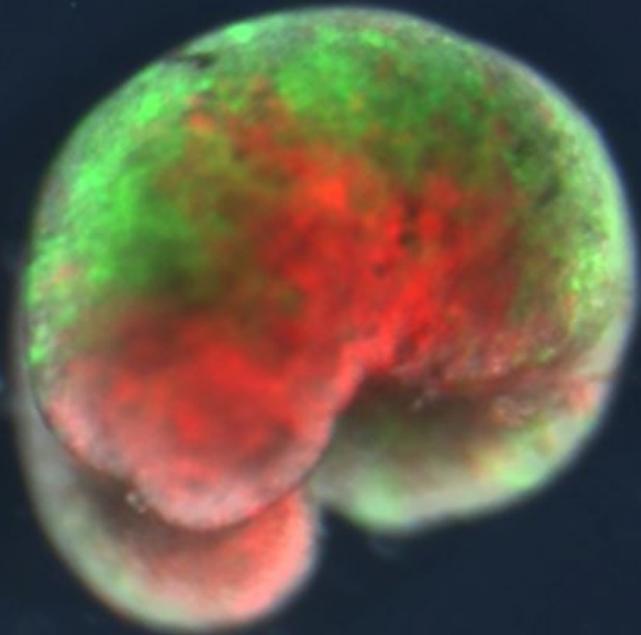
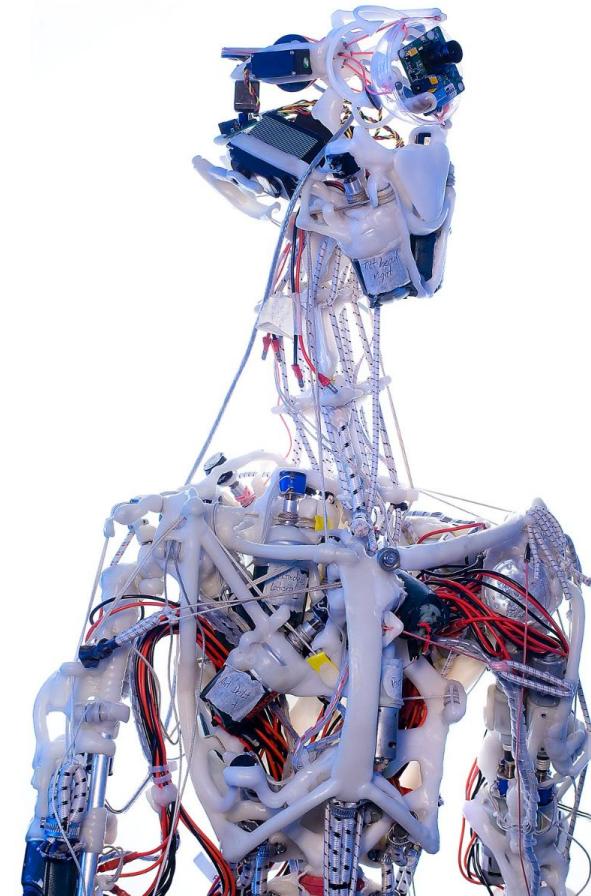
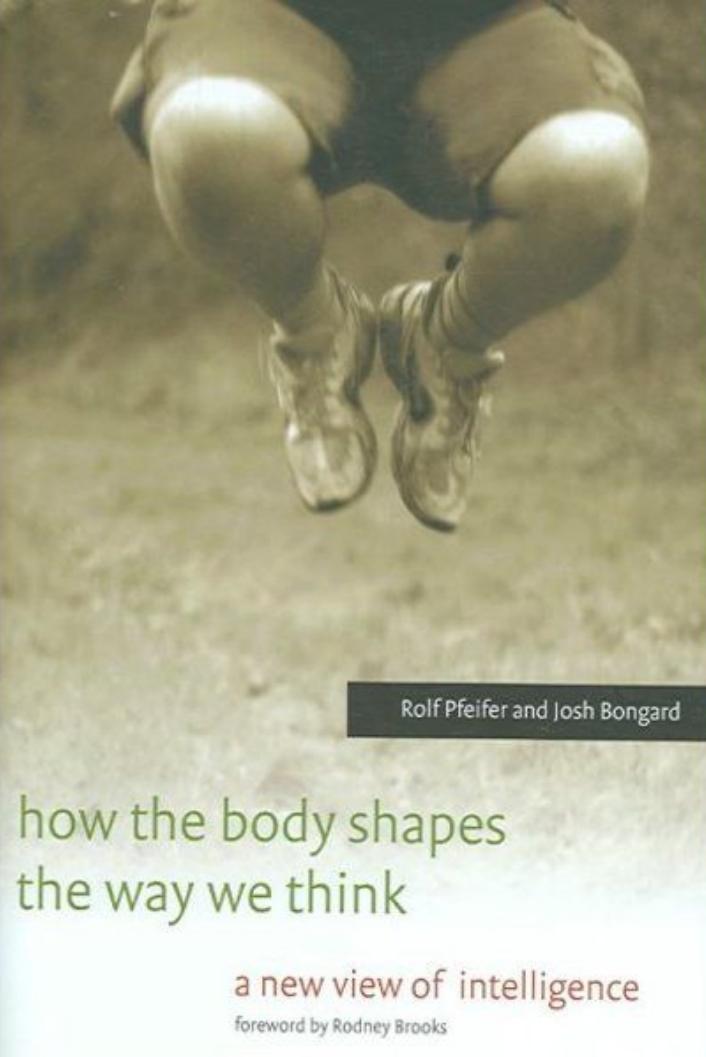


