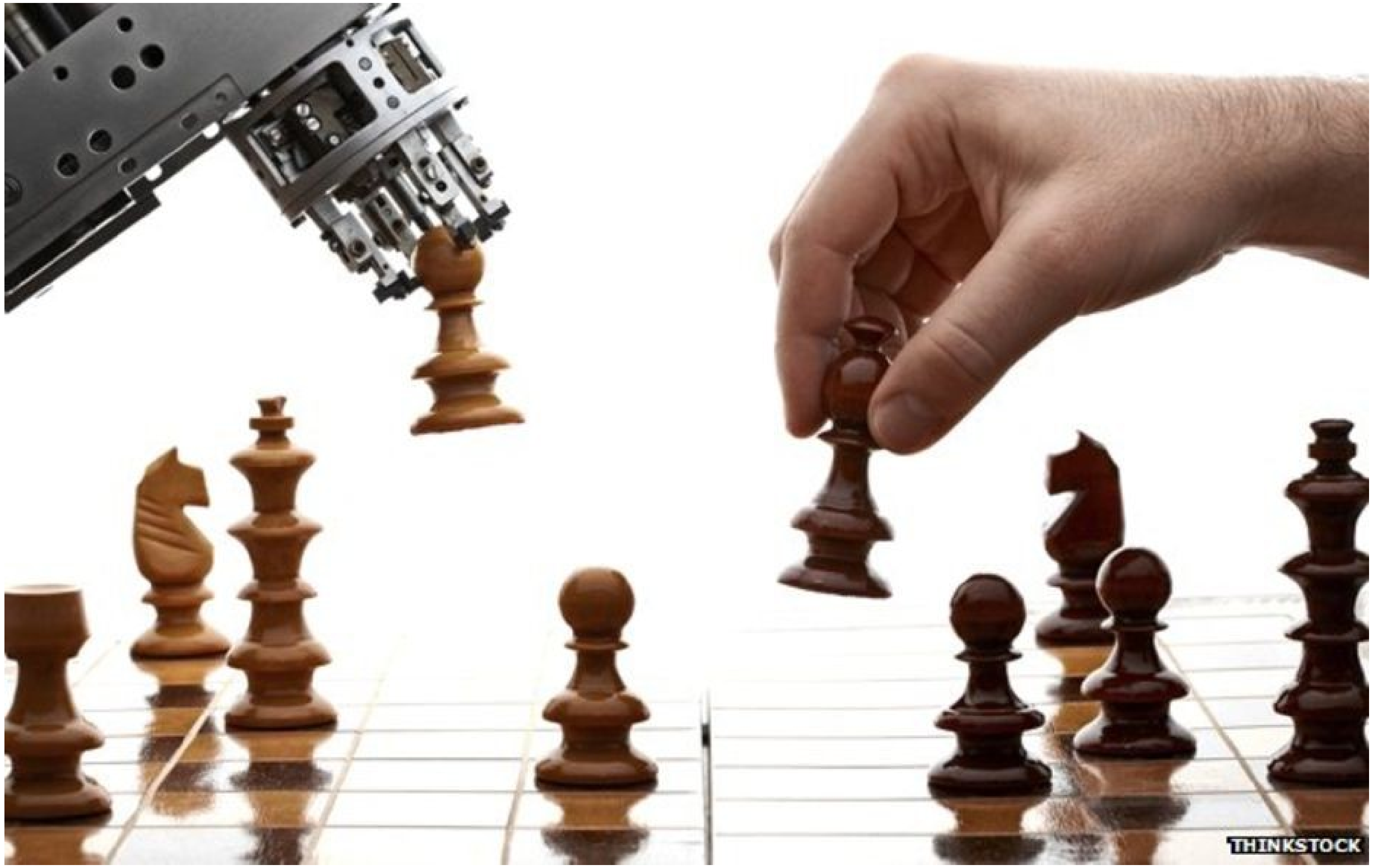


Introduction to Artificial Intelligence

COSC 4550 / COSC 5550

Professor Cheney

12/4/17

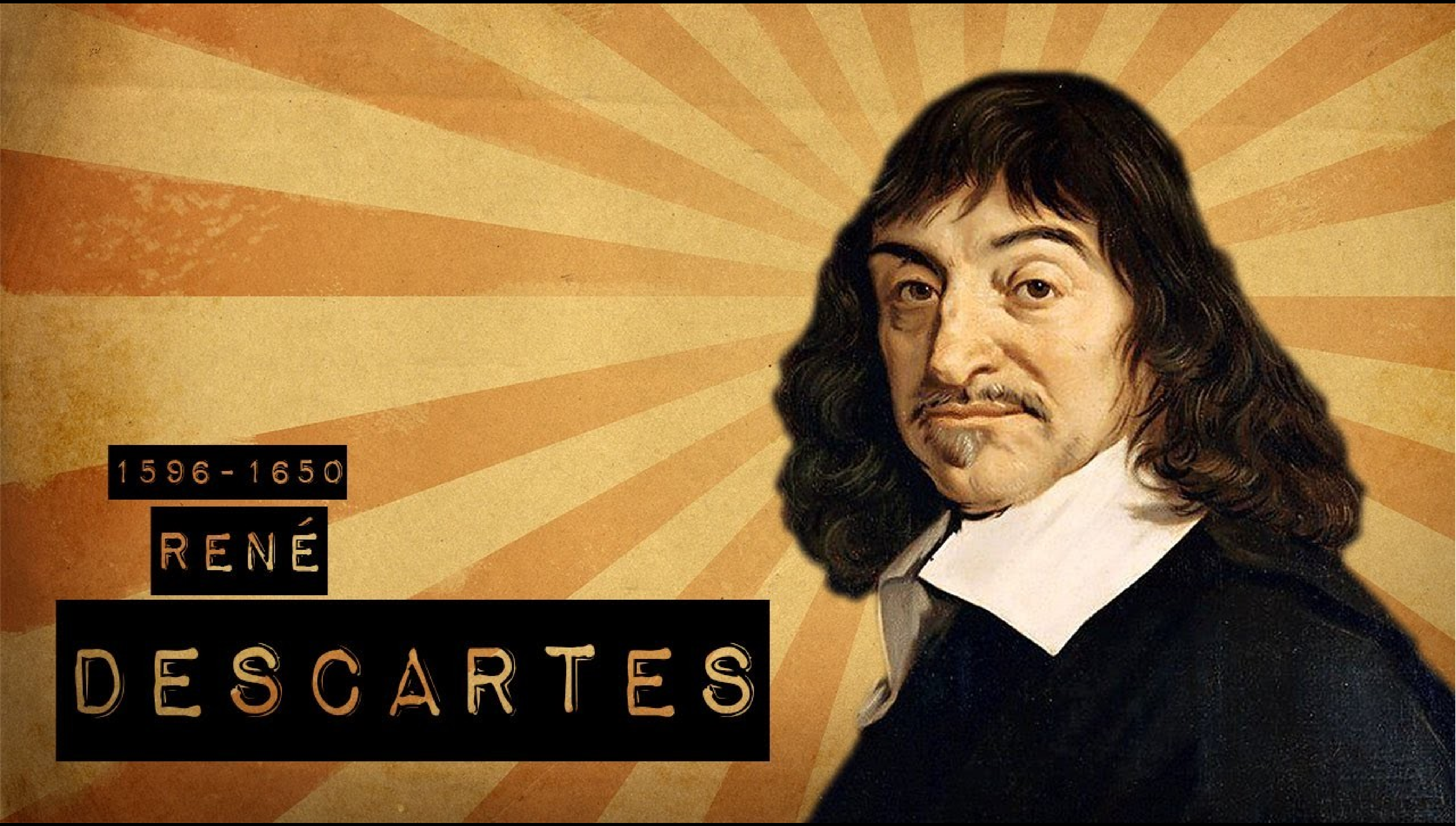
project presentations start Friday!!!

links to YouTube videos due Thursday night

video grading criteria on course website

5 minute max length strictly enforced!

embodied intelligence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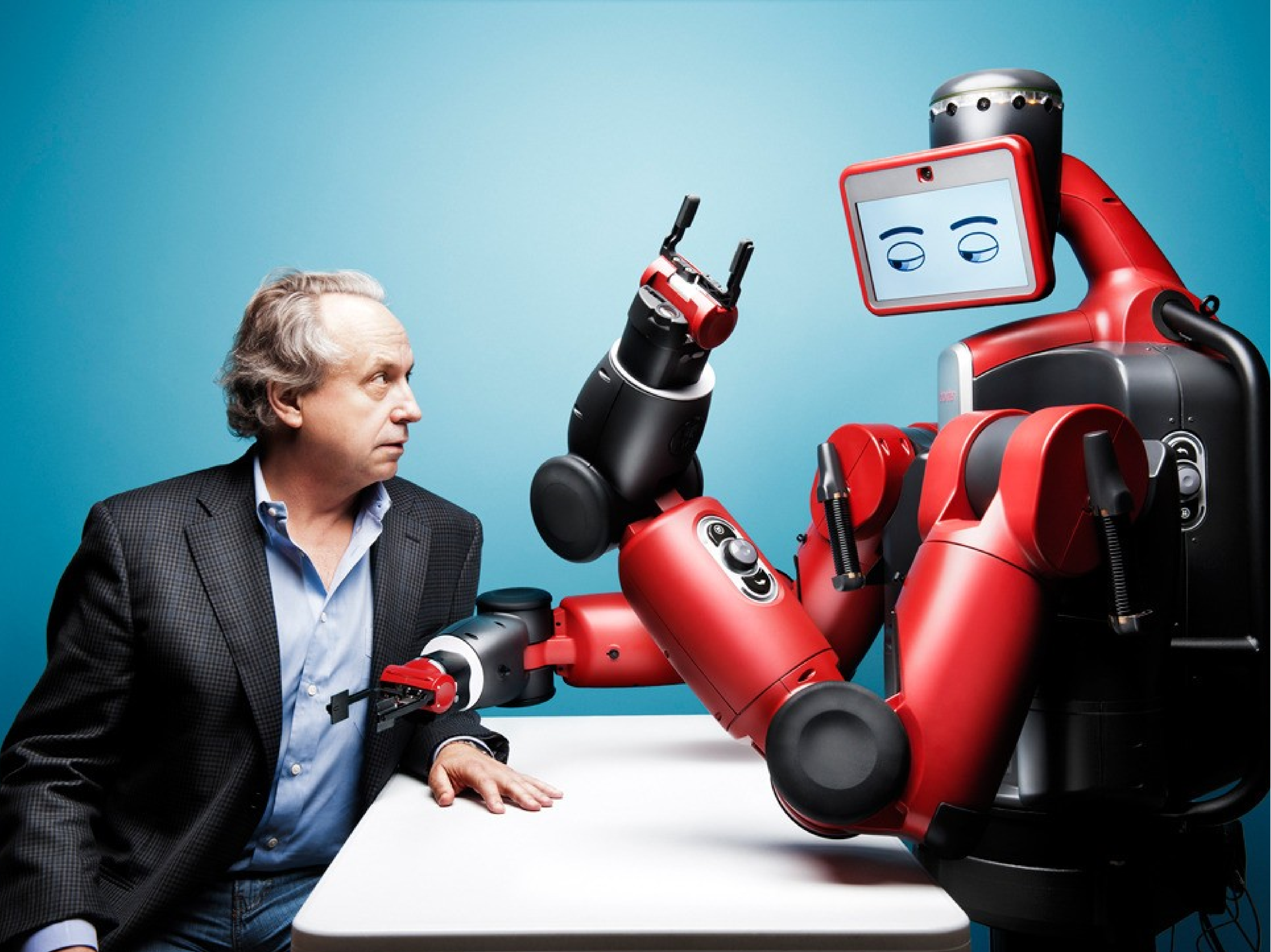


PROCEEDINGS OF THE THIRD INTERNATIONAL CONFERENCE ON SIMULATION OF ADAPTIVE BEHAVIOR

From animals to animats 3

edited by Dave Cliff, Philip Husbands,
Jean-Arcady Meyer, and Stewart W. Wilson

Modern Robotics
(COSC 4560 / COSC 5560)

how can we use ideas from biology to improve the optimization of robots?

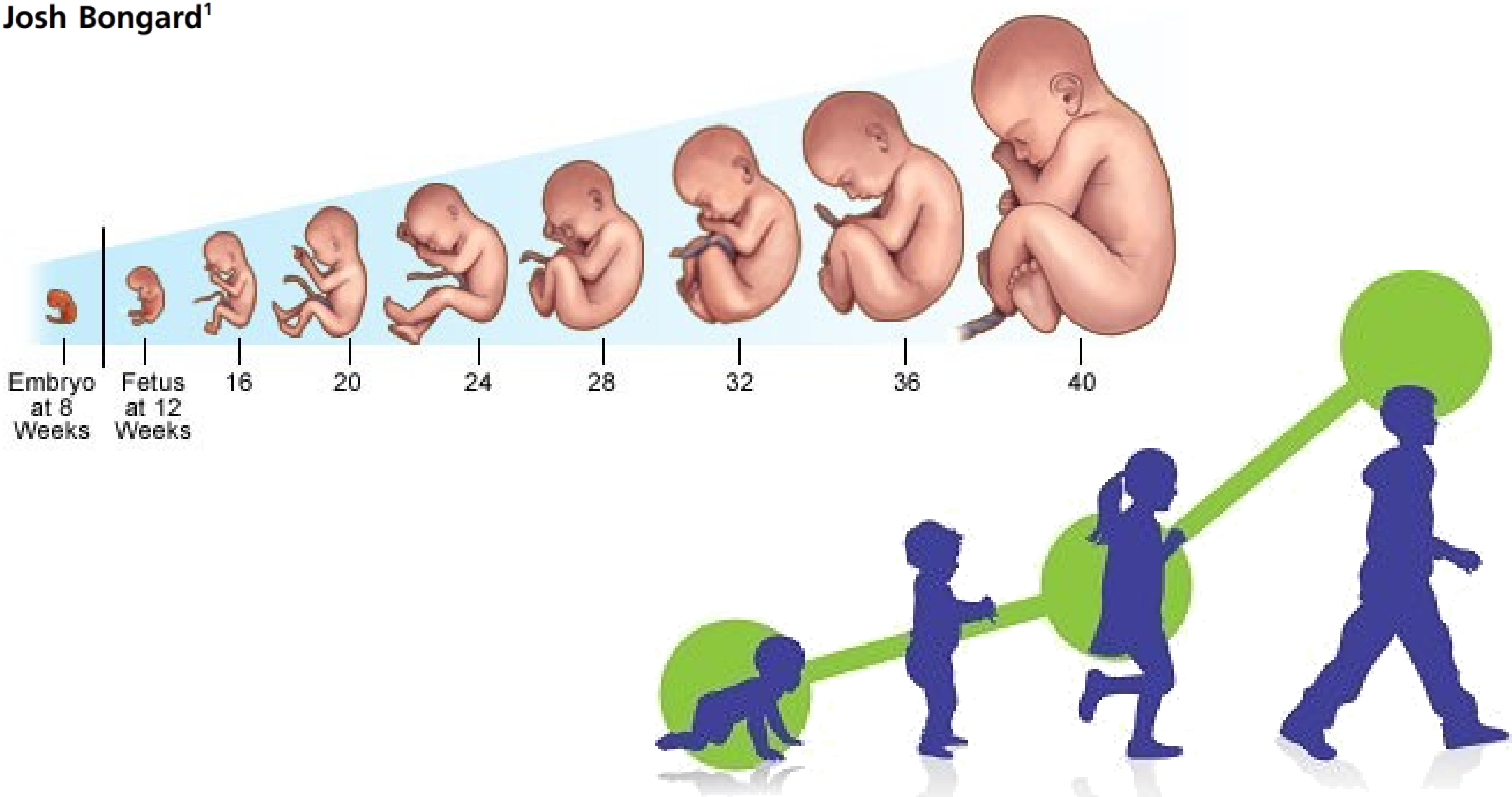
how can we use robots to improve the understanding of optimization in biology?

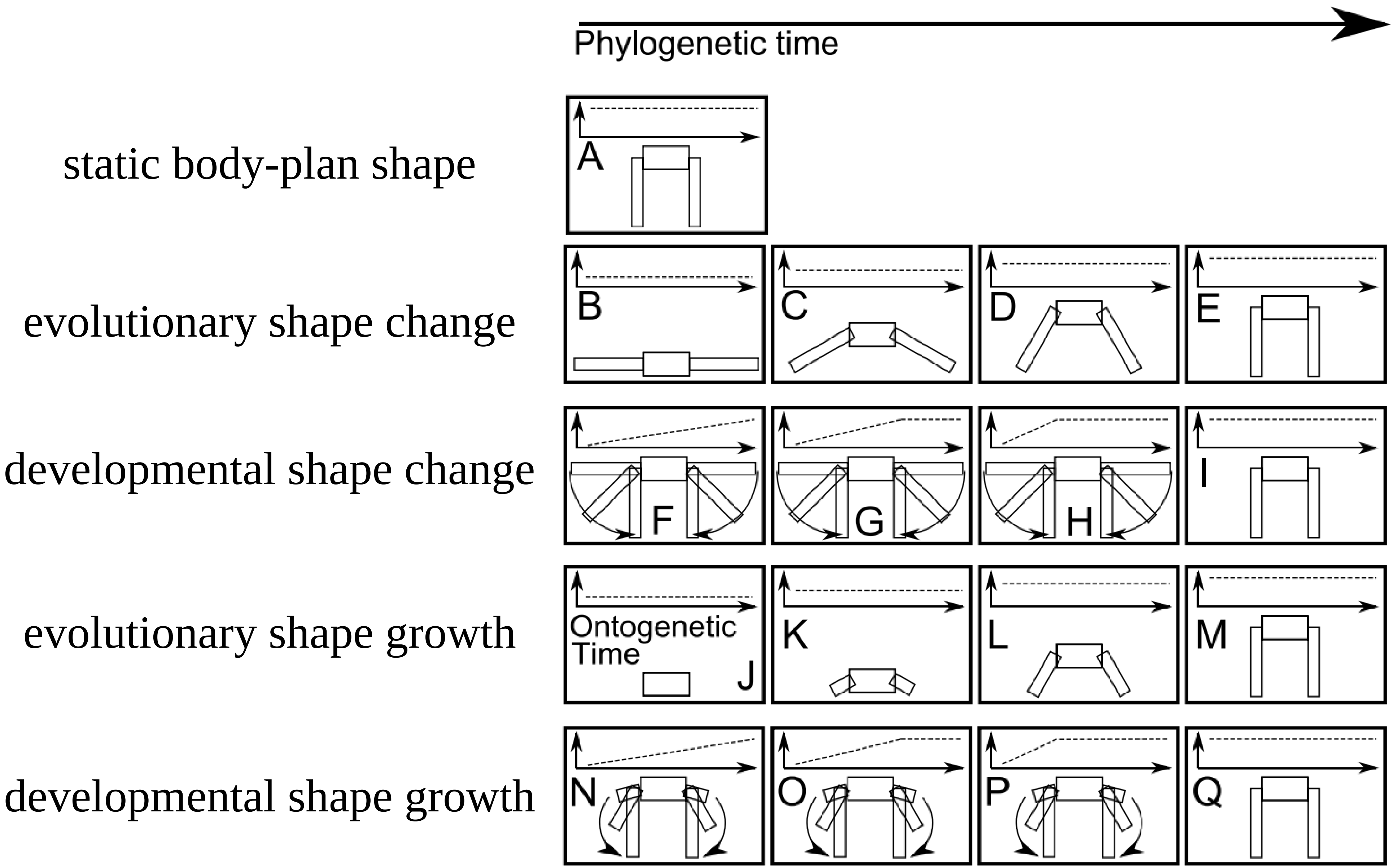
Morphological change in machines accelerates the evolution of robust behavior

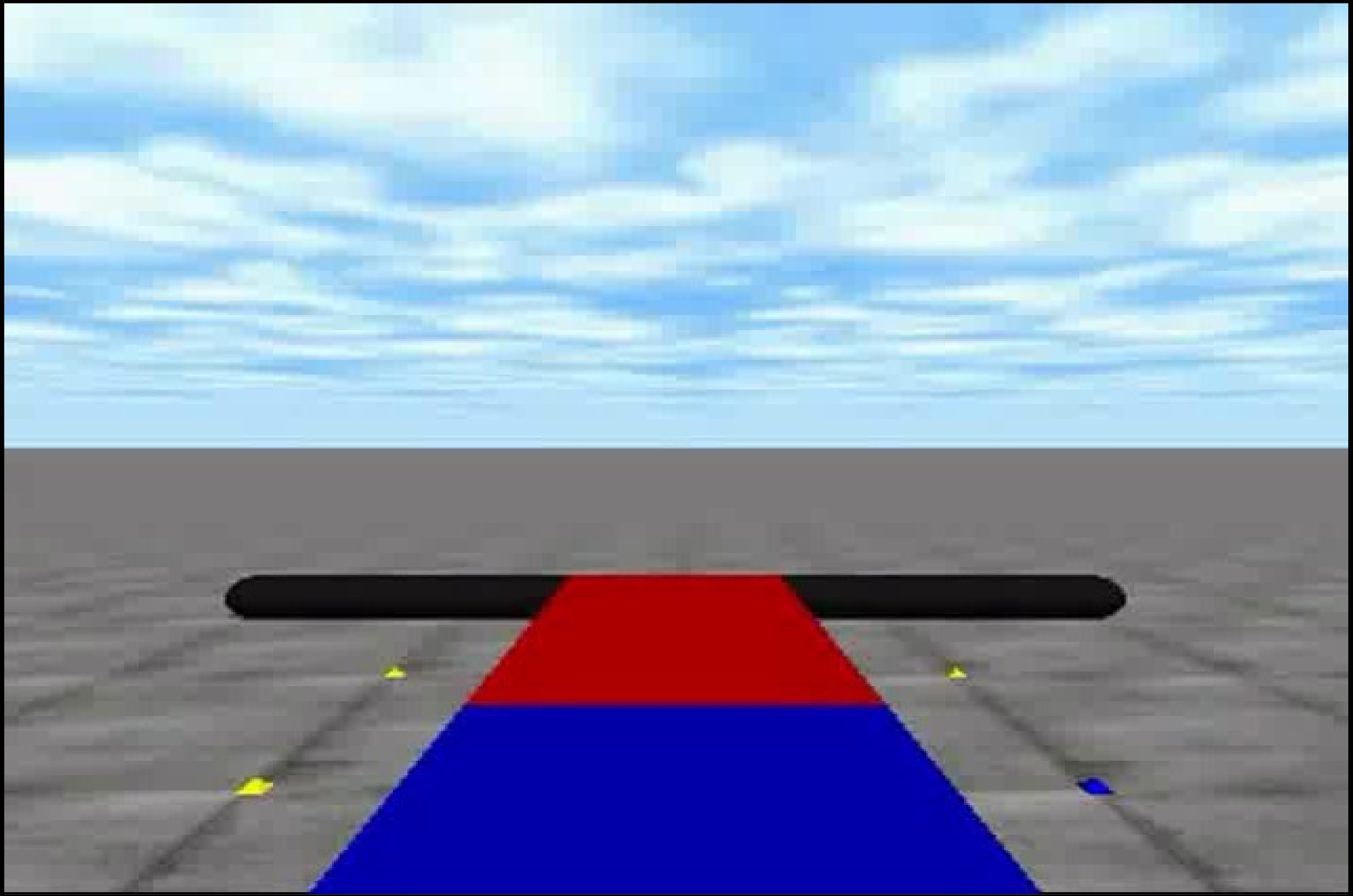
Josh Bongard[1]

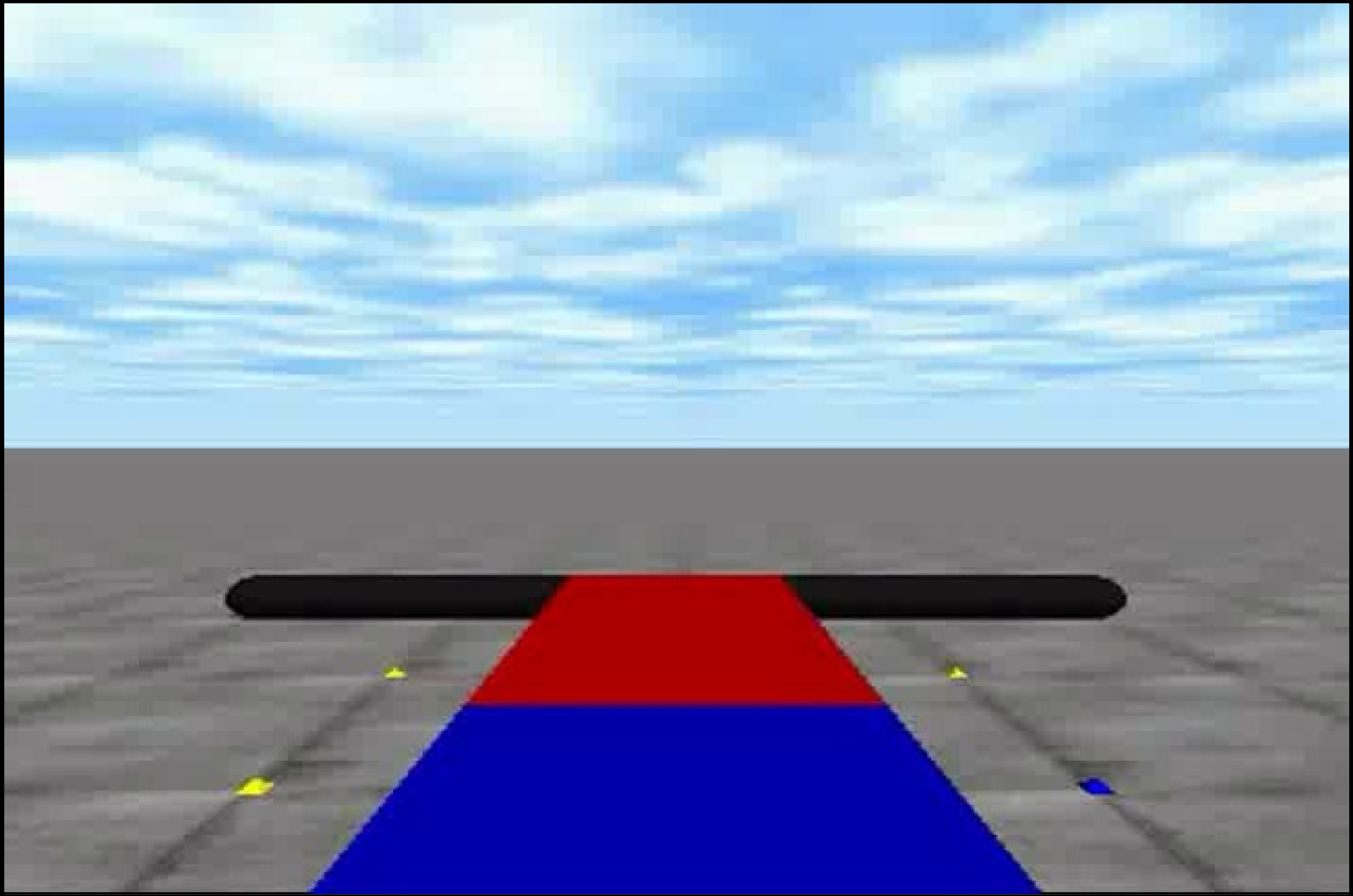
Morphological change in machines accelerates the evolution of robust behavior

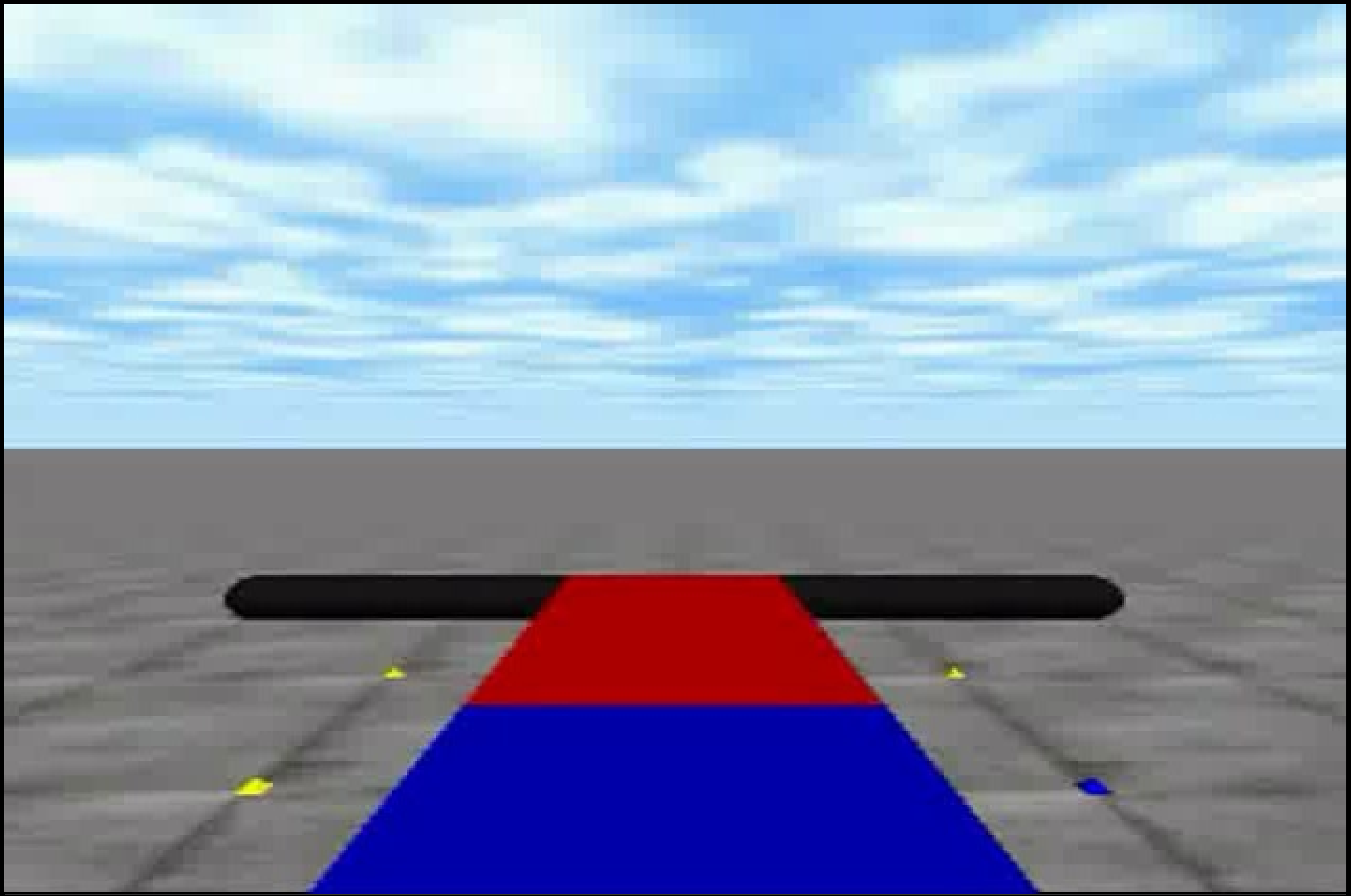
Josh Bongard[1]

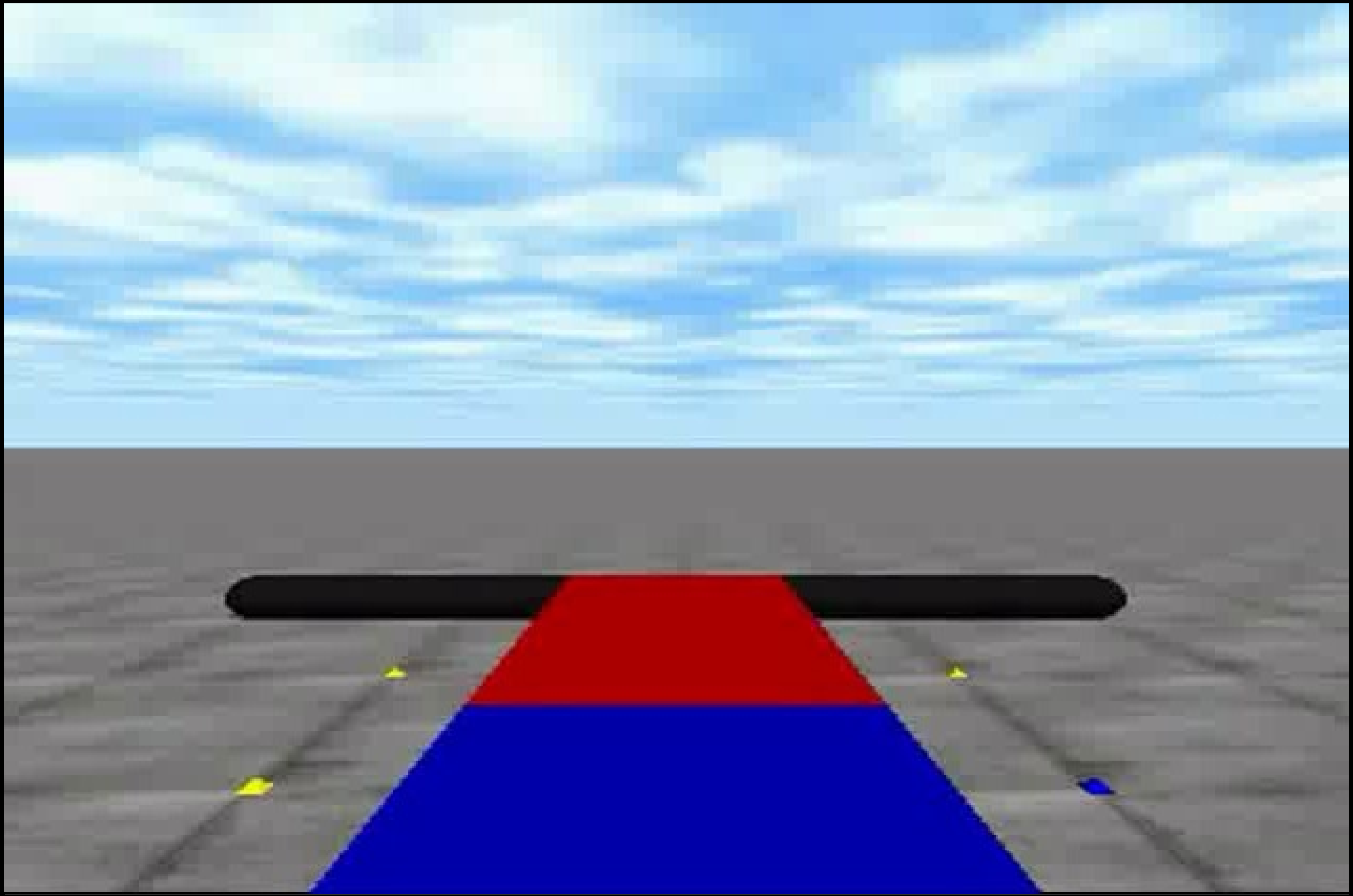


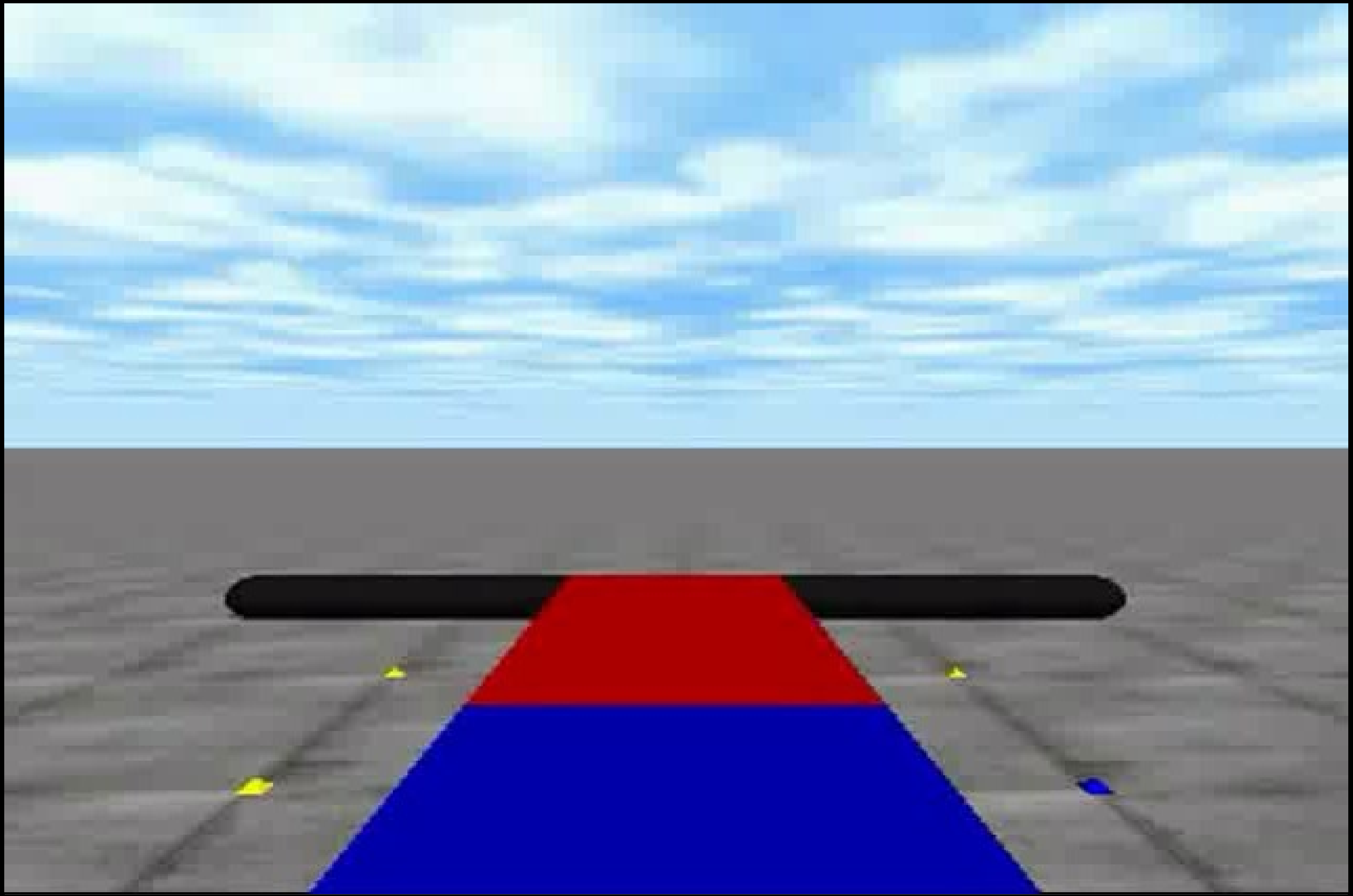

Phylogenetic time
static body-plan shape
evolutionary shape change
developmental shape change
evolutionary shape growth
developmental shape growth
A
B
C
D
E
F
G
H
I
Ontogenetic Time
J
K
L
M
N
O
P
Q

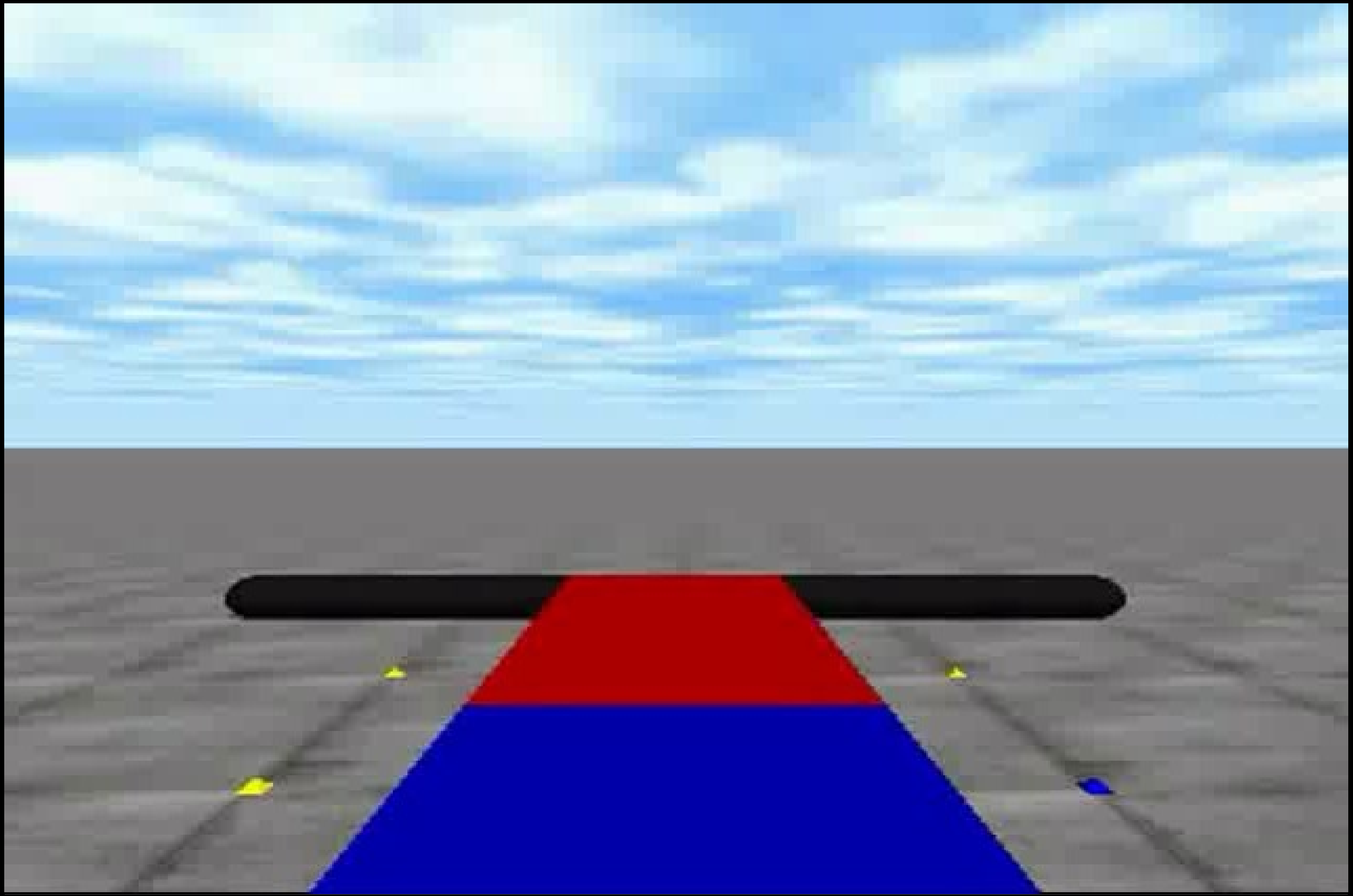


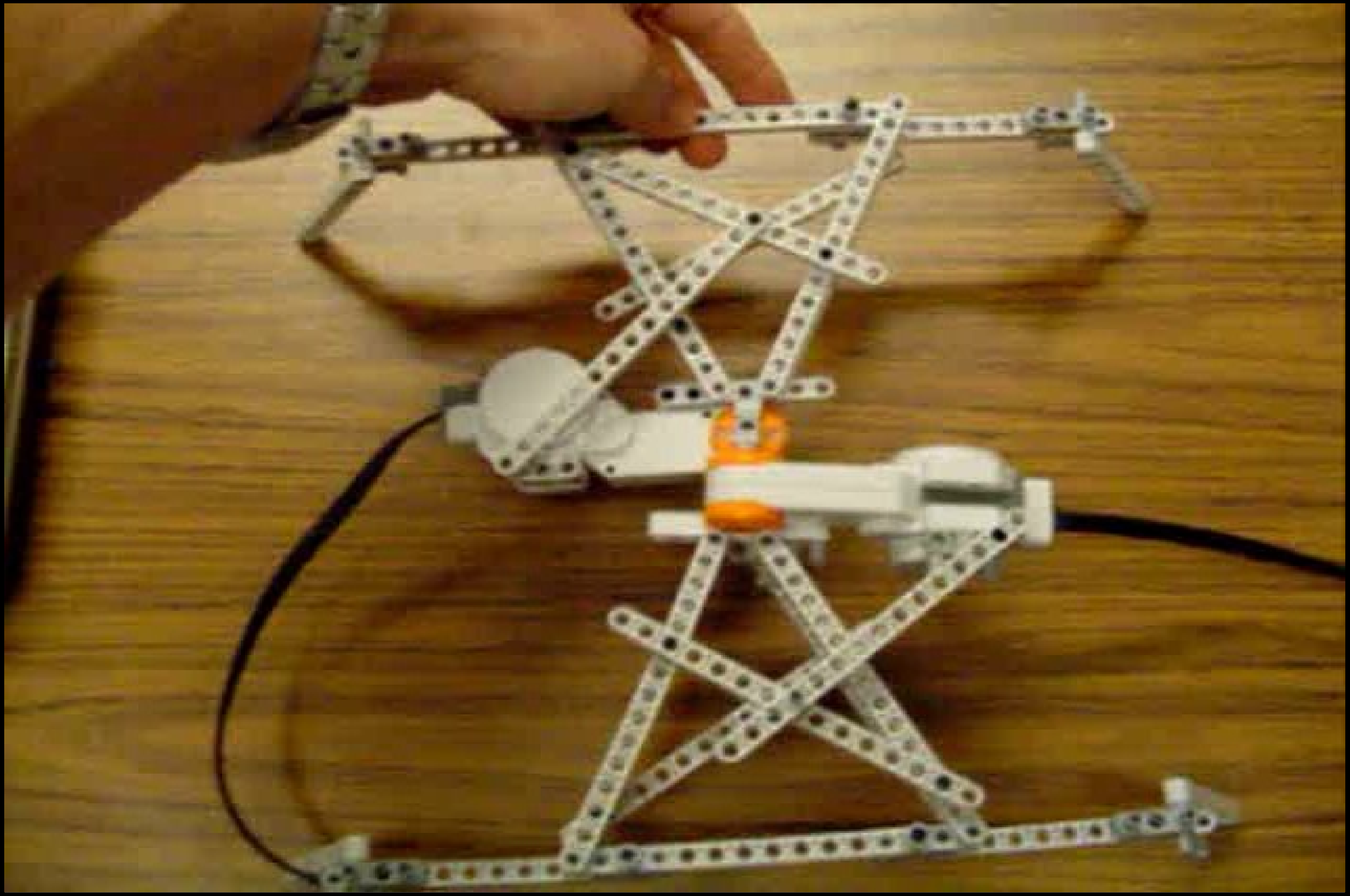












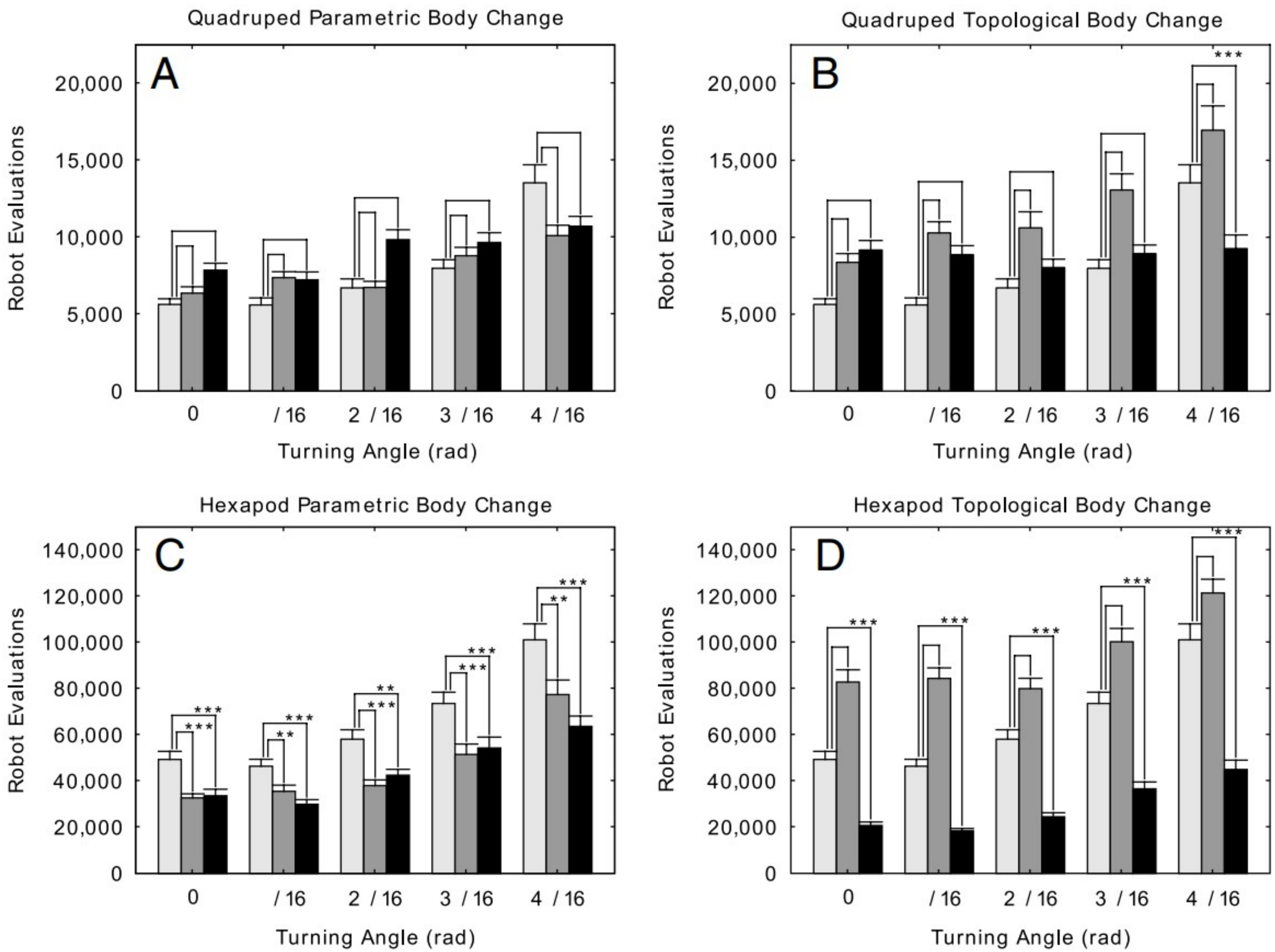


Fig. 3. How morphological change affects the time to discovery of the desired behavior in the quadruped (*A* and *B*) and hexapod (*C* and *D*) robot. Light gray bars indicate the number of controllers that had to be evaluated when no morphological change was allowed. Dark gray bars indicate the discovery time when the robots' body plans did not change during a robot's lifetime, but did change over evolutionary time. Black bars indicate the discovery time when body plans changed during each robot's lifetime, and also over evolutionary time. The dark gray and black bars in *A* and *C* report the impact of changing the robot's body plans parametrically; the dark gray and black bars in *B* and *D* report the impact of changing the robot's body plans topologically. Asterisks report statistically significant differences between no morphological change and topological, ontogenetic morphological change. Error bars report one unit of standard error of the mean.

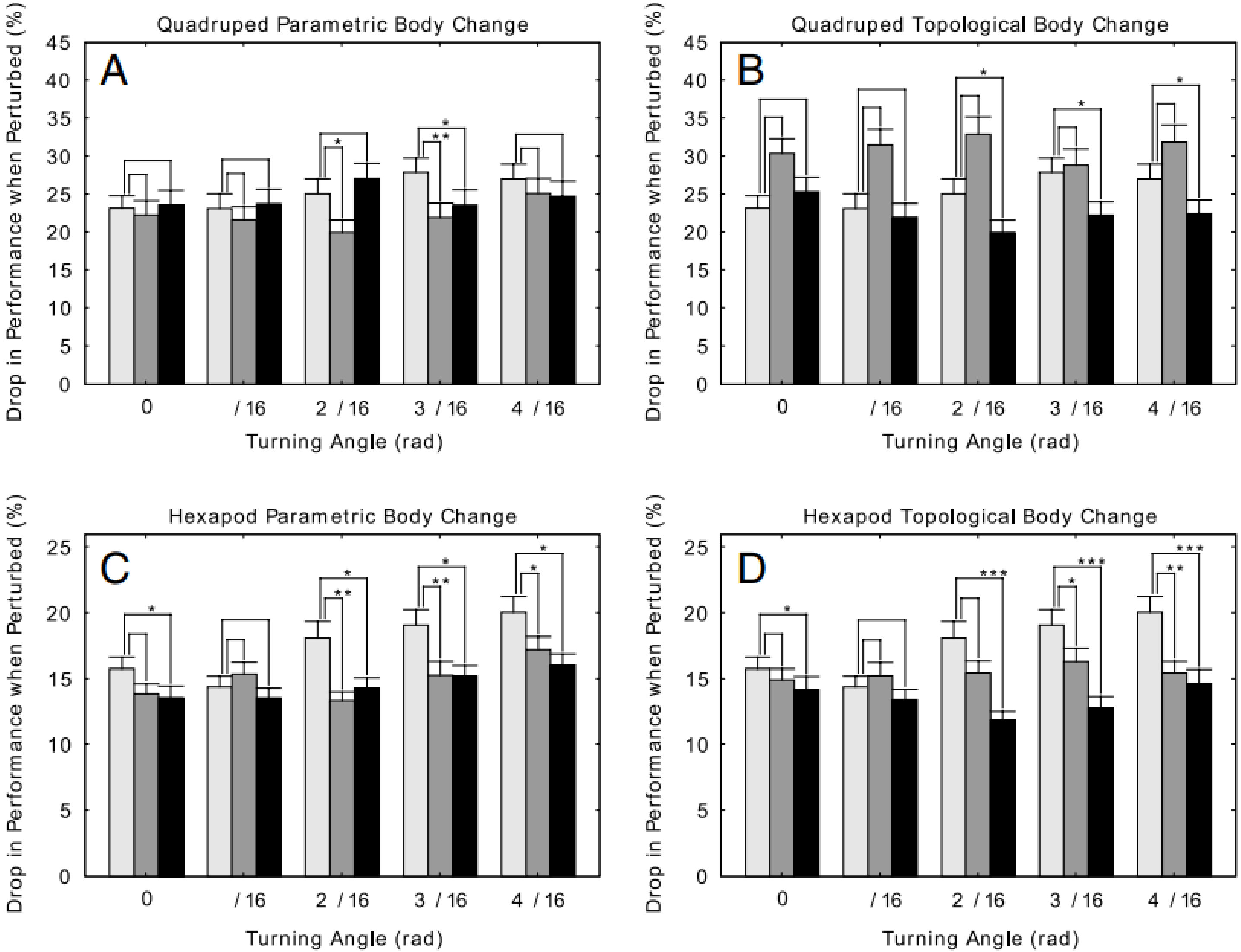


Fig. 4. How morphological change affects the robustness of the discovered behaviors. Bars report results from the same set of trials described in Fig. 3. The final robot capable of phototaxis from each independent experiment was reevaluated 100 times in the same simulated environment in which it evolved, but now exposed to small random external perturbations. The reduction in its ability to reach the light source was computed as the percent difference between the original distance it traveled and its new distance traveled during the perturbation.

this paper (and ALife in general) is great because it:

provides an (optimization) efficiency rationale
for a constraint problem in biology

uses a simple toy robotic model to zoom in on one
specific aspect of a very complex biological phenomenon

uses an established theory from psychology (shaping)
to explain the results from this toy model

uses repeated controlled experiments to show the conditions
when this phenomenon does and doesn't hold true

to demonstrate the difficulty/ethics of performing behavioral experiments on the role of developmental trajectories in a biological setting...

Journal of Comparative and Physiological Psychology
1963, Vol. 56, No. 5, 872–876

MOVEMENT-PRODUCED STIMULATION IN THE DEVELOPMENT OF VISUALLY GUIDED BEHAVIOR[1]

RICHARD HELD[2] AND ALAN HEIN[2]

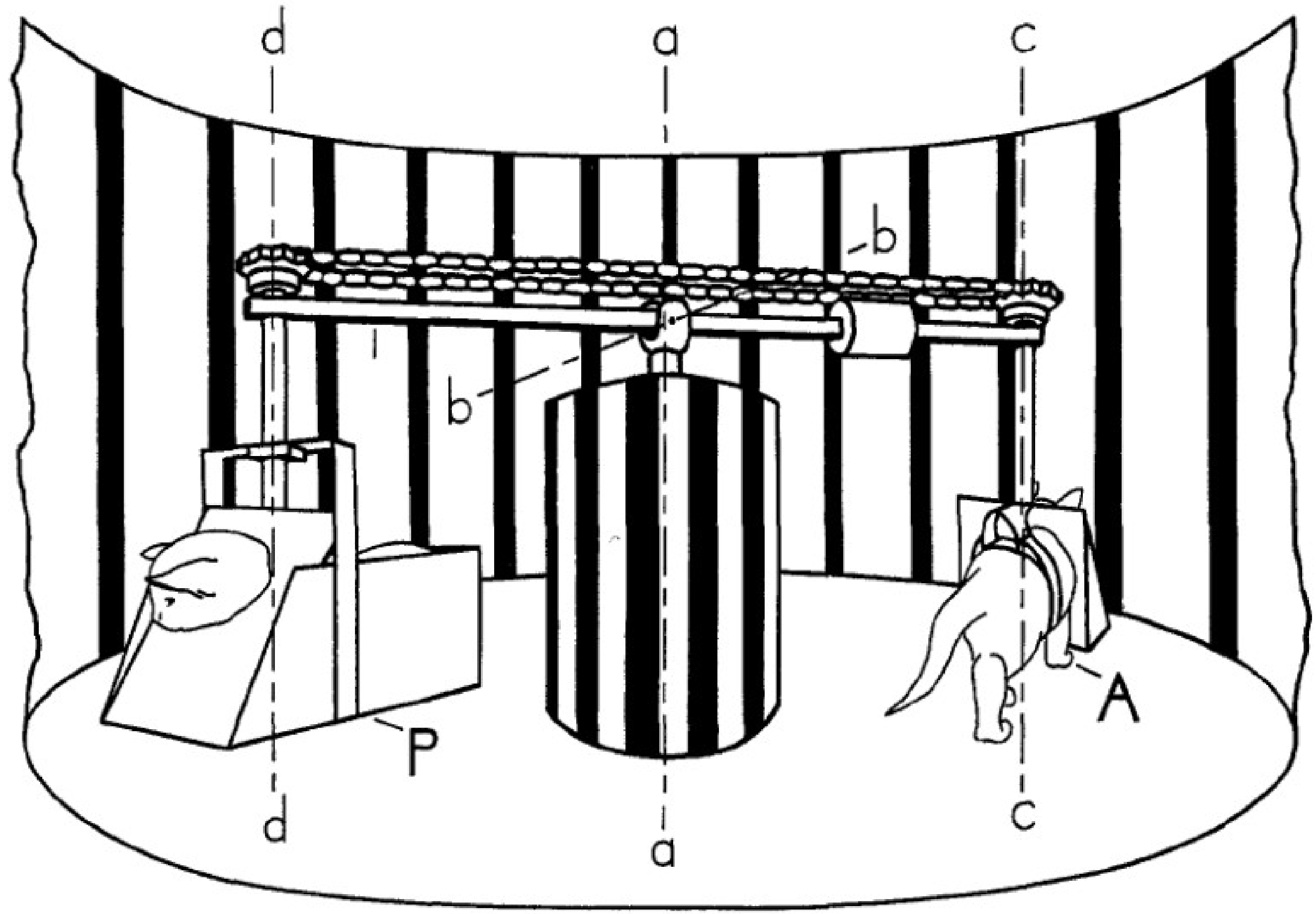


FIG. 1. Apparatus for equating motion and consequent visual feedback for an actively moving (A) and a passively moved (P) *S*.

despite getting the same visual inputs,
passive subjects did not:

recognize visual cliffs

respond to a blink test

anticipate surfaces

(after having time to explore, some behaviors were regained
but such experiments are still considered inhumane today)

the idea of creating robust morphologies and behaviors also applies to the ideas we're studied this semester

(e.g. control policy optimization, and updating beliefs with via Bayesian optimization)

INSIGHT
Machine intelligence

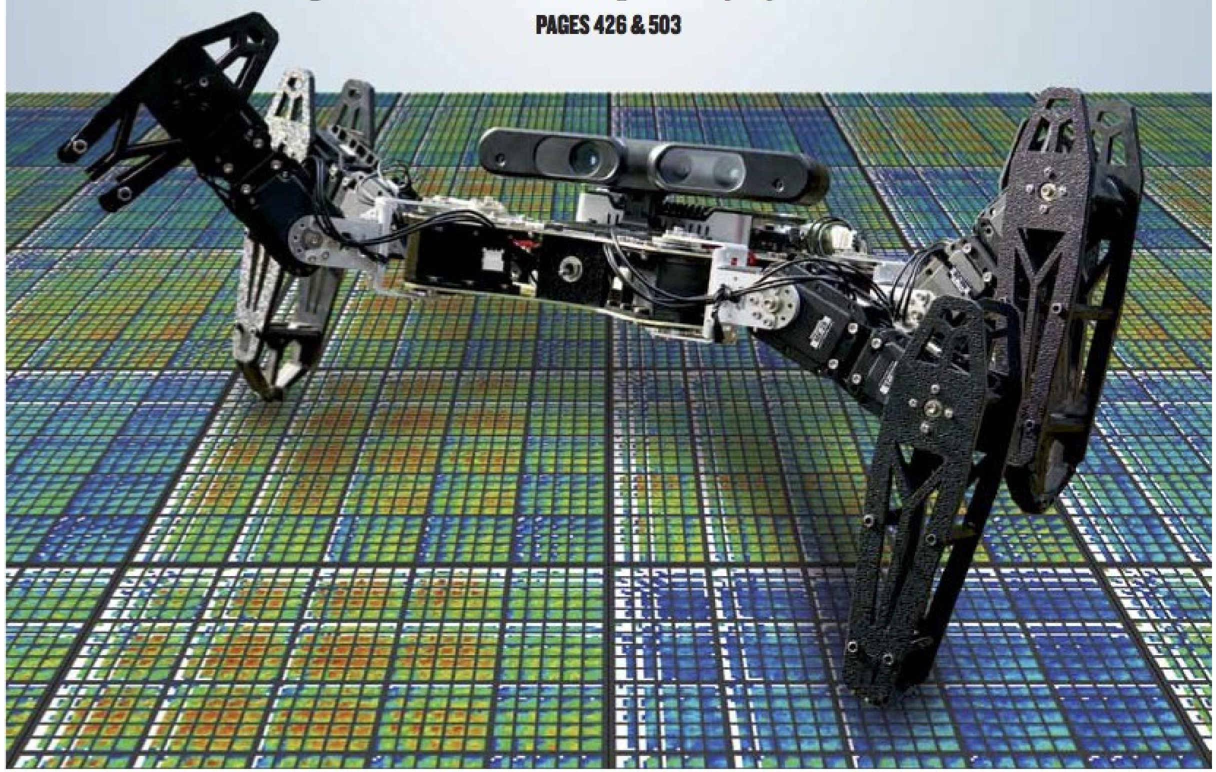
nature

THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE

Back on its feet

Using an intelligent trial-and-error learning algorithm this robot adapts to injury in minutes

PAGES 426 & 503



COGNITION

WHY FISH NEED TO BE CLEVER

Social behaviours need plenty of brainpower

PAGE 412

ARTIFICIAