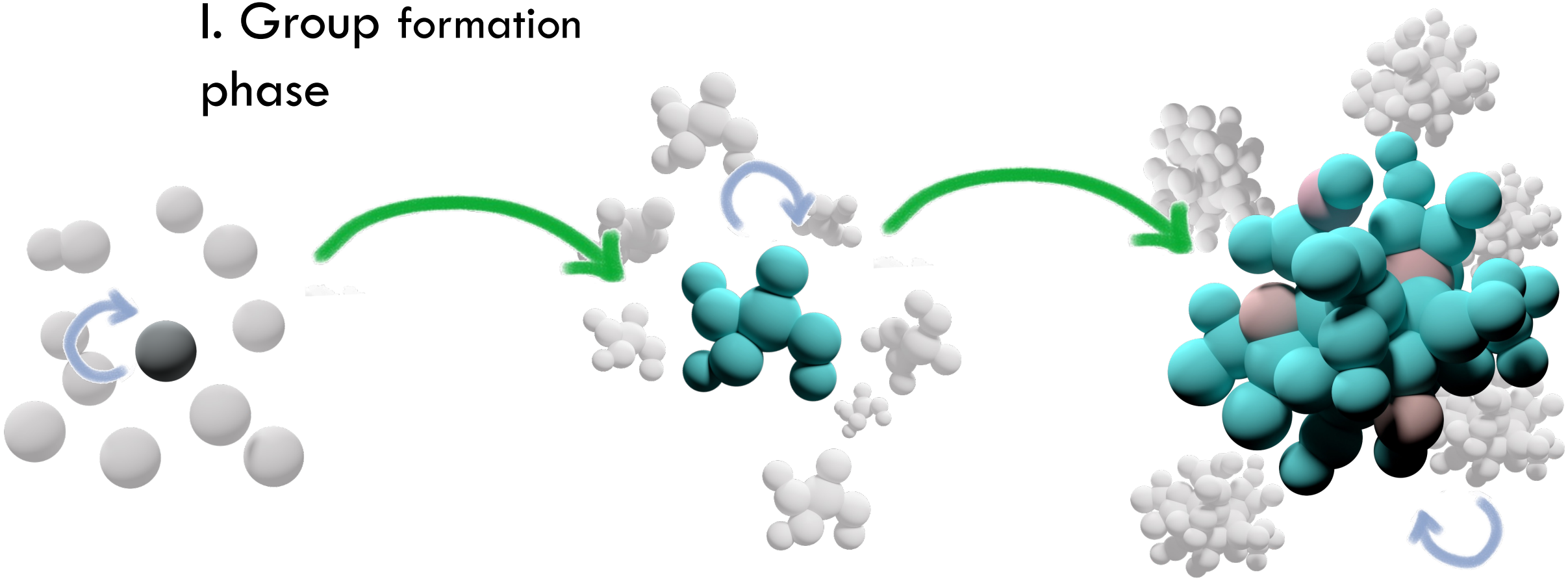


Transition to multicellularity



Transition to multicellularity

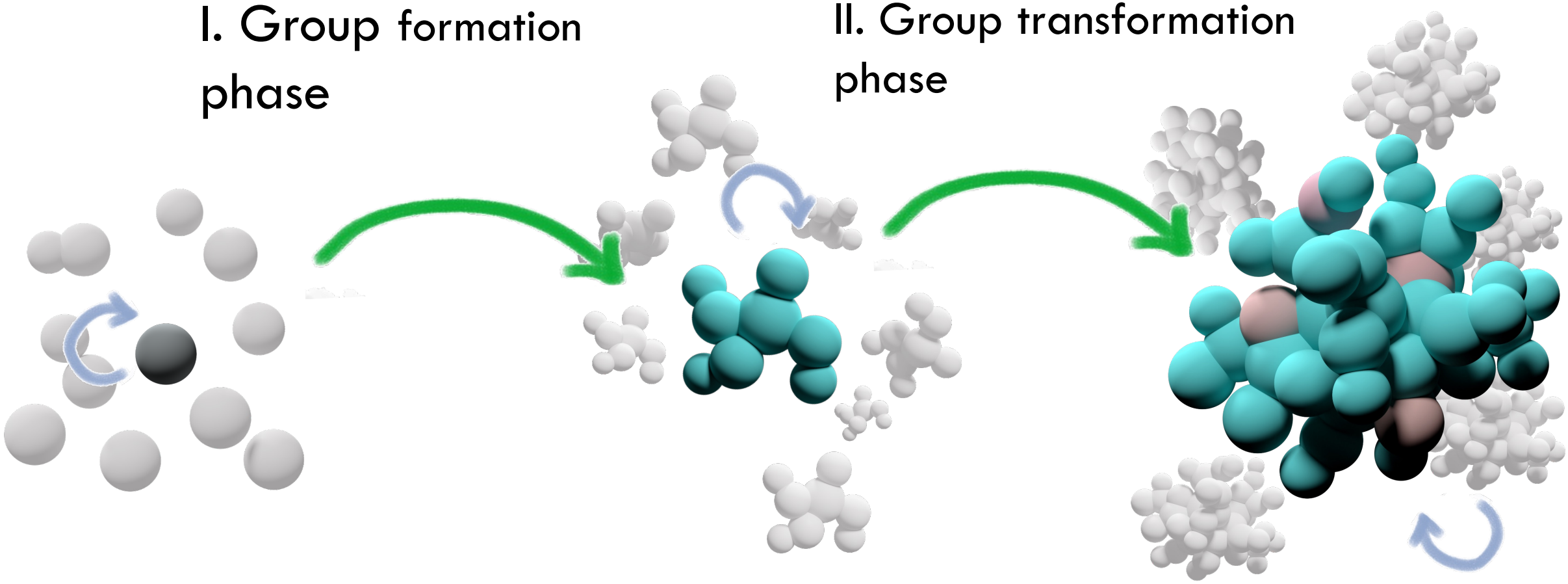
I. Group formation phase



Transition to multicellularity

I. Group formation phase

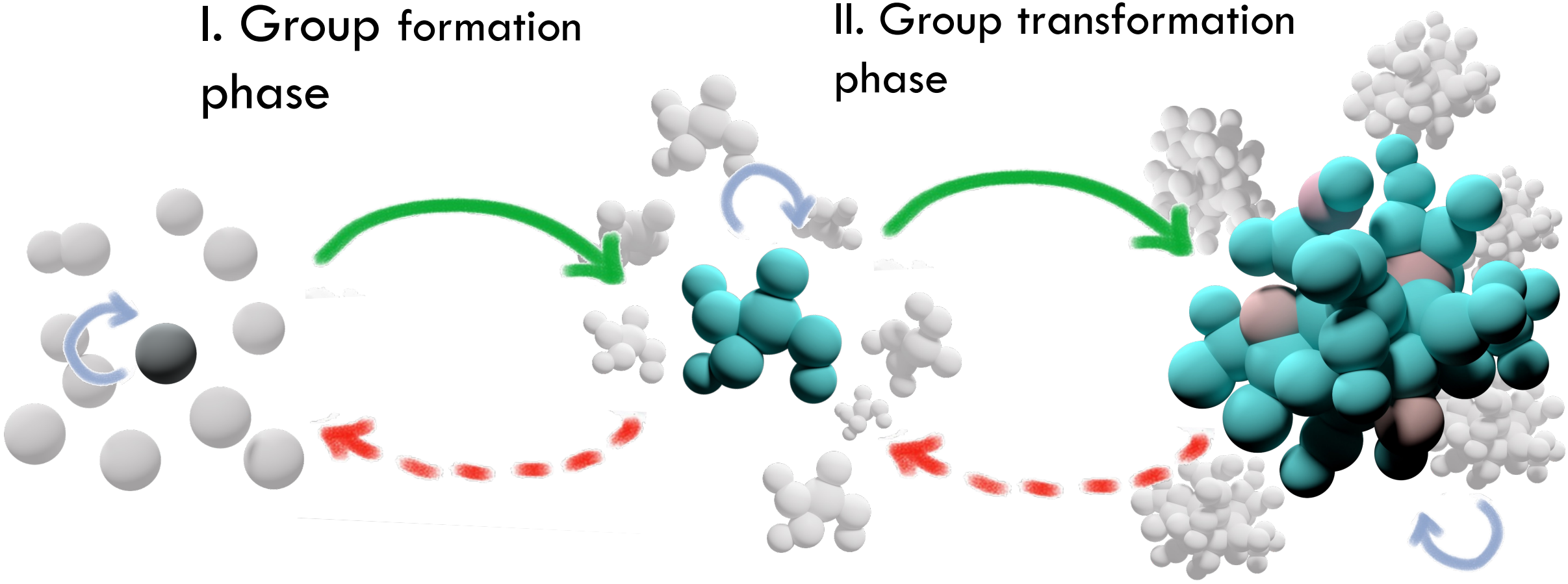
II. Group transformation phase



Transition to multicellularity

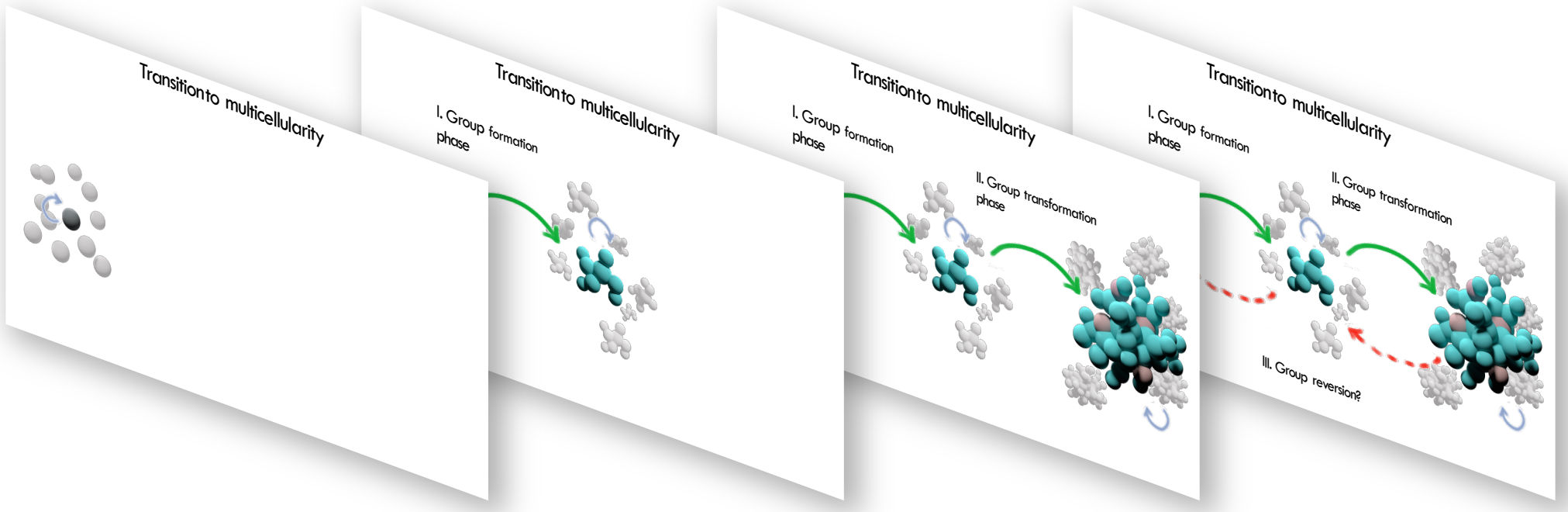
I. Group formation phase

II. Group transformation phase

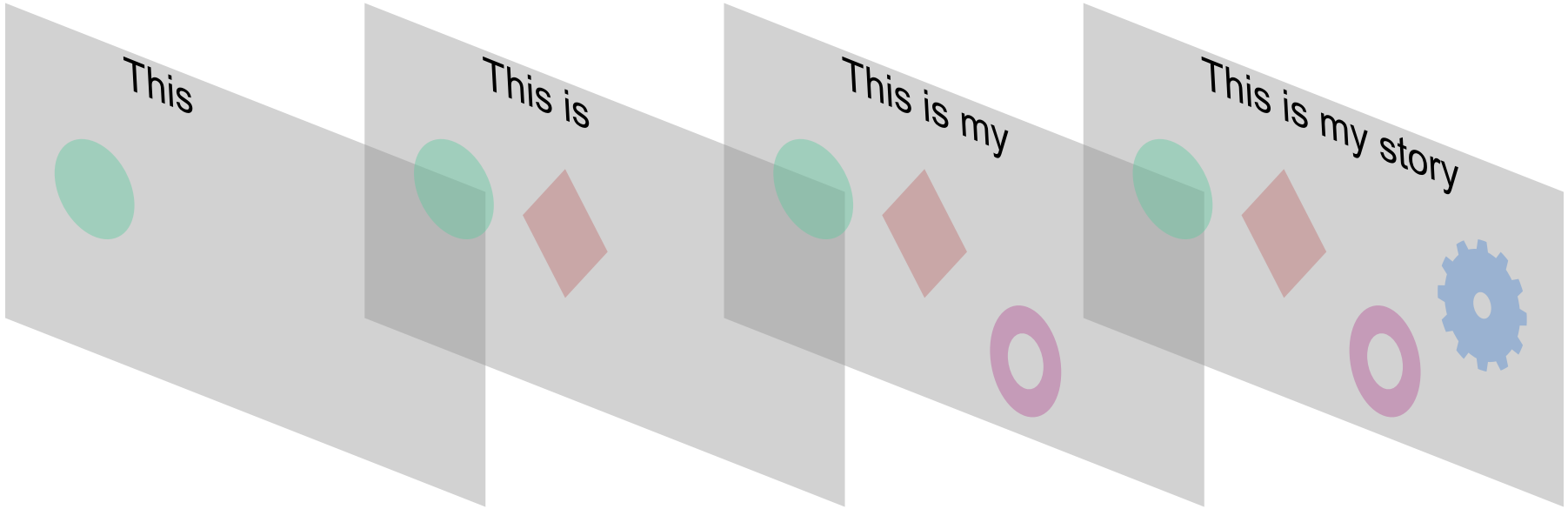


III. Group reversion?

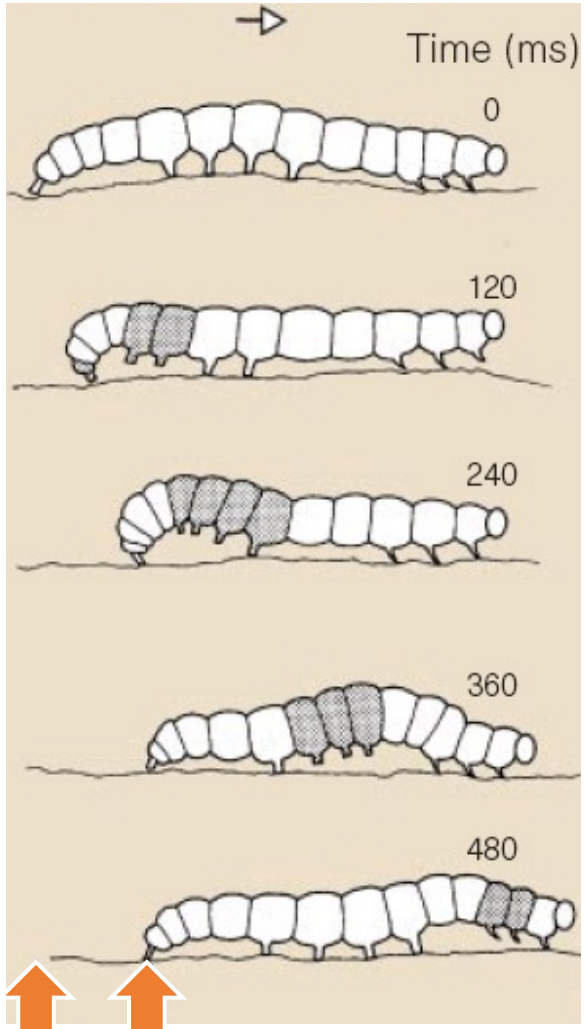
This… is… my… story…



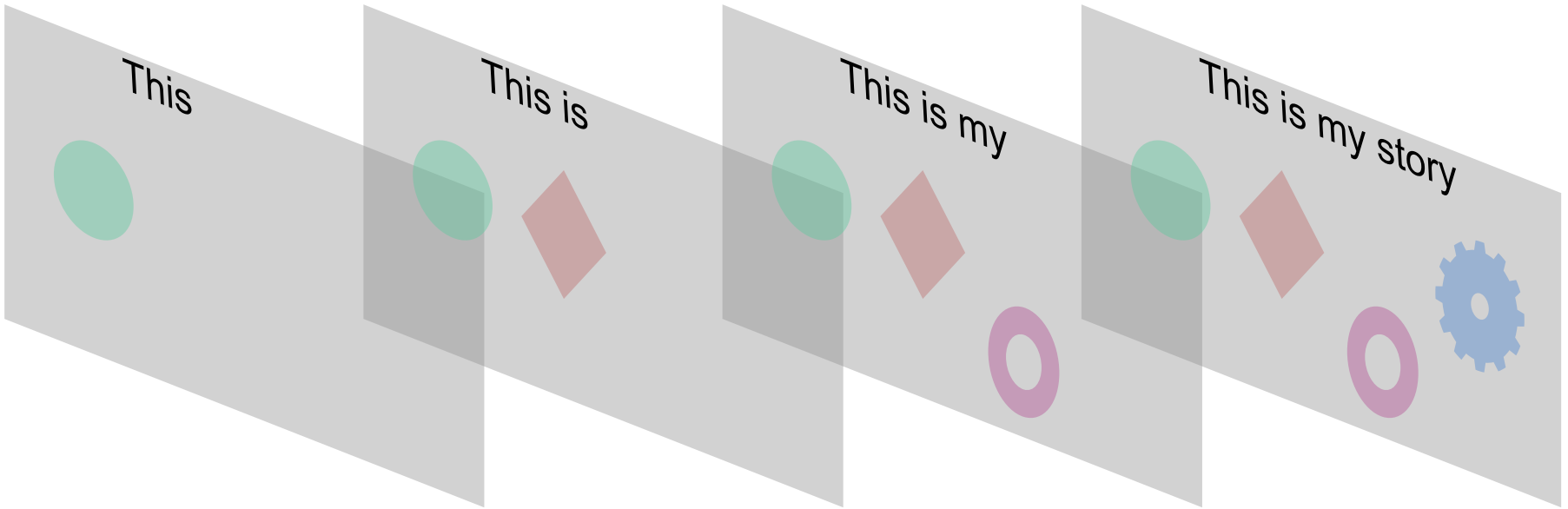
How do you achieve this?



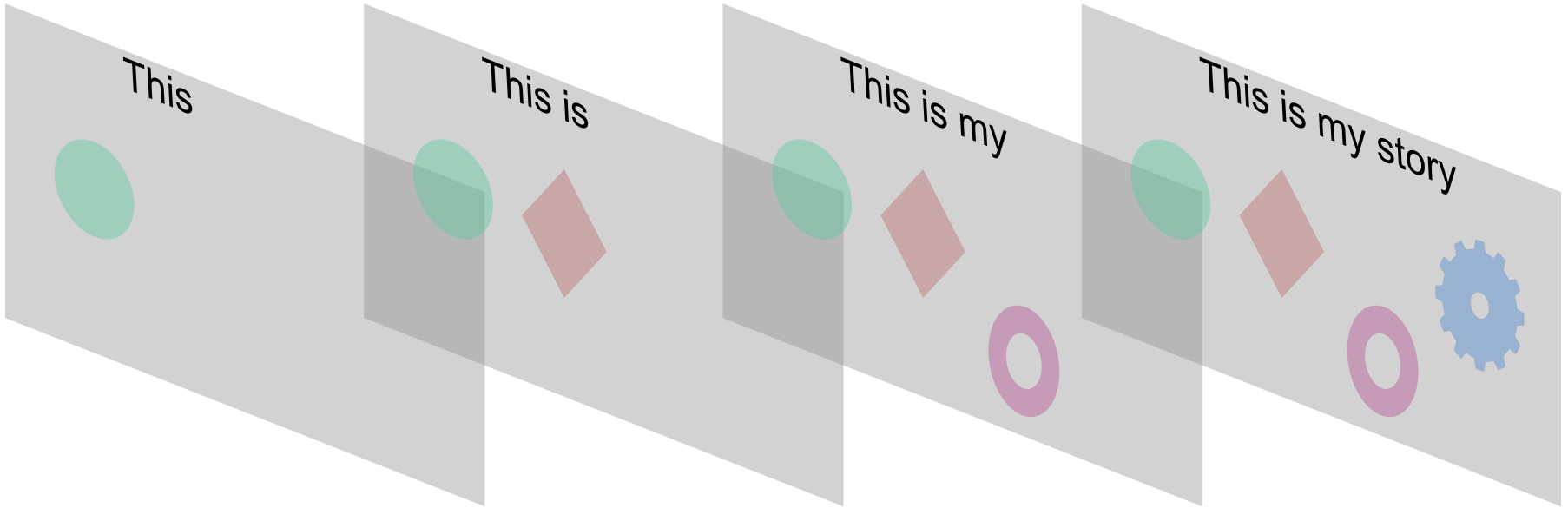
Caterpillar method



Brackenbury, 1997



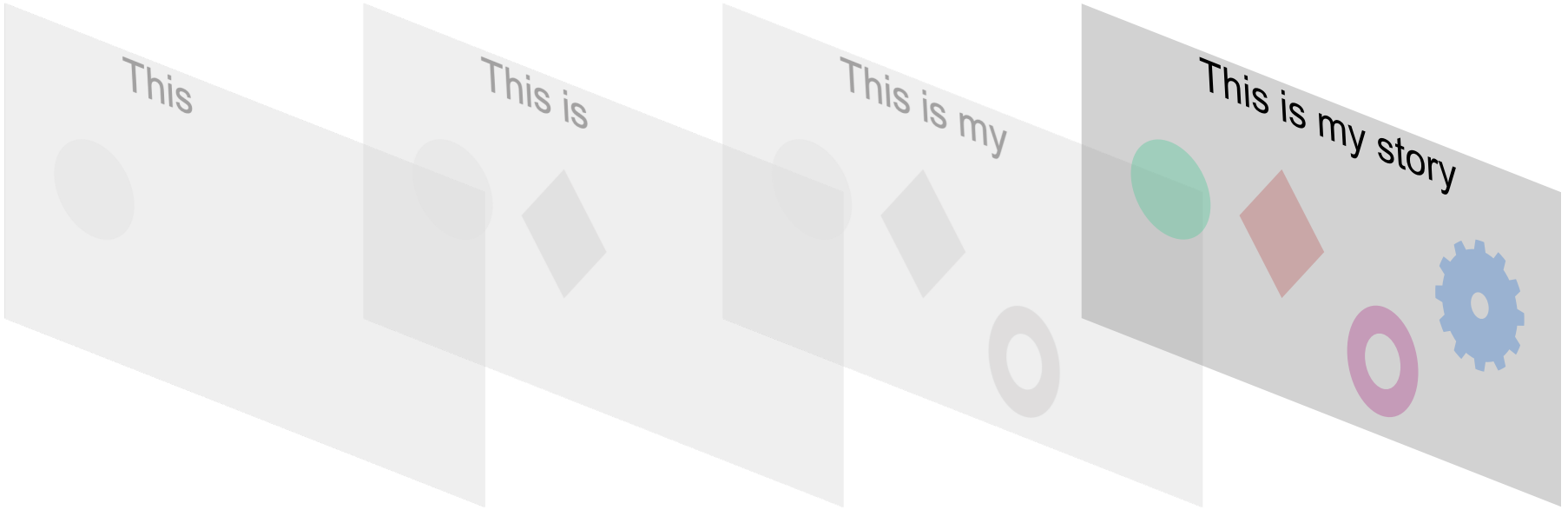
Backtracking



This is the last slide you'll make

Start here: the 'finished' slide

Backtracking



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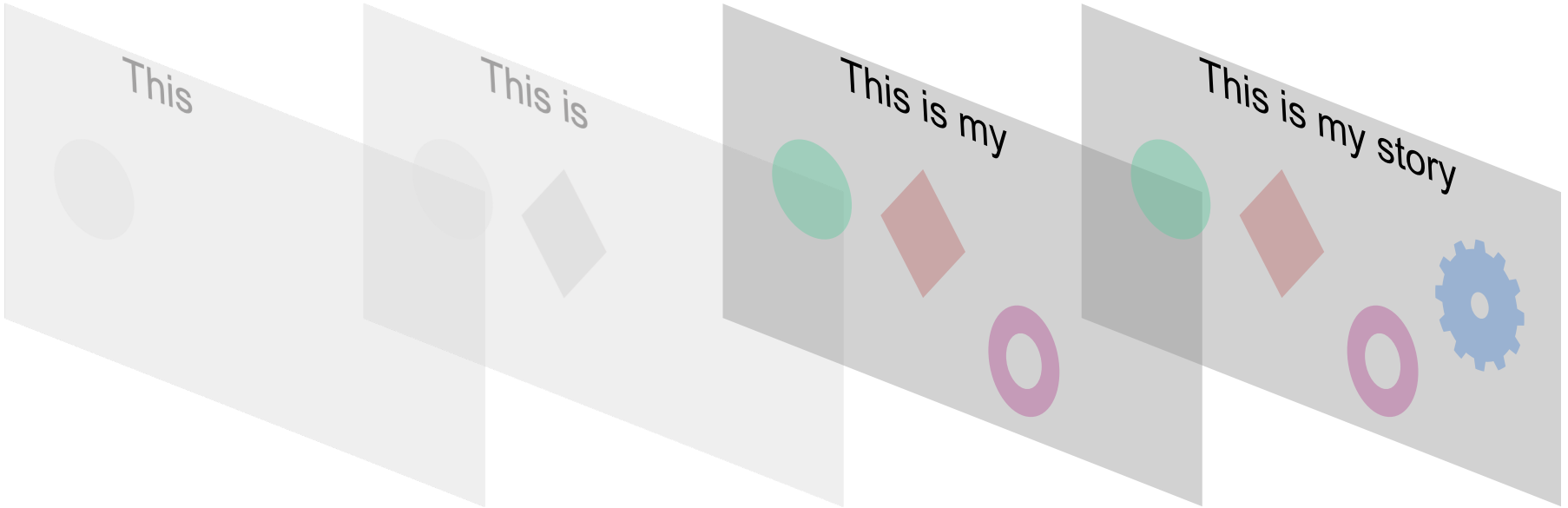
Backtracking



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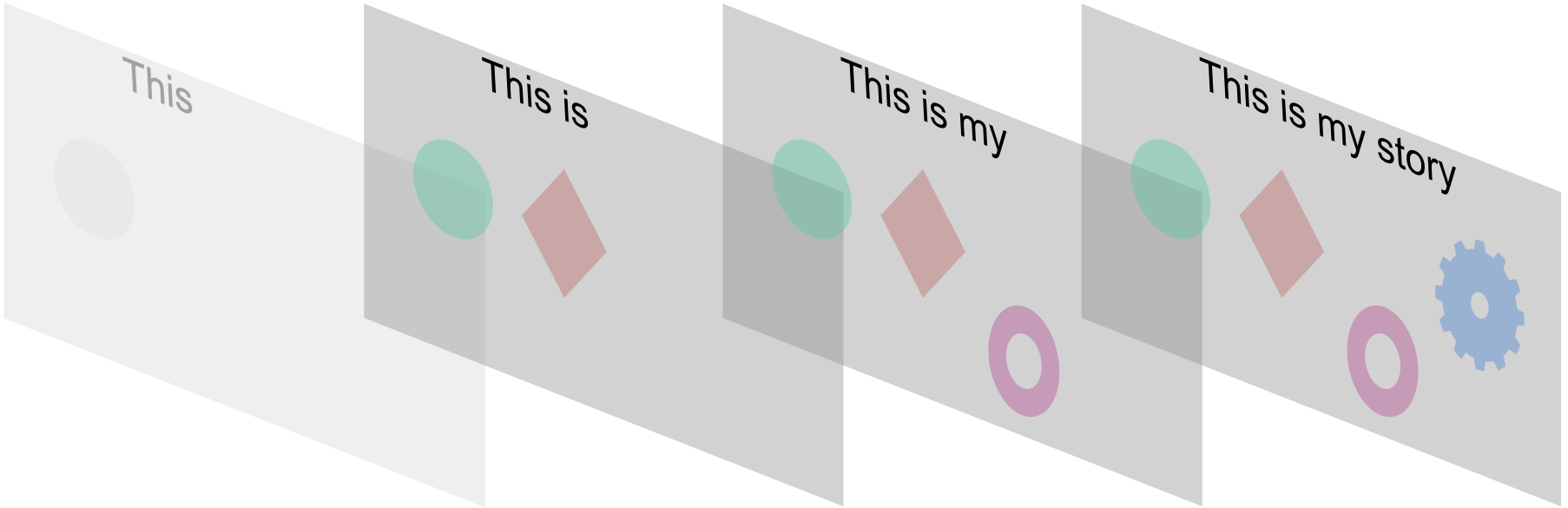
Backtracking



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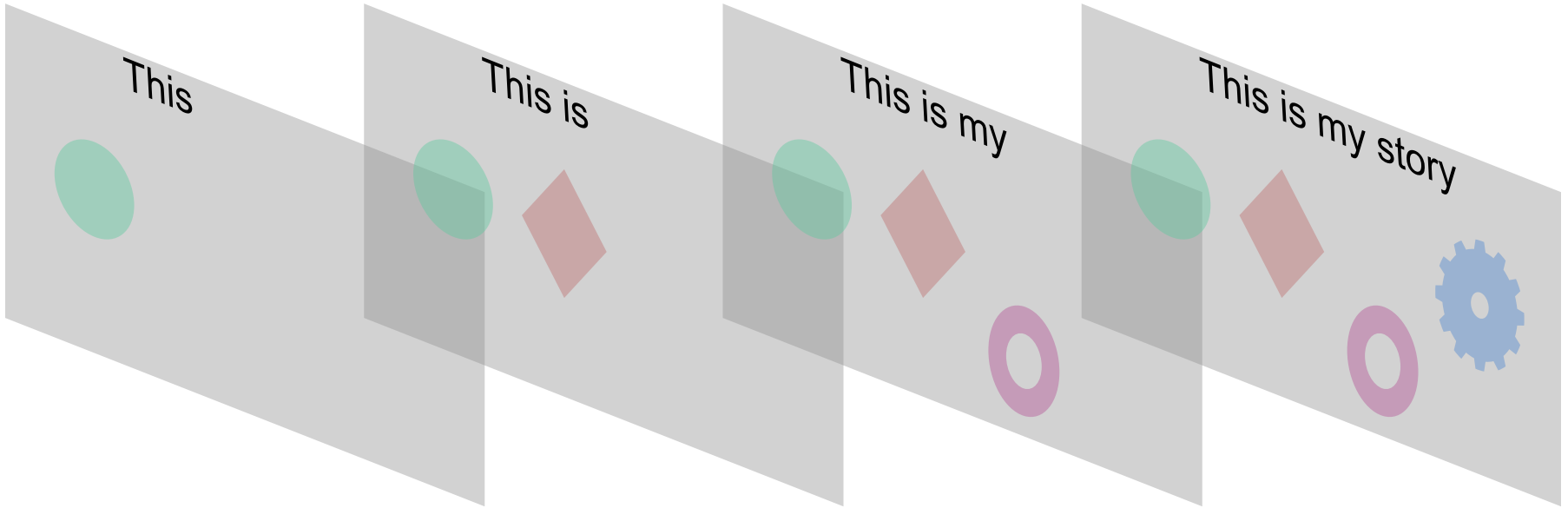


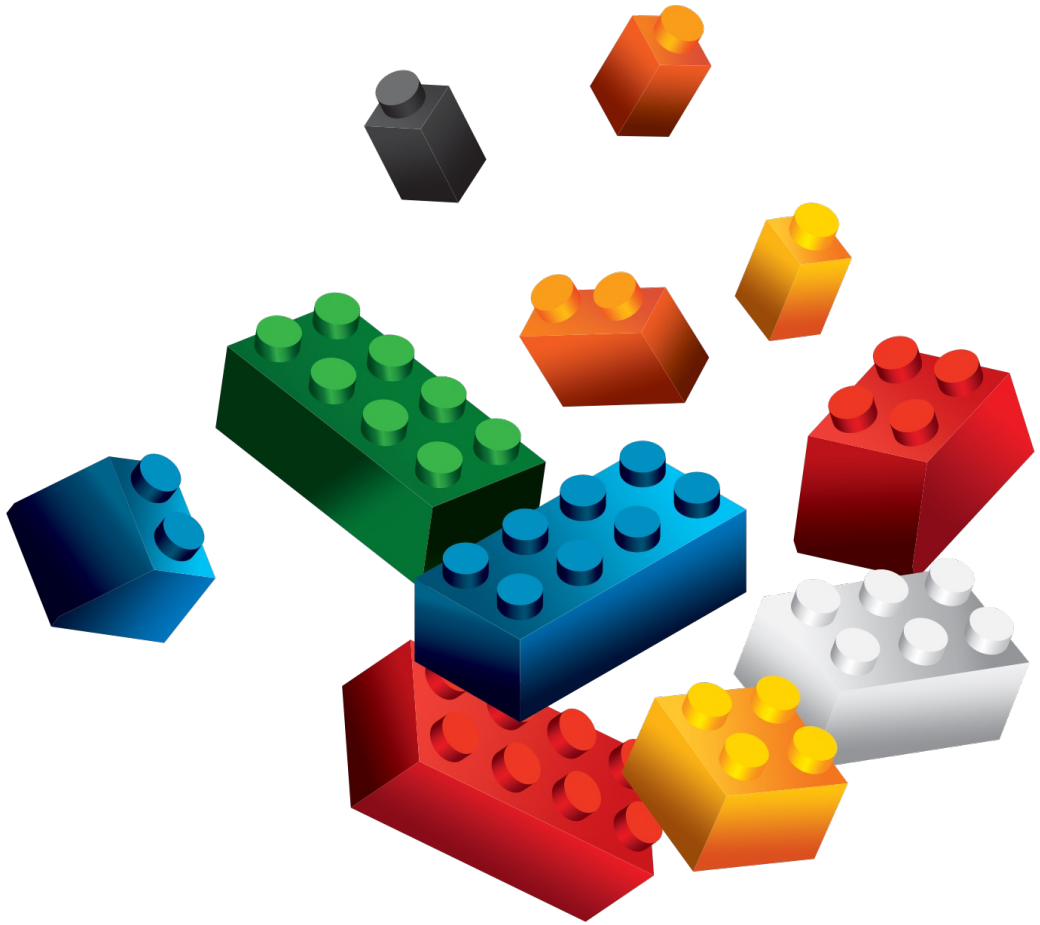
This is the last slide you'll make

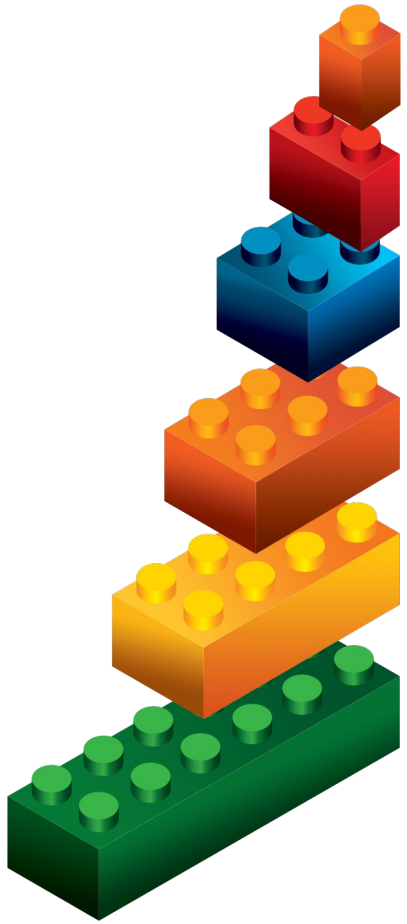
Start here: the 'finished' slide

Caterpillars fill specific passages of your story

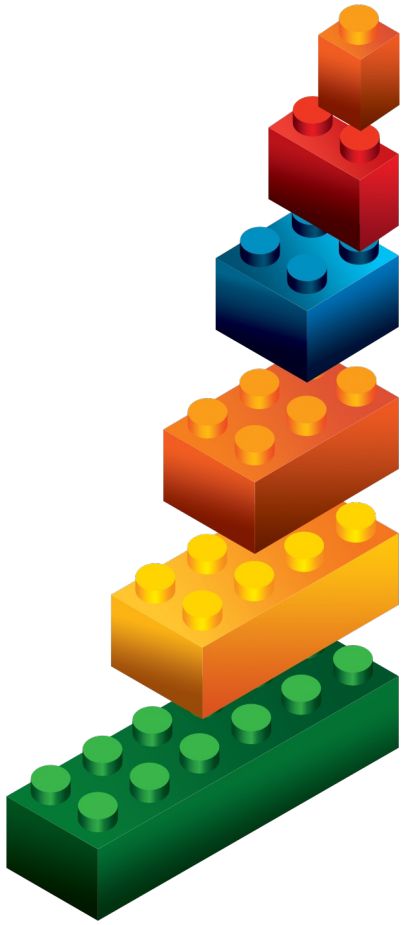
vice.com

In short: you're fighting the entropy of information





It’s your job to organize it into a story



It's your job to organize it into a story

SCIENTIFIC LIFE | ONLINE NOW

The science of storytelling: the David Attenborough style of scientific presentation

William C. Ratcliff

Published: July 19, 2023 • DOI: https://doi.org/10.1016/j.molmed.2023.05.002

es

Abstract

Many scientists approach speaking as they do writing a paper: an opportunity to present their data. But data without proper context is difficult to absorb. In this article, I describe a philosophy and set of heuristics for giving an engaging, narratively driven talk, inspired by the legendary documentaries of Sir David Attenborough.

Big picture context (Madagascar)

Zoom in on specific topic of paper

Identify gap in the Knowledge

Say what you did

Say how your results fill the gap in the knowledge, and how this impacts the way we think about the big picture topic.

Abstract

Evolutionary transitions in individuality are central to the emergence of biological complexity. Recent experiments provide glimpses of processes underpinning the transition from single cells to multicellular life and draw attention to the critical role of ecology. Here, we emphasize this ecological dimension and argue that its current absence from theoretical frameworks hampers development of general explanatory solutions. Using mechanistic mathematical models, we show how a minimal ecological structure comprising patchily distributed resources and between-patch dispersal can scaffold Darwinian-like properties on collectives of cells. This scaffolding causes cells to participate directly in the process of evolution by natural selection as if they were members of multicellular collectives, with collectives participating in a death–birth process arising from the interplay between the timing of dispersal events and the rate of resource use by cells. When this timescale is sufficiently long and new collectives are founded by single cells, collectives experience conditions that favour evolution of a reproductive division of labour. Together our simple model makes explicit key events in the major evolutionary transition to multicellularity. It also makes predictions concerning the life history of certain pathogens and serves as an ecological recipe for experimental realization of evolutionary transitions.

Cover letter

We are pleased to submit our paper "**Topological constraints in the origins of reproductive specialization**" to be considered for publication in *eLife*.

Reproductive specialization (e.g., cellular differentiation into germ and somatic cells) is a hallmark of complex multicellular organisms. Specialization is thought to evolve due to trade-offs in a cell's ability to both reproduce and to aid in the survival of the organism. Reproductive specialization is of central importance to multicellularity - it not only facilitates the evolution of organismal complexity by mitigating conflicts between cellular and multicellular fitness, but it is also the primary route through which multicellular organisms evolve novel, more complex traits.

A large body of literature, from evolutionary game theory to economic bargaining theory, has shown that complete reproductive specialization should only evolve when the payoff from differentiation *accelerates* with increased specialization. Indeed, this is considered a fundamental constraint on the evolution of any kind of specialization. In this paper, we show that germ-soma differentiation is different from other forms of biological specialization, and as a result, can evolve under a much broader set of conditions, including conditions without accelerating payoffs.

First, we investigate the potential for emergent reproductive specialization to evolve in simple multicellular organisms, modeled as networks of connected, interacting cells. Through a combination of graph theoretic analysis and evolutionary dynamic modeling, we analyze the extent to which specialization can emerge between cells in a network, insofar as selection acts at the scale of the multicellular organism as a whole. We show that the fundamental asymmetry of exchange rules (i.e., a cell cannot share the ability to reproduce, but it can help other cells survive) and different evolutionary optima for multicellular fitness vs. the fitness of component cells, allow reproductive specialization to evolve even when the returns from specialization *decelerate* with greater investment in trade. This is a major conceptual advance in our understanding of how reproductive specialization can evolve, overturning decades of prior theory.

Second, we show that the cellular topology of multicellular organisms plays a key role in either promoting or constraining the evolution of reproductive specialization. We find that specialization is strongly promoted in simple multicellular organisms that grow with permanent cell-cell bonds, forming tree-like topologies. Such topologies appear to be ancestral to nearly all eukaryotic lineages that ultimately evolved 'complex multicellularity' (i.e., large size, multiple cell types, and complete reproductive specialization), and readily arises in laboratory models of early multicellularity. We identified the topology of two representative early multicellular organisms: a billion year old fossilized red algae, *Bangiamorpha*, and snowflake yeast, a laboratory model system of early multicellularity, and then used these topologies to parameterize evolutionary models. The topology of both organisms strongly promotes the emergence of reproductive specialization in our evolutionary dynamic framework.

Our work combines theory, numerical simulations, and image-based topological analyses of early multicellular organisms. Our focus on network topology provides unique insight into the origin of reproductive specialization in multicellular organisms—a critical step for the evolution of complex life on Earth. We anticipate that this paper will be of broad interest to the readers of *eLife*, including those with an interest in evolutionary biology, cellular biology, computational biology, developmental biology, and the physics of living systems.

This manuscript contains 4252 words in the main text, with one table and four main figures composed of 16 sub-panels. The supplementary information section contains 1400 words including figure captions, one table, and two supplemental figures totaling five panels. None of the submitted material has been published or is under consideration elsewhere. We do not have any related papers in press or under consideration.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Peter J. Yunker, Assistant Professor, School of Physics, Georgia Institute of Technology
William C. Ratcliff, Associate Professor, School of Biology, Georgia Institute of Technology

Whole paper

Introduction

First PP big picture context

Then zoom in on topic. Say what is known on this topic, and what the gap is (2-4 PPs). If you have room, explain why this gap persists and how your research circumvents this gap.

Say what you did (last PP)

Results

Say what you did. The story should be understandable from the figures, so make them first and use them to lay out the progression.

Discussion

Reprise big picture context for paper (first few sentences of first PP)

Restate major results (second part of first PP)

Explain how your results fit in with the broader literature. How do your results change the way we think about the knowledge gap, big picture topic, and/or methods? What are key next steps? Limitations? End with a clear restatement of how this work changes the way we think about the big picture topic.

Methods

Easy-say what you did.