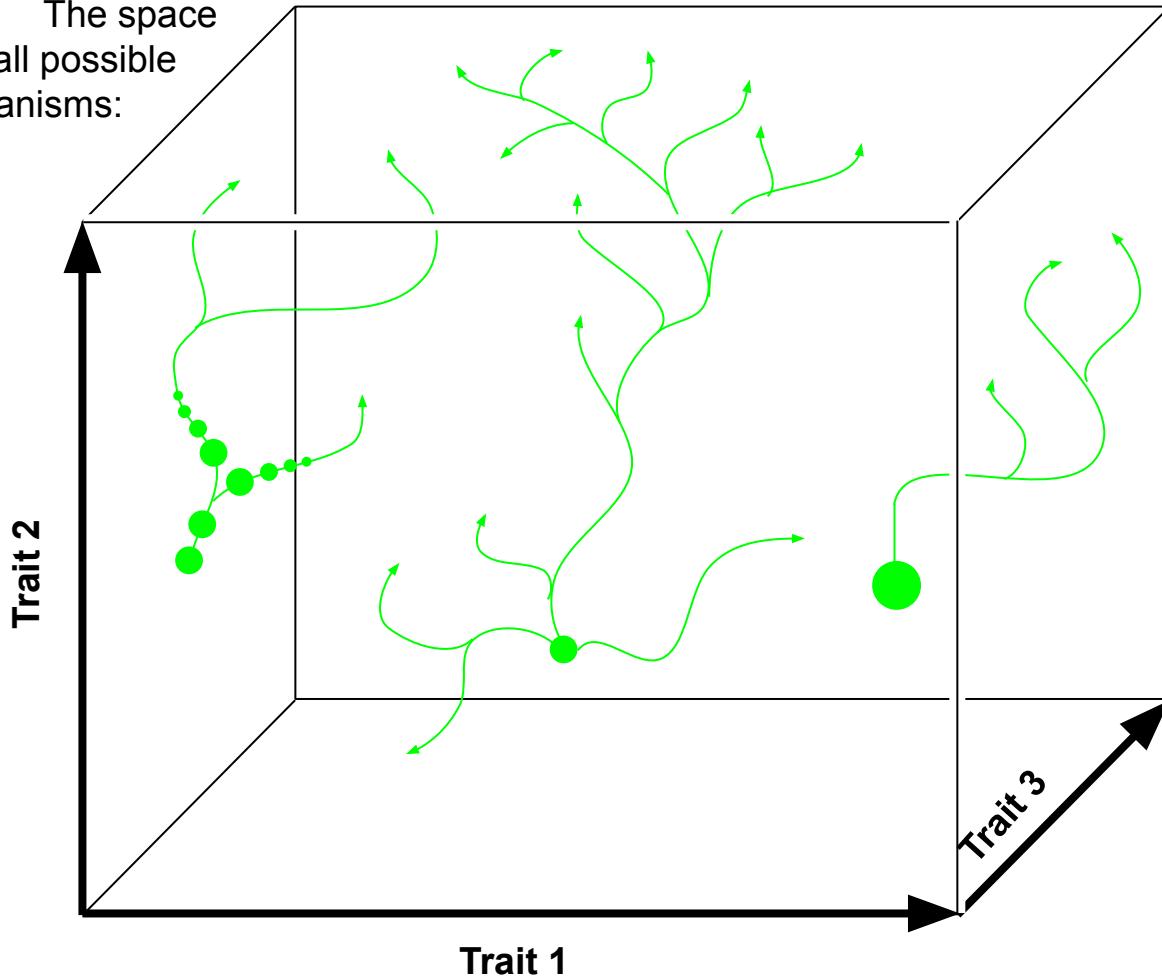
From rigid to soft to biological robots



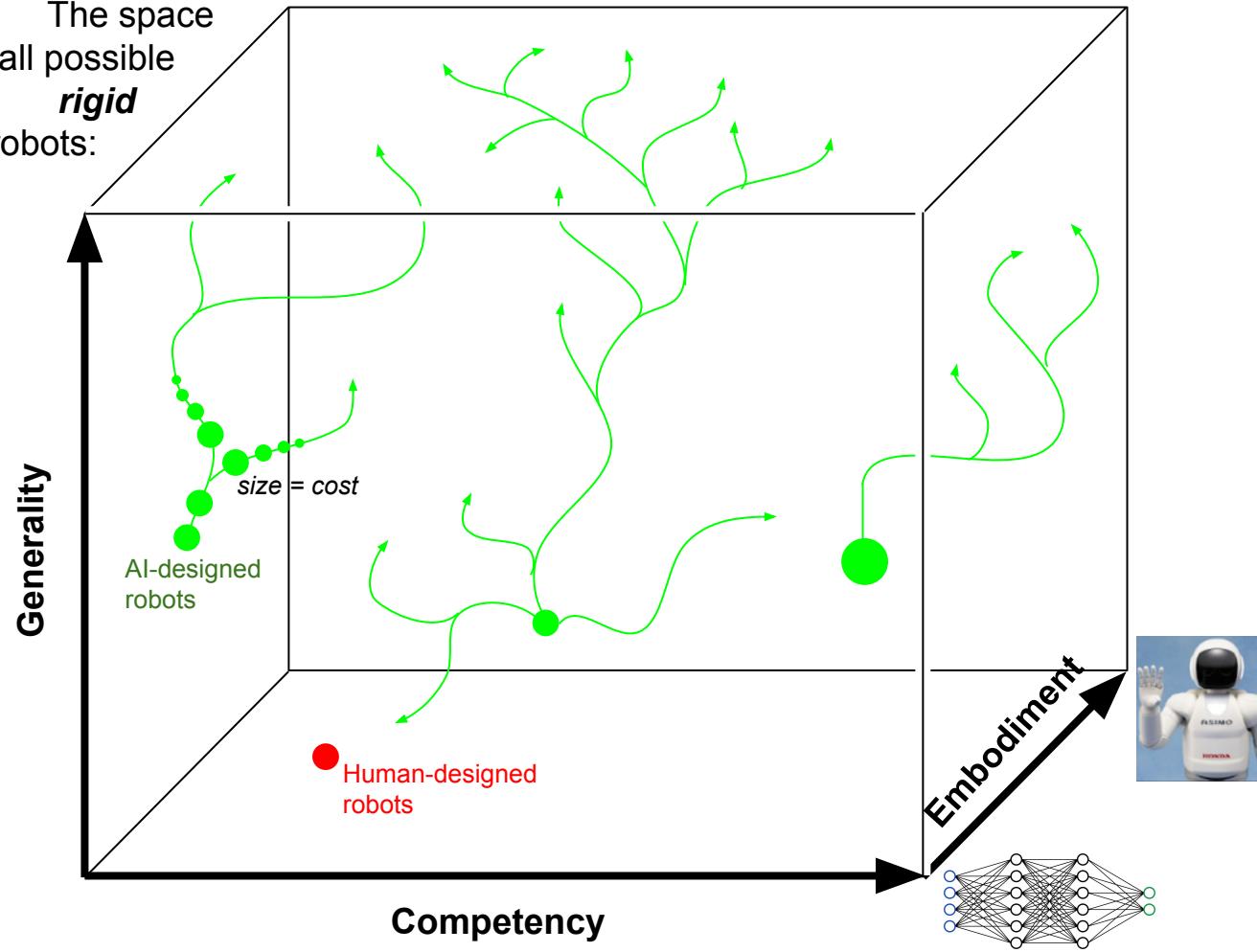
Josh Bongard
University of Vermont



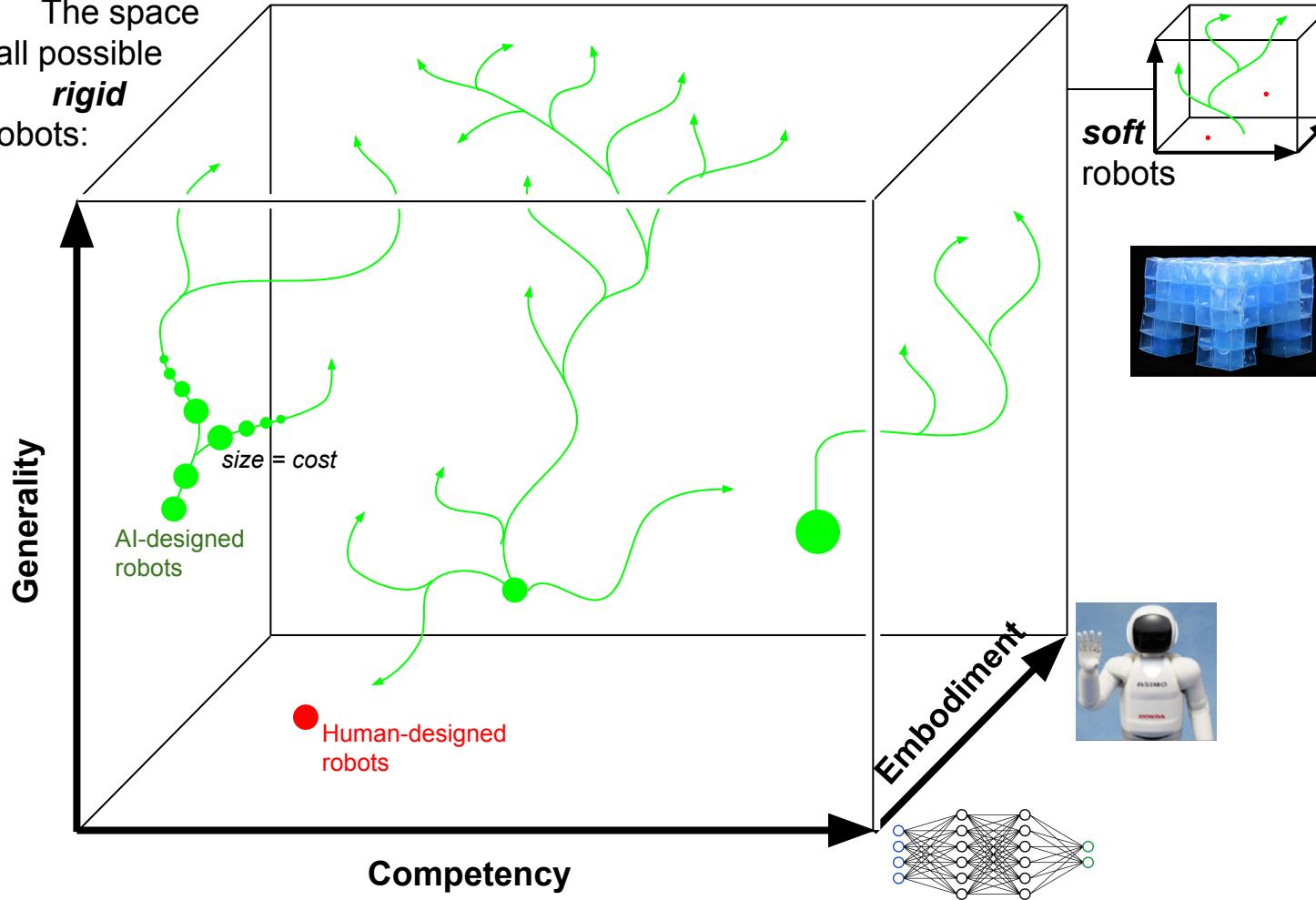
The space
of all possible
organisms:



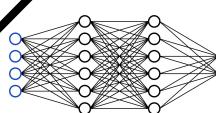
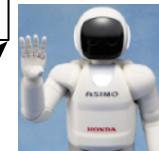
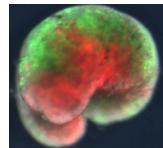
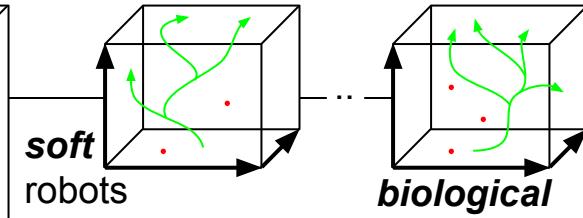
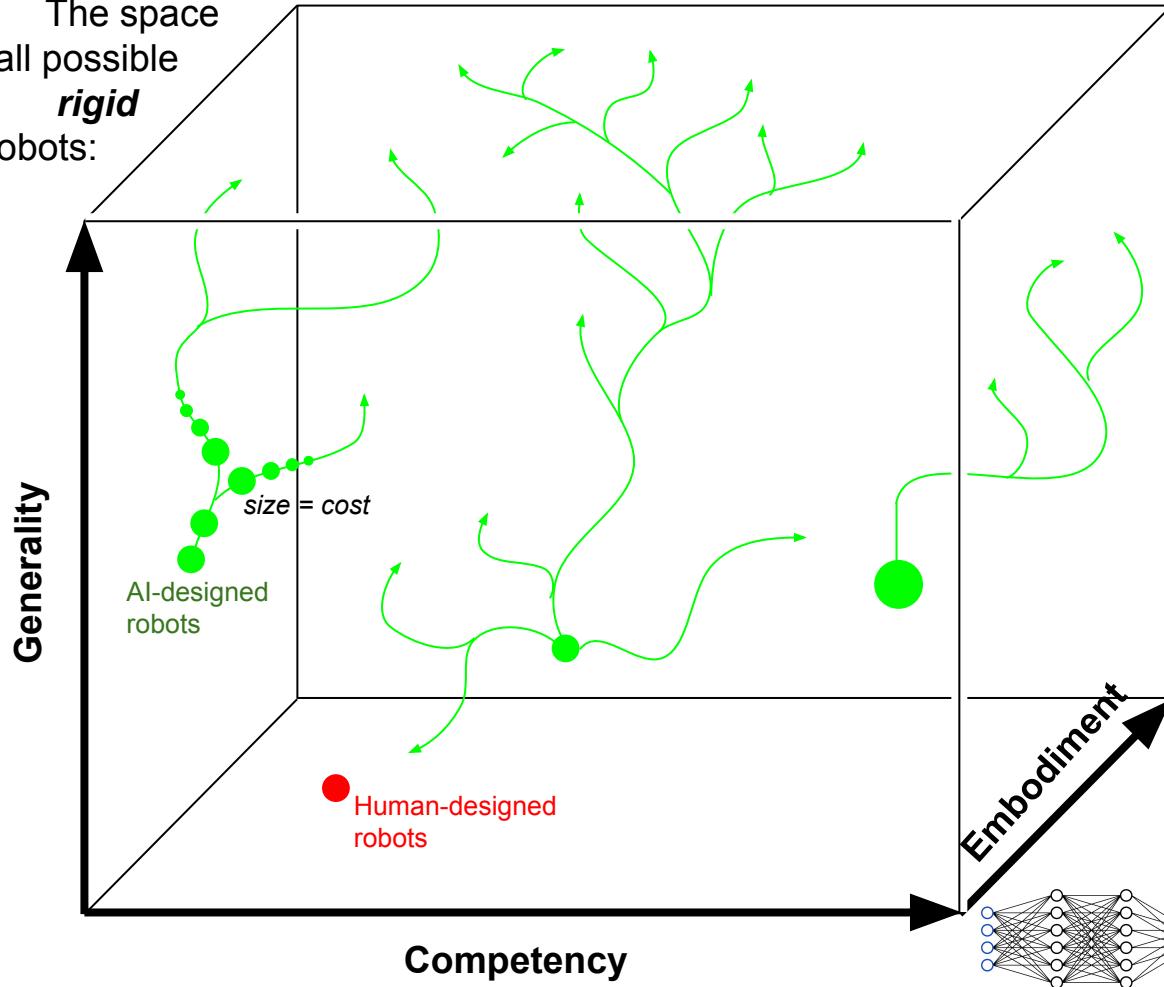
The space
of all possible
rigid
robots:

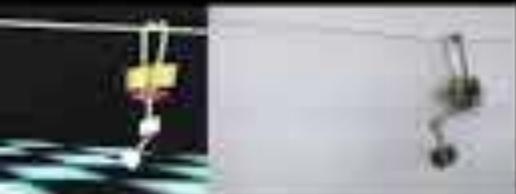


The space
of all possible
rigid
robots:



The space
of all possible
rigid
robots:





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CLAWAR, 2002



Bongard, Zykow & Lipson
Science, 2006



Bongard,
PNAS, 2011



Rosser, Kok, Chahl, Bongard
RSS, 2019



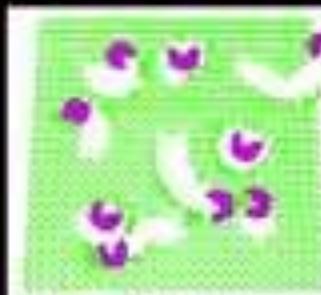
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Bongard, Kramer-Bottiglio, RoboSoft, 2020



Shah, Powers, Tilton,
Kriegman, Bongard,
Kramer-Bottiglio,
Nature Mach Int, 2020



Kriegman, Blackiston,
Levin, Bongard
PNAS, 2020



Kriegman, Blackiston,
Levin, Bongard
PNAS, 2021



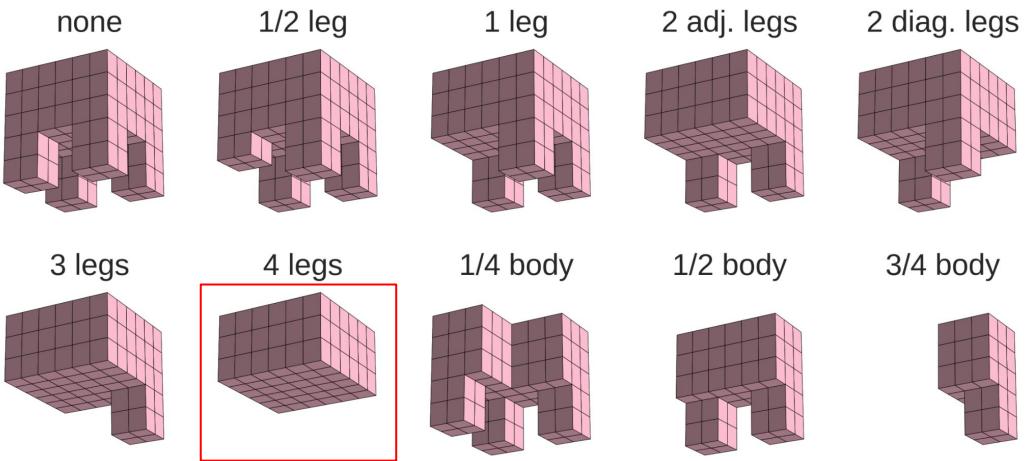
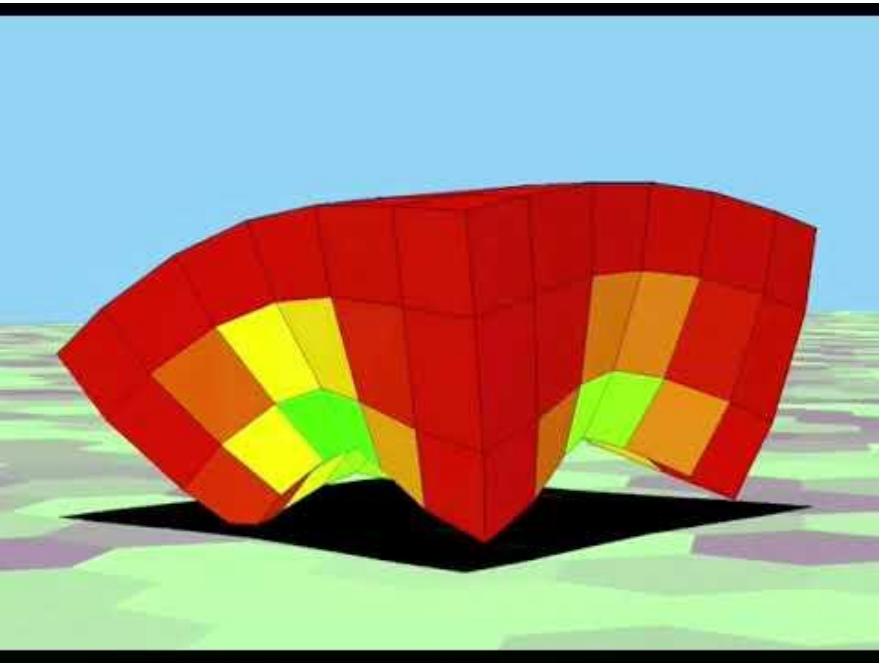
Parsa, Wang, O'Hern, Shattuck,
Kramer-Bottiglio, Bongard,
Proc of GECCO, 2022

Intact

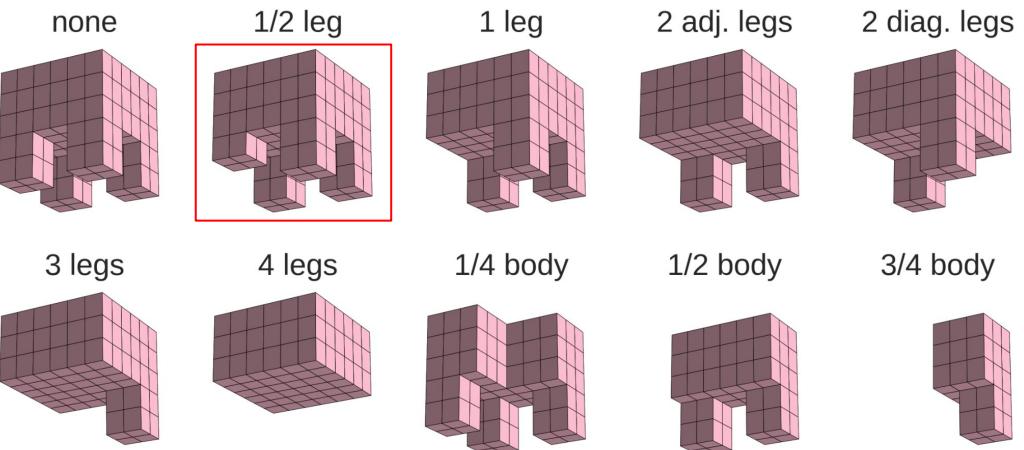
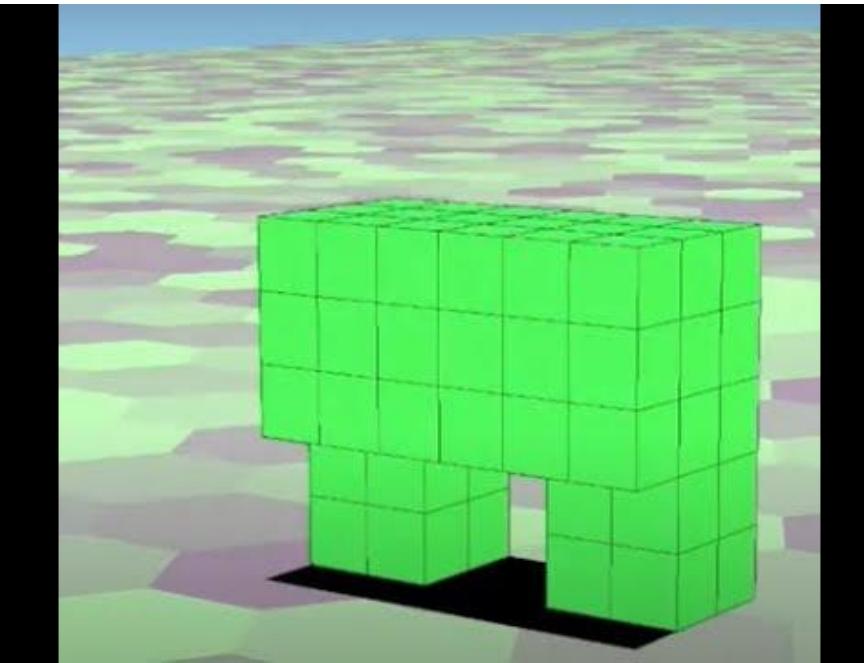


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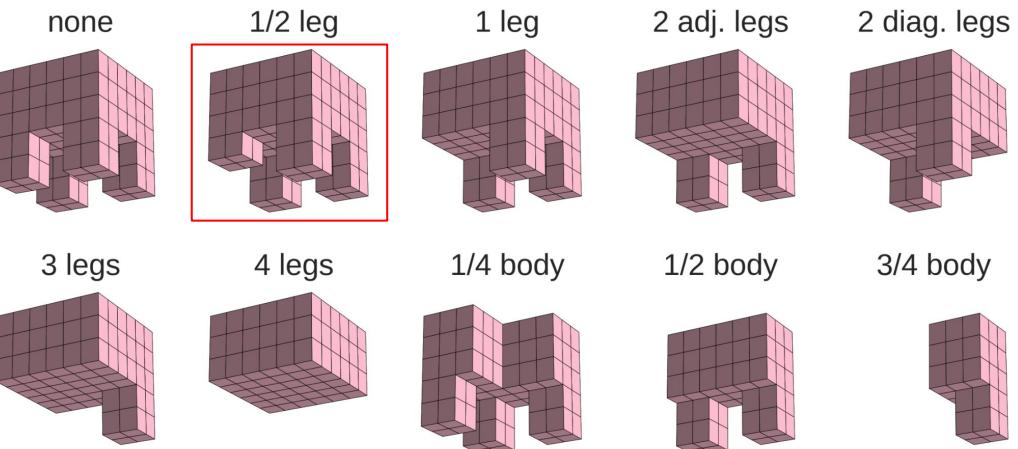
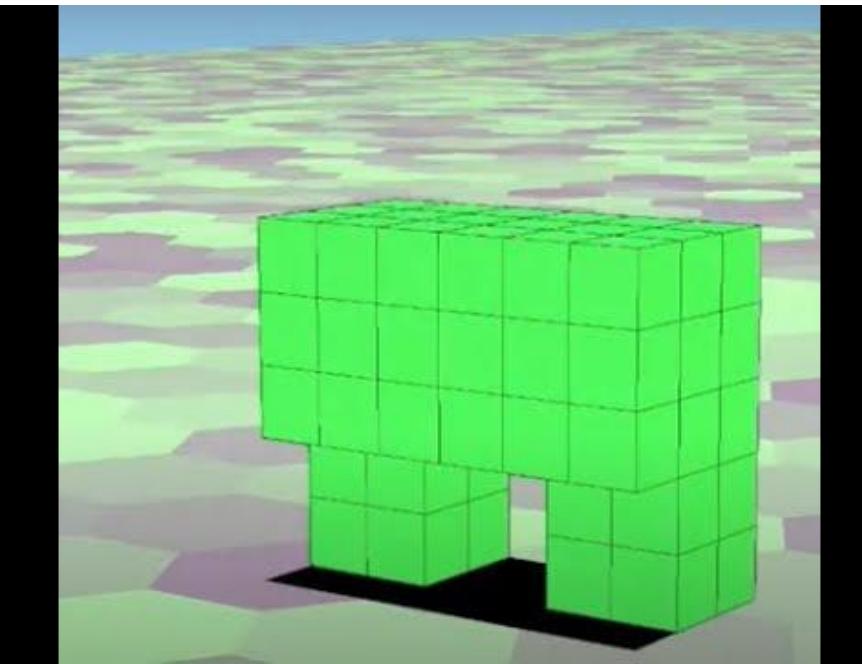




Kriegman,
Walker,
Shah,
Levin,
Kramer-Bottiglio,
Bongard.
RSS
(2019)



Kriegman,
Walker,
Shah,
Levin,
Kramer-Bottiglio,
Bongard.
RSS
(2019)

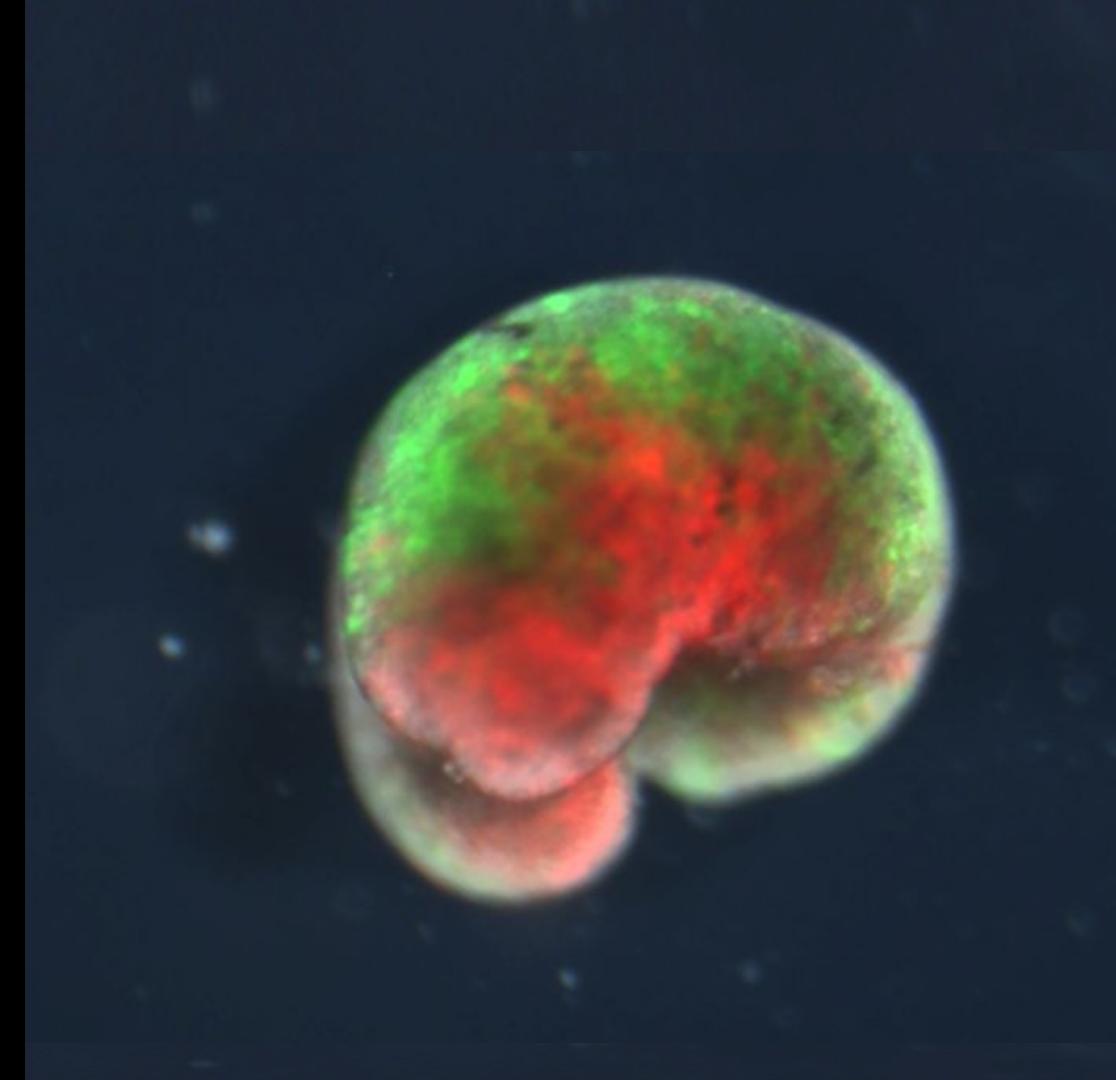


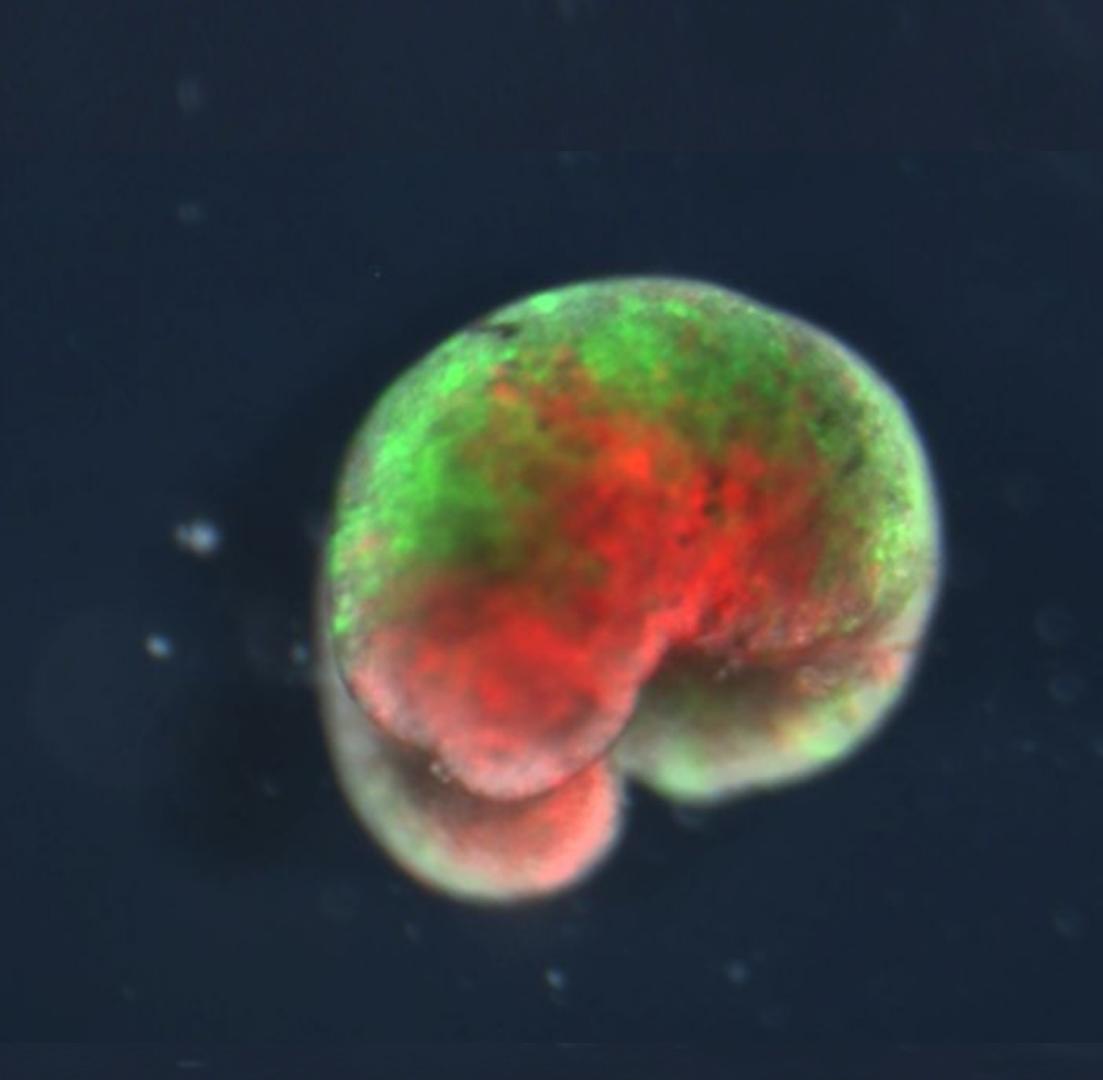
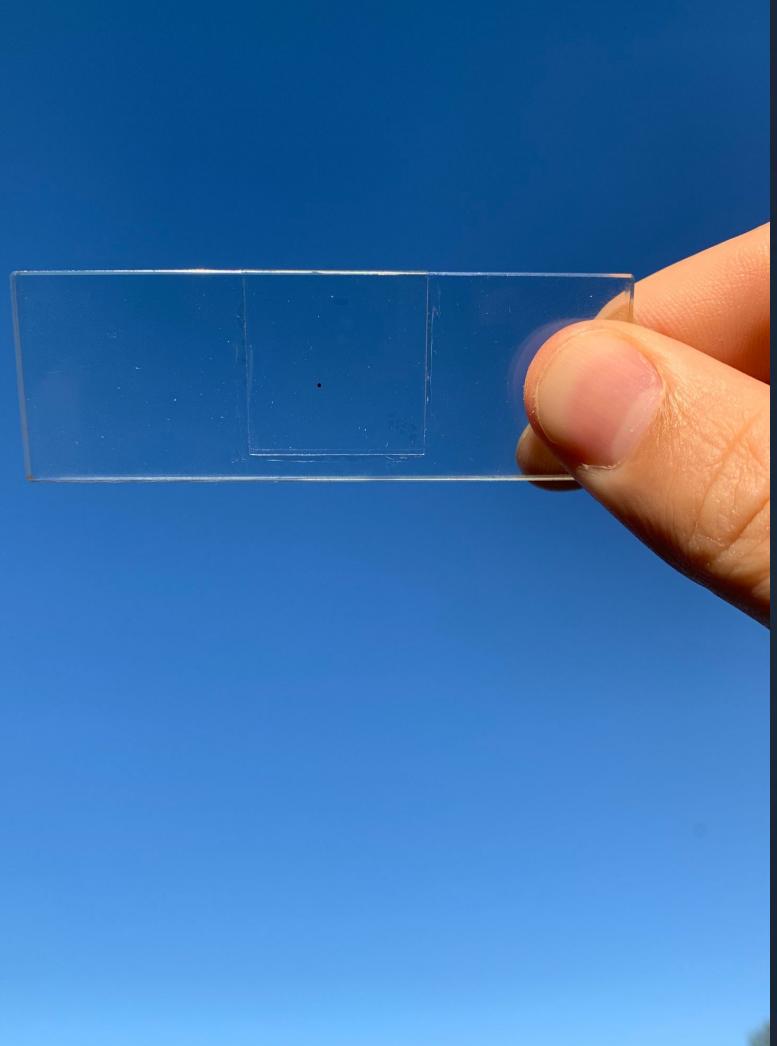
Kriegman,
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Kramer-Bottiglio,
Bongard.
RSS
(2019)

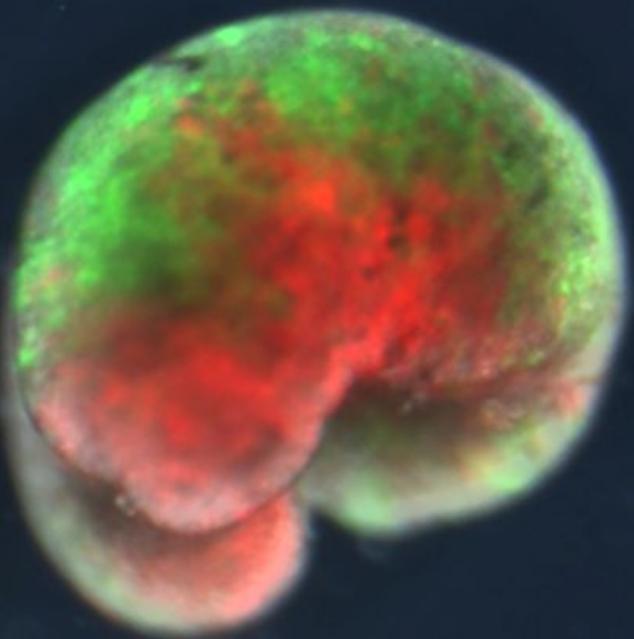




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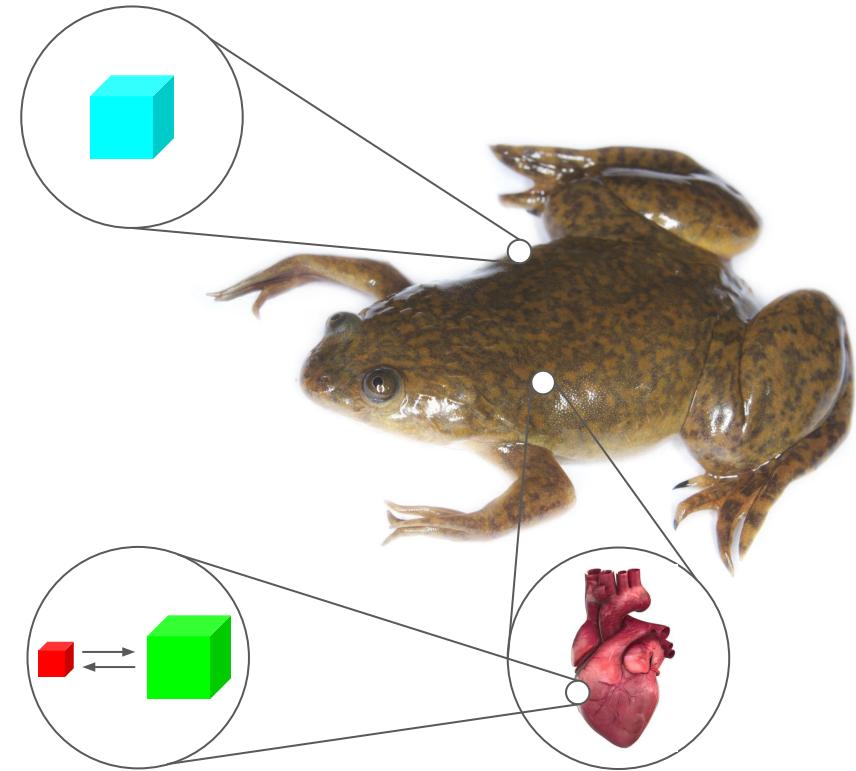




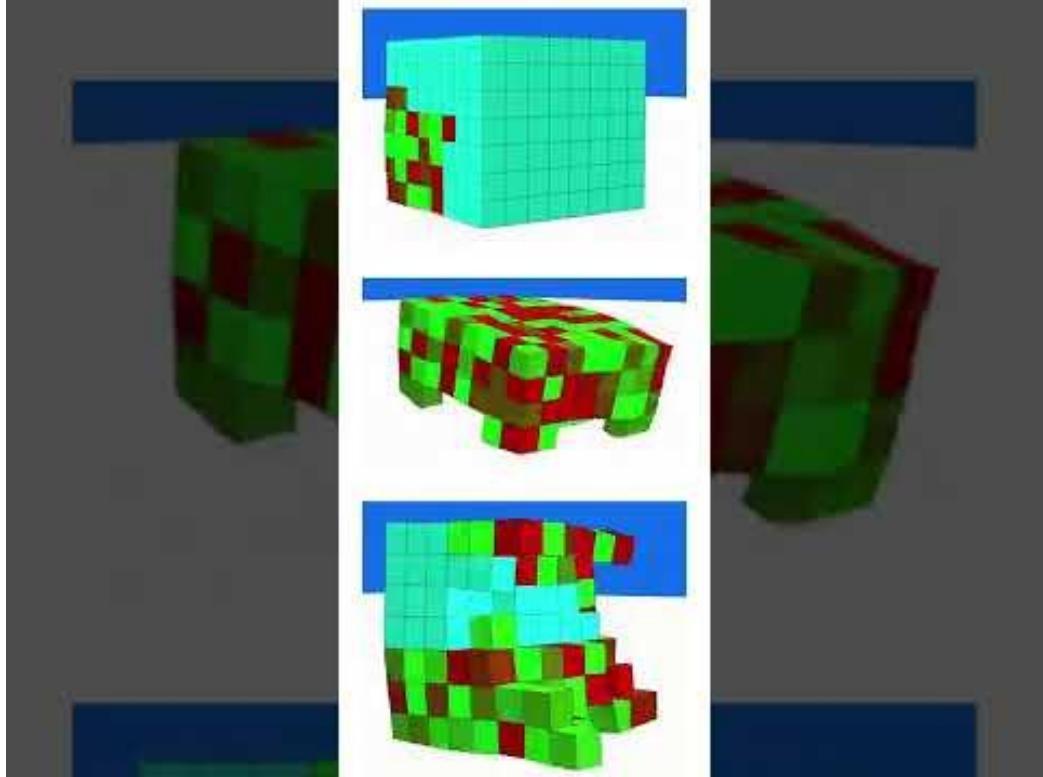
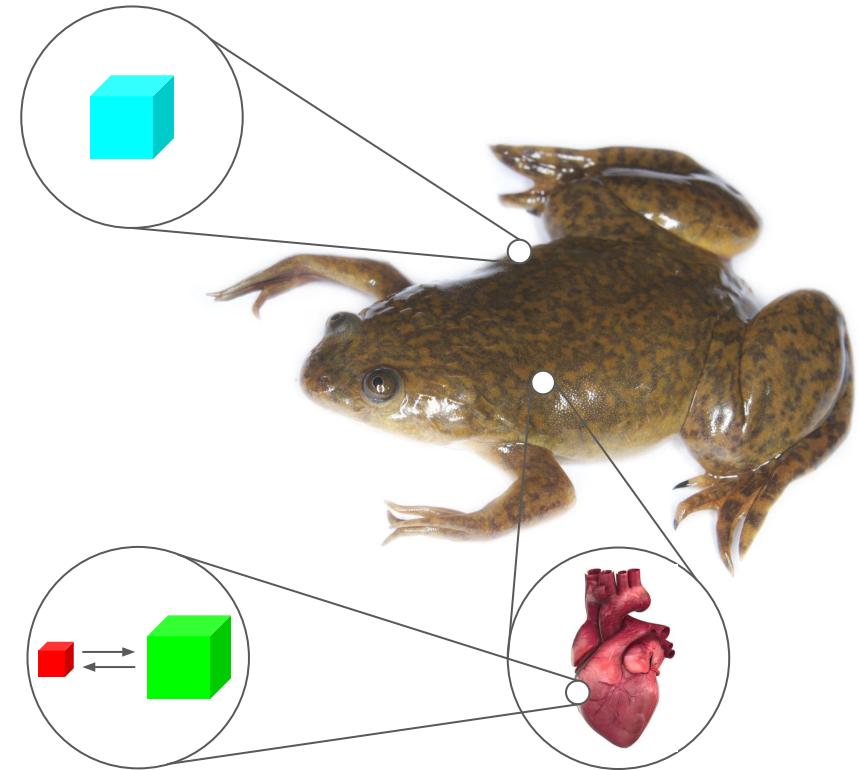


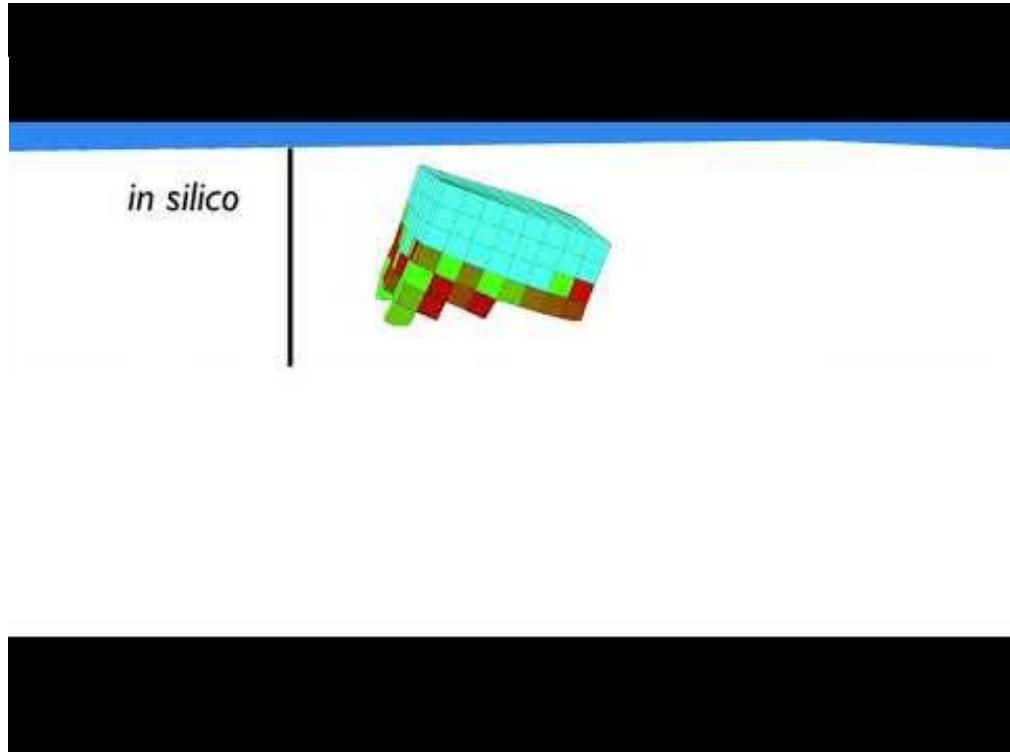
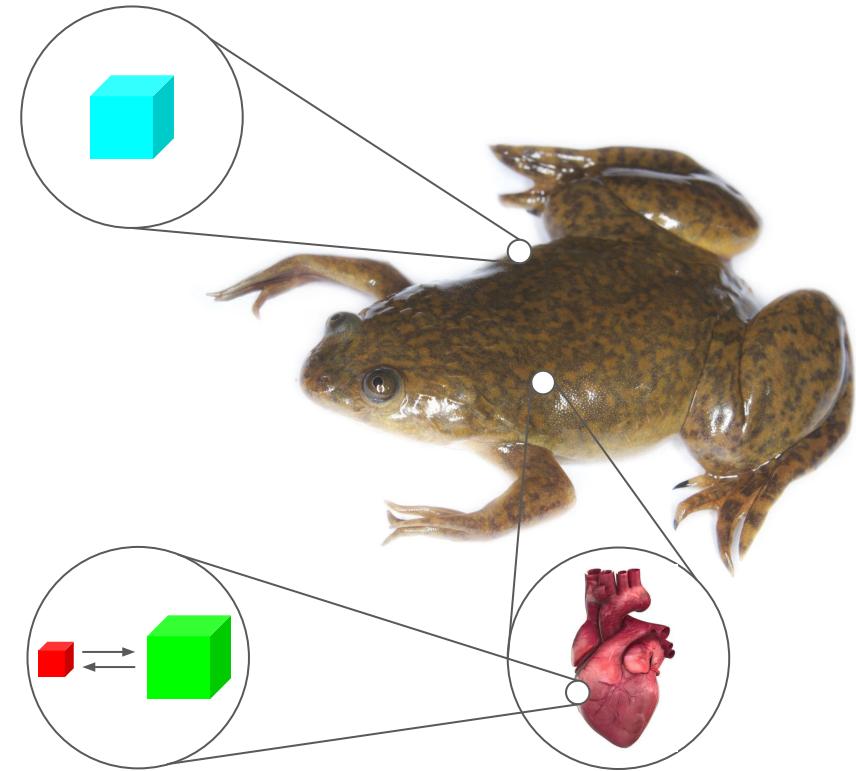


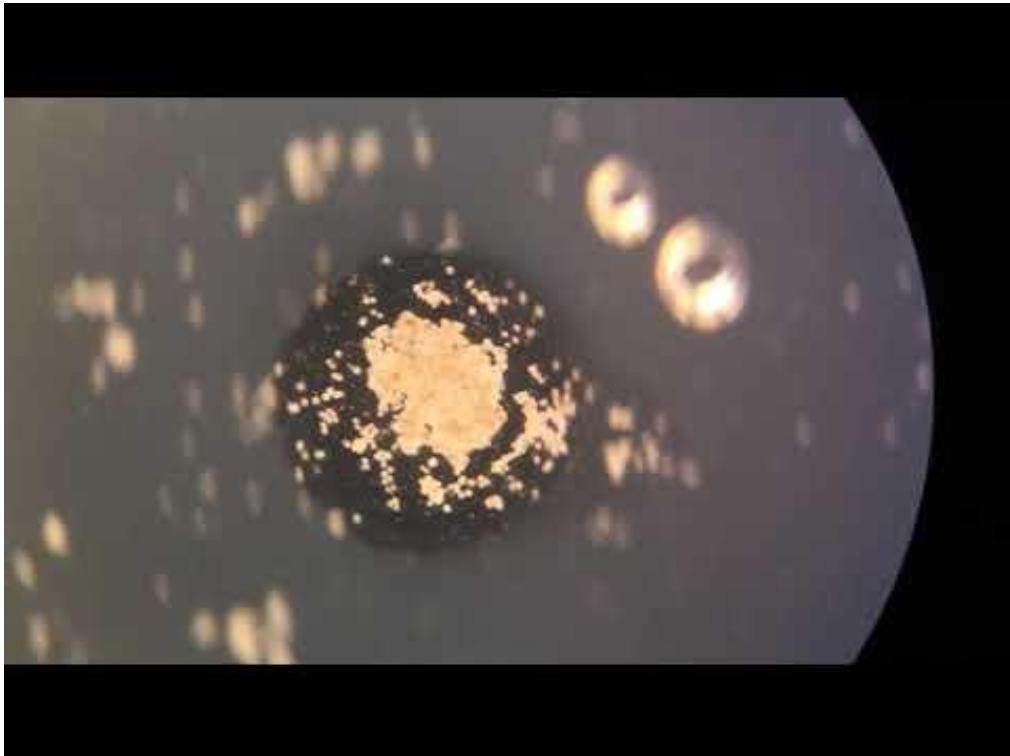
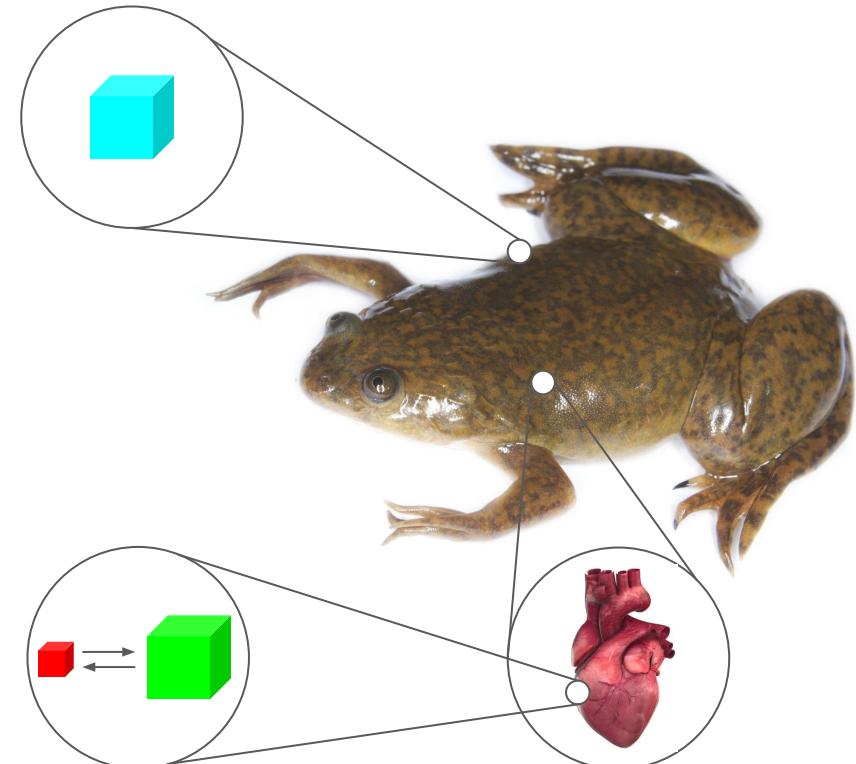
precursor cells



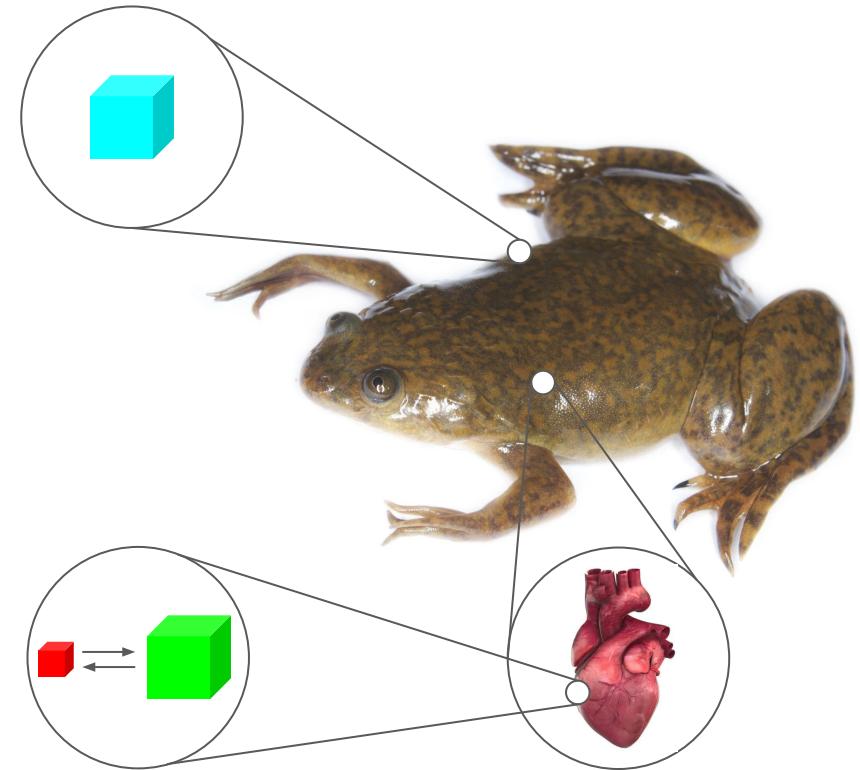
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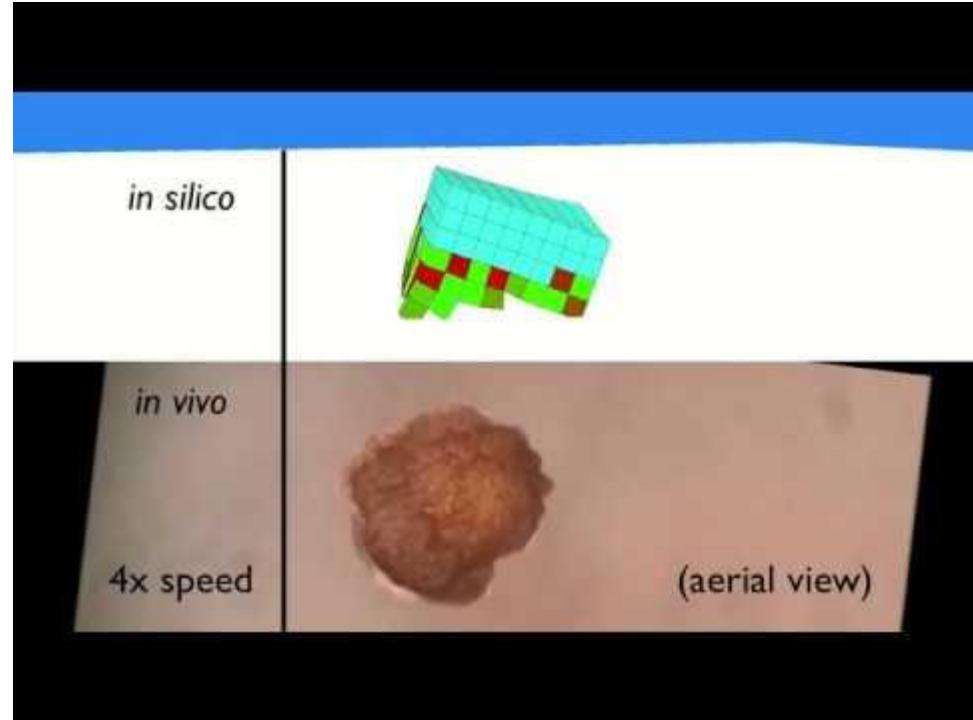
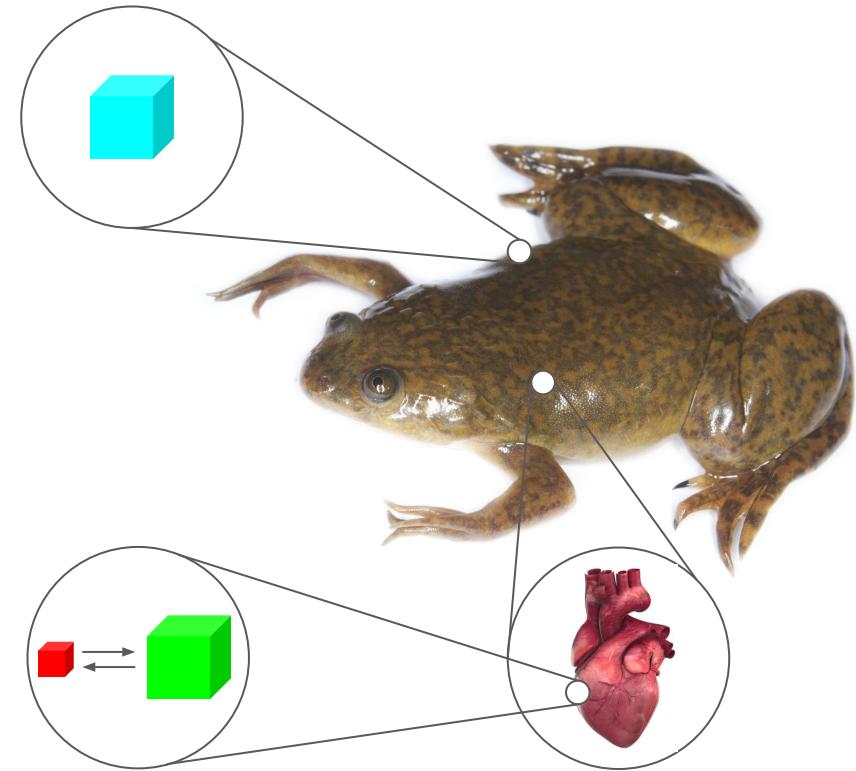


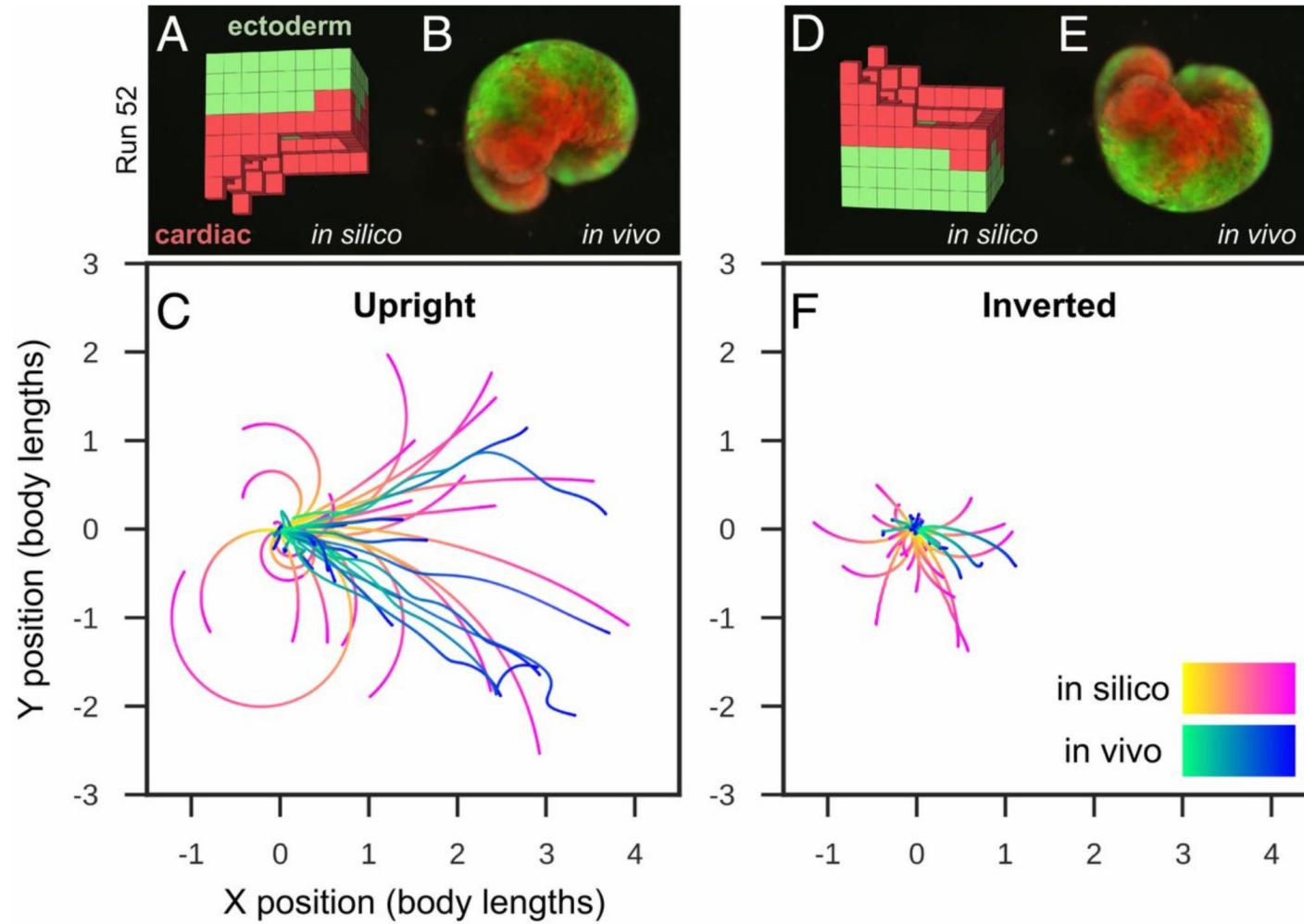


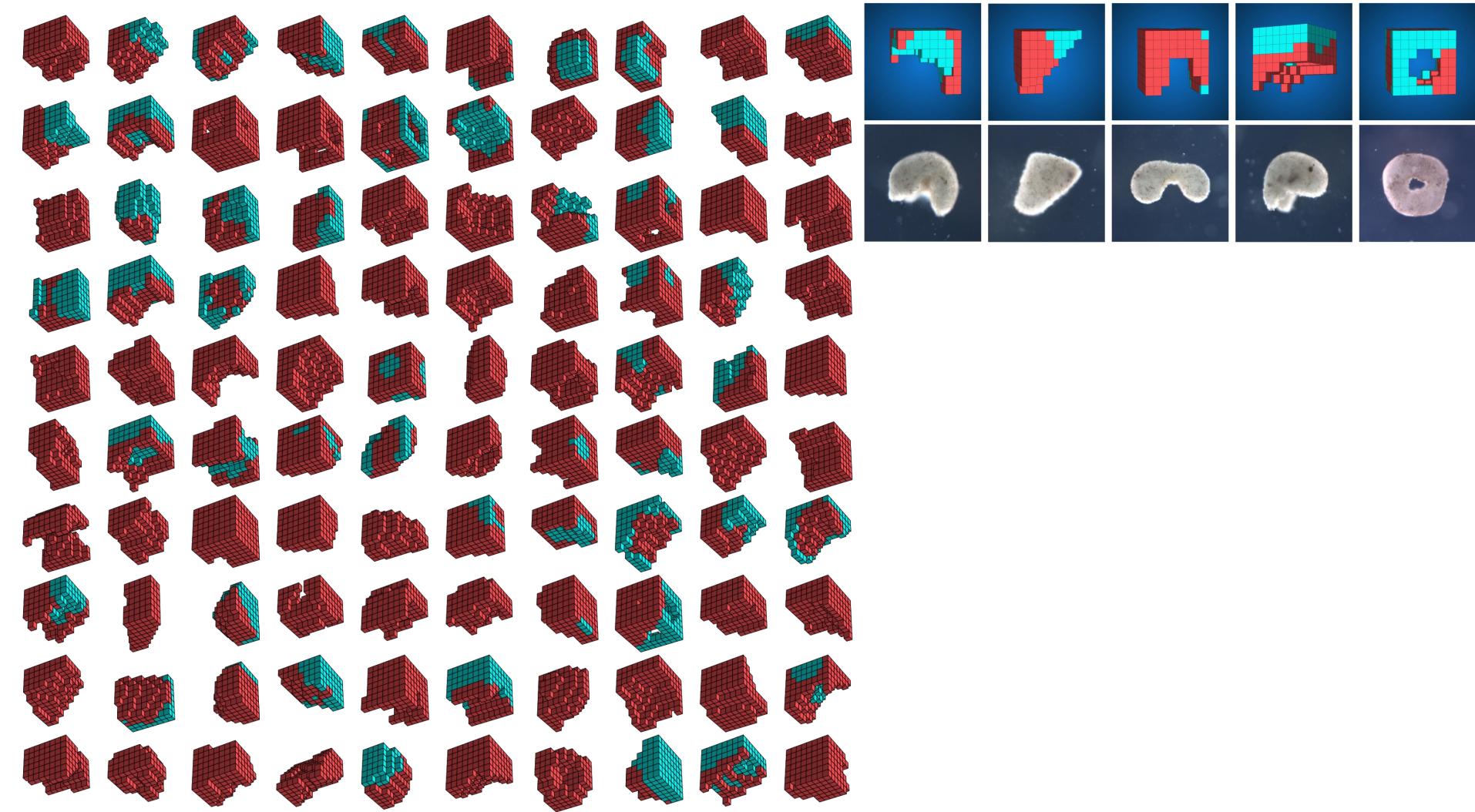
Kriegman, Blackiston, Levin & Bongard (2020). *PNAS*.



Kriegman, Blackiston, Levin & Bongard (2020). *PNAS*.









Collective
behavior



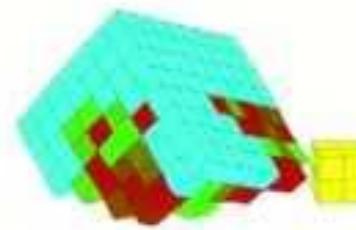
in silico



in vivo



Object manipulation

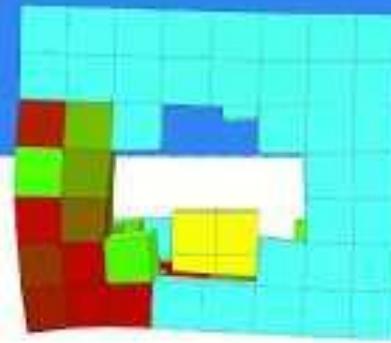


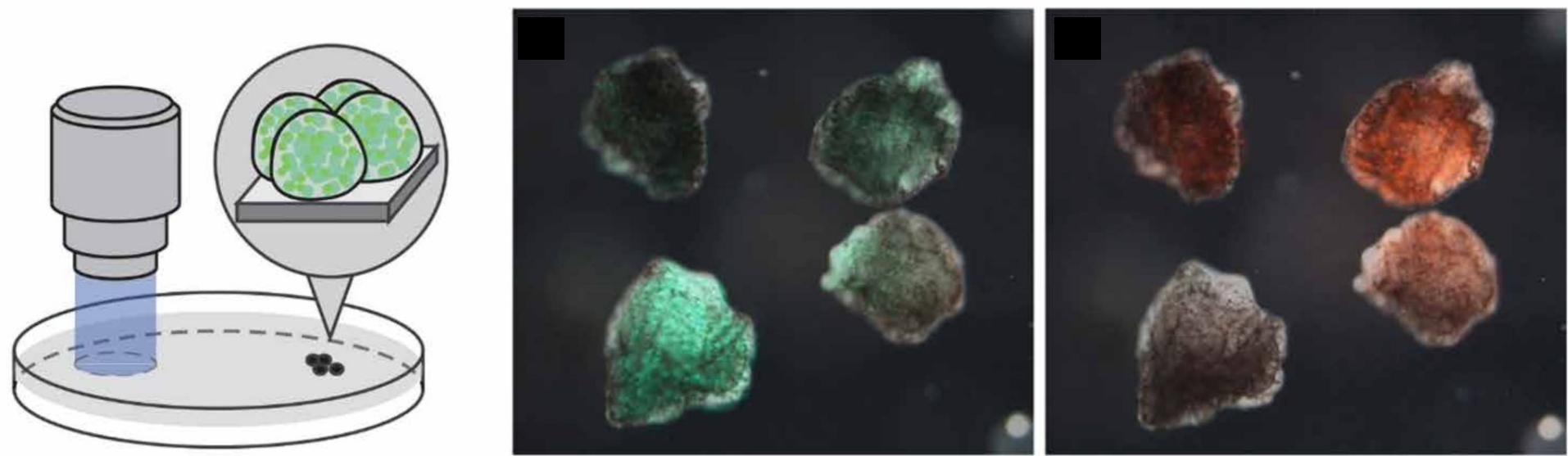
in silico



in vivo

Object transport





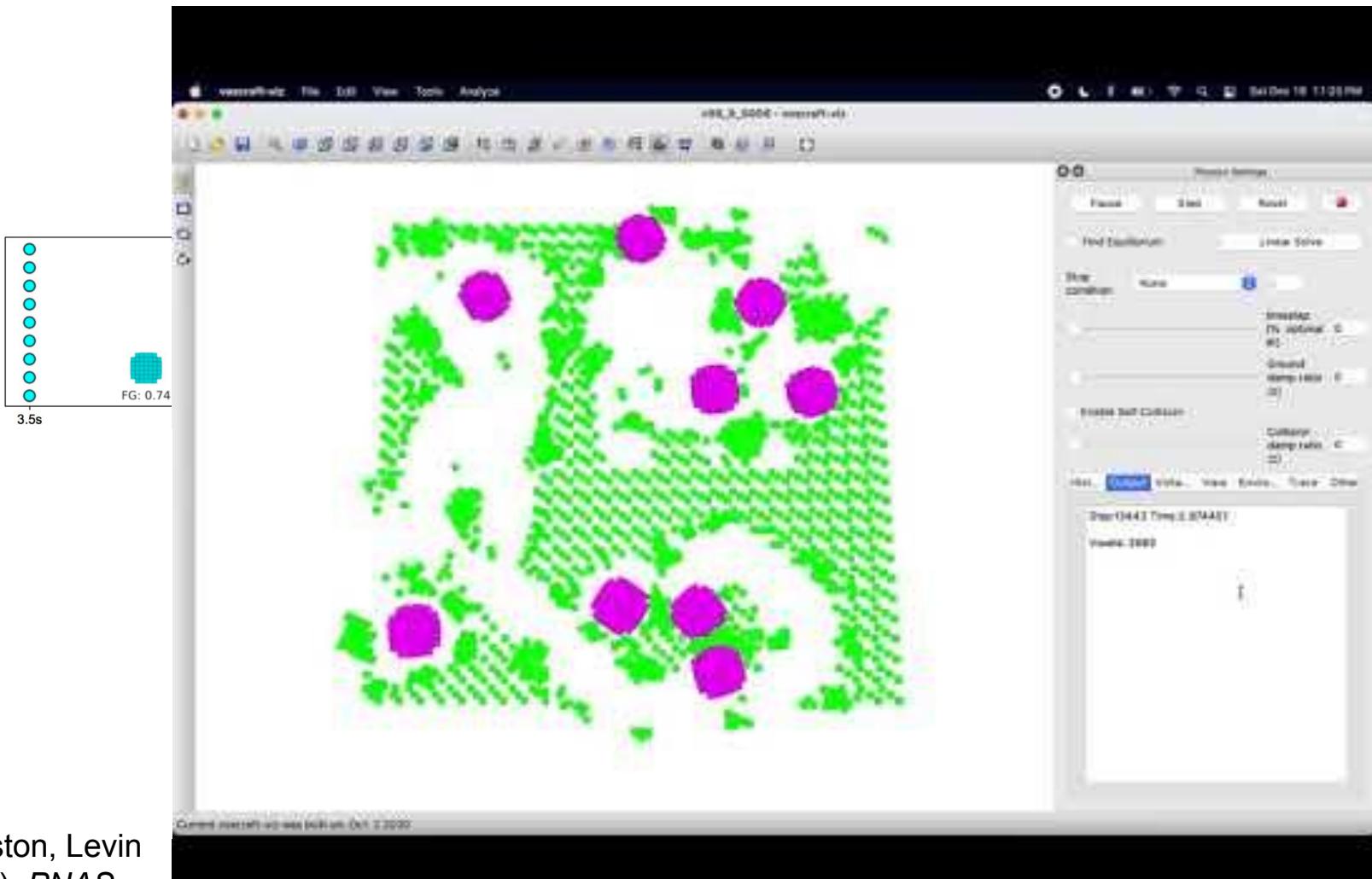
Blackiston, Kriegman,
Bongard & Levin (2021).
Science Robotics.

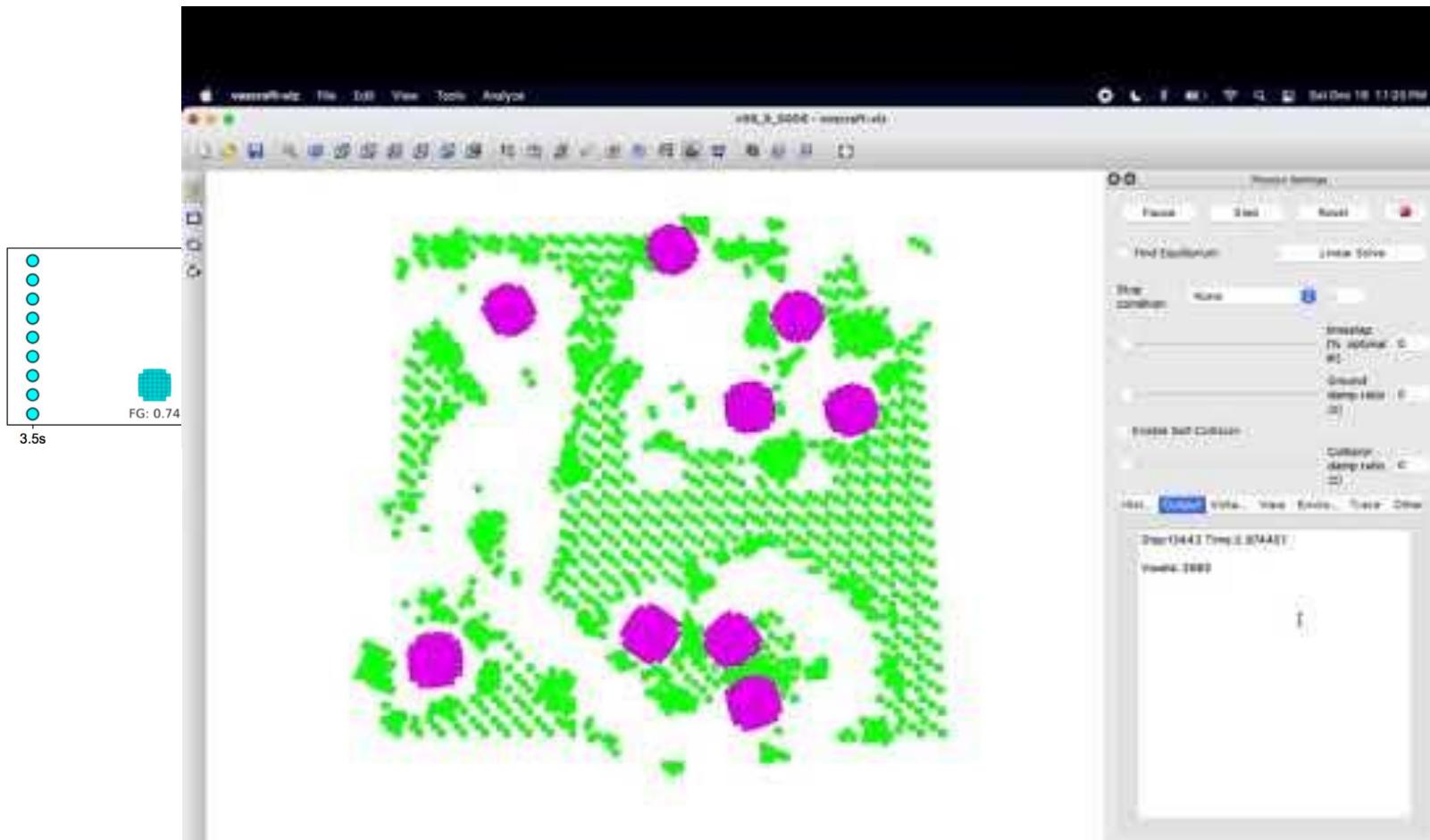


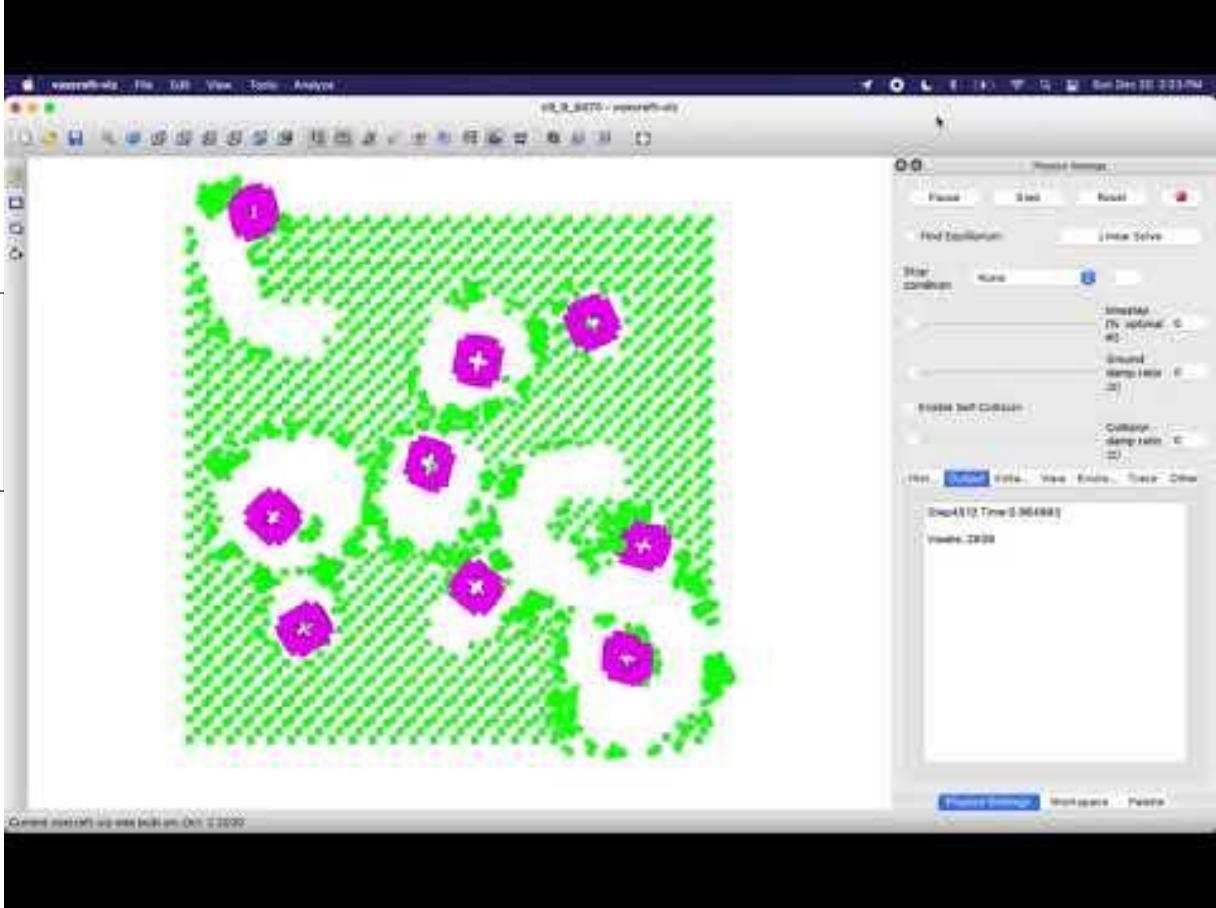
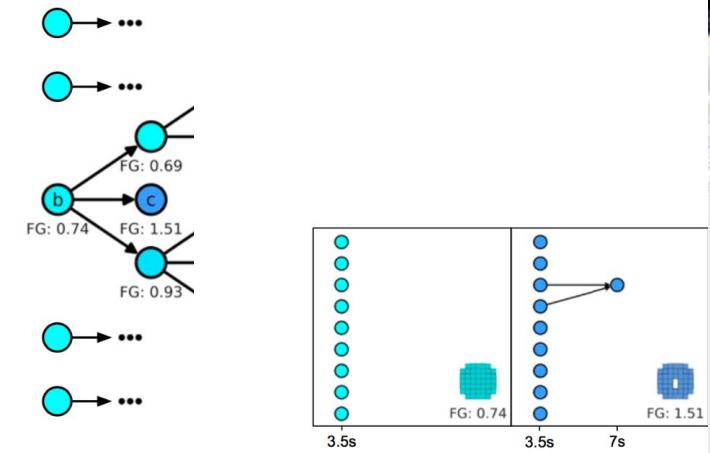
Kriegman, Blackiston, Levin & Bongard (2021). *PNAS*.

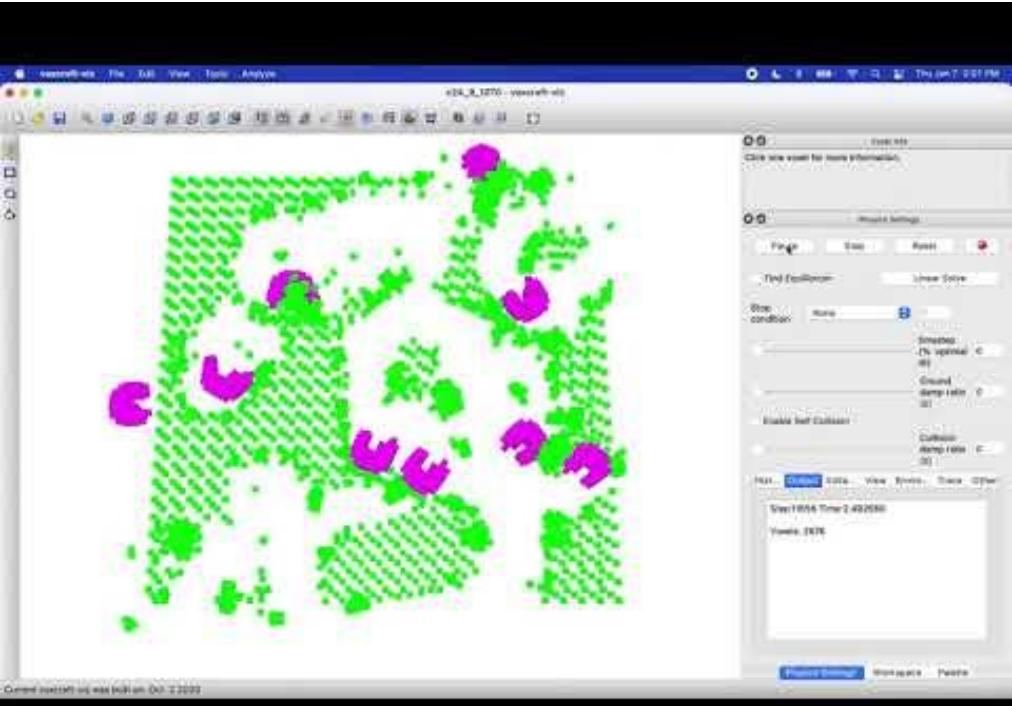
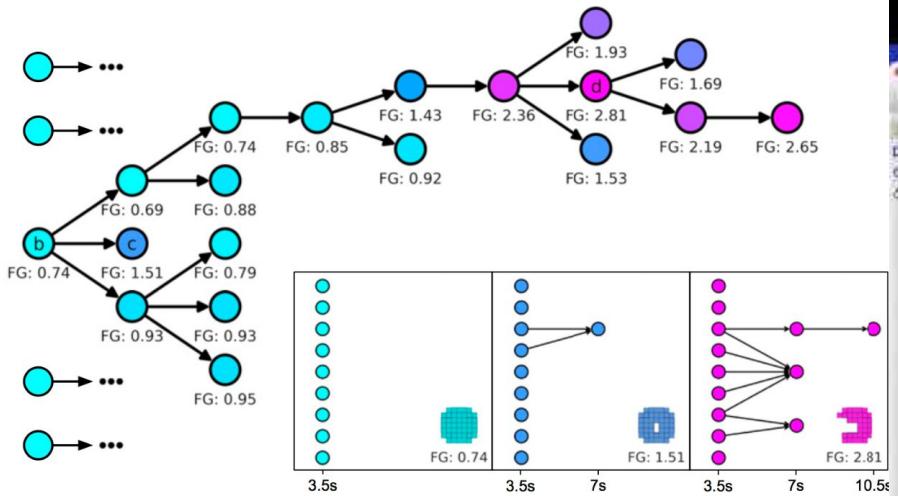


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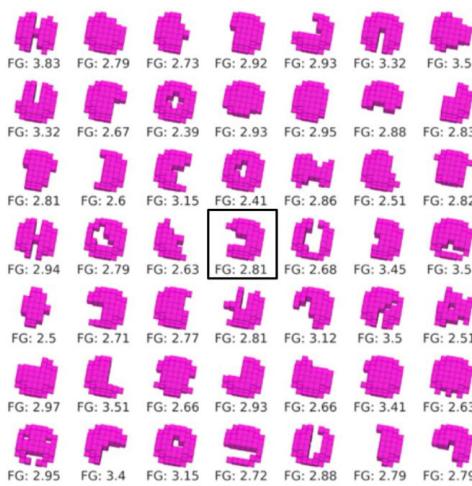
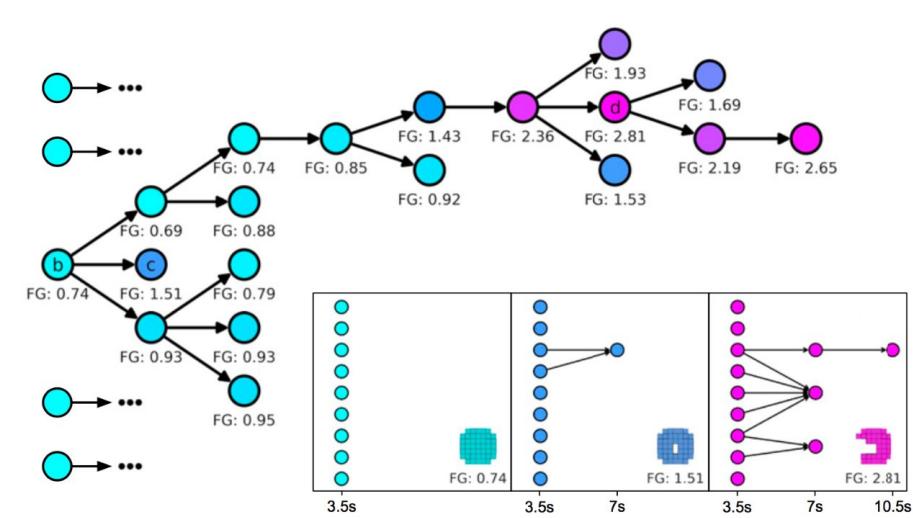


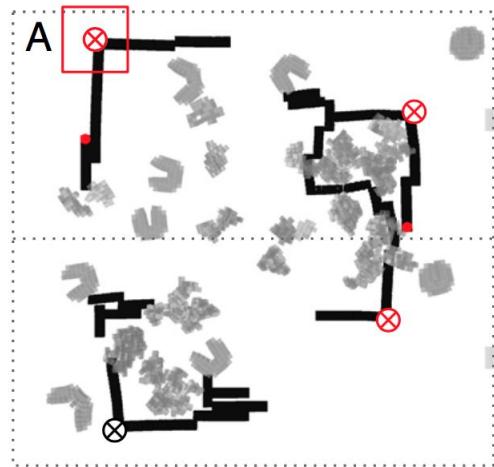




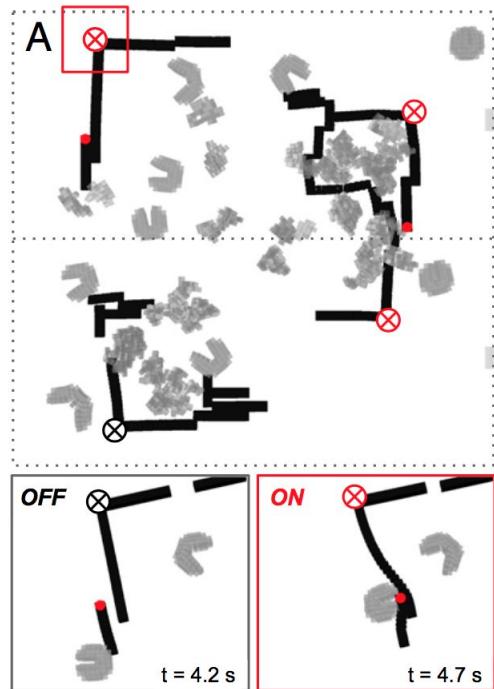


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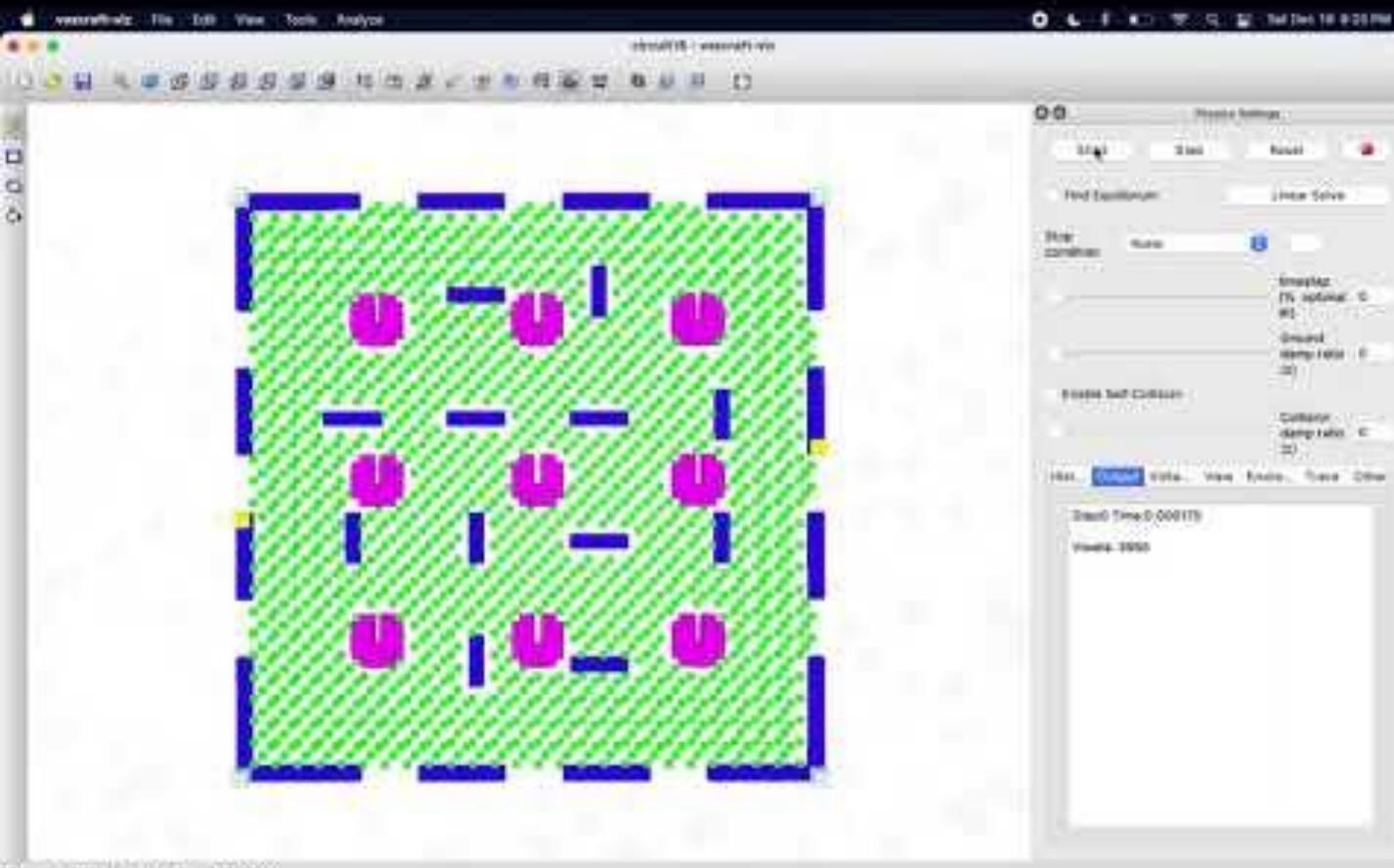




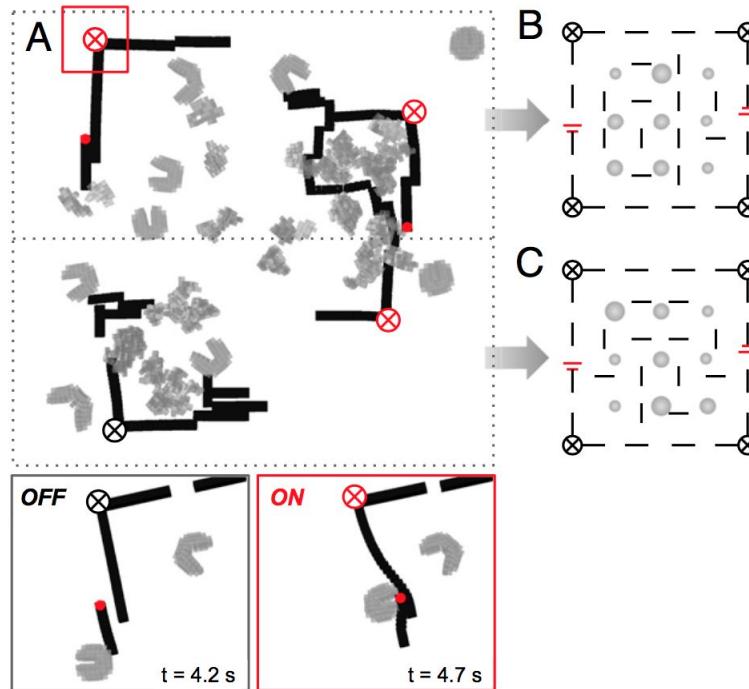
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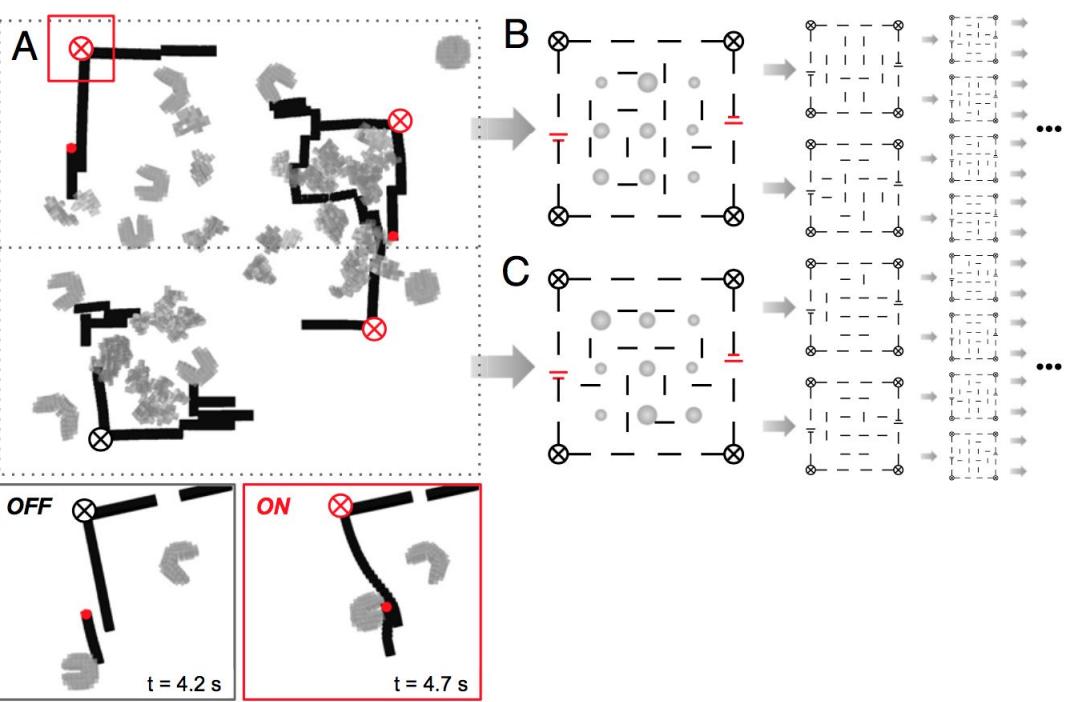
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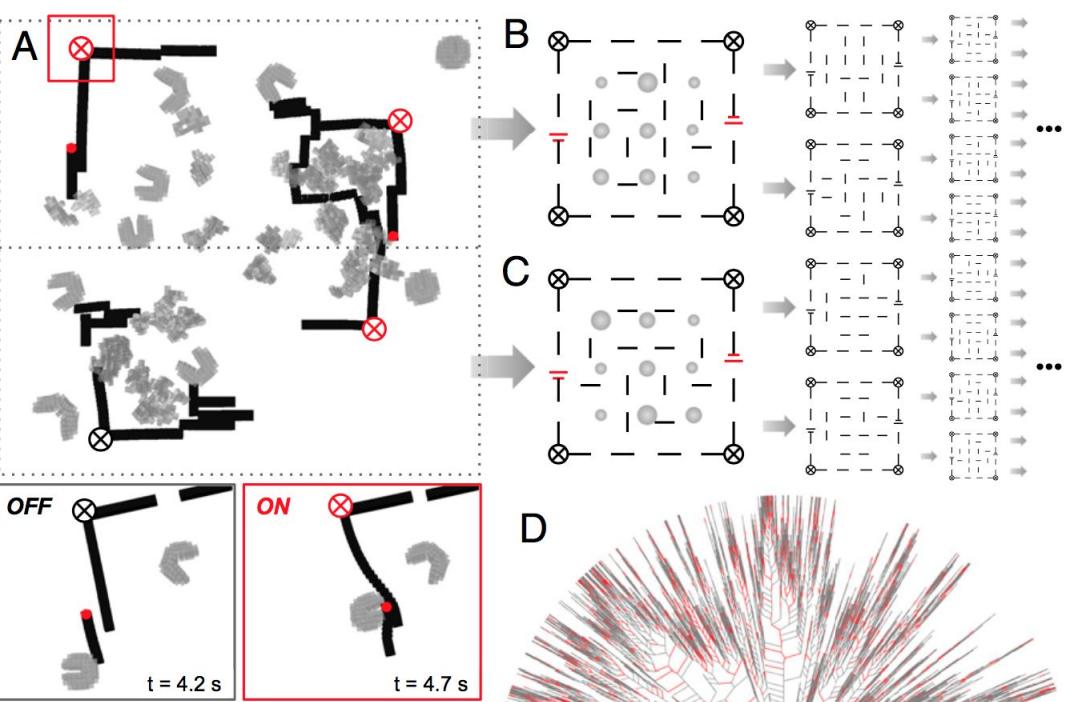
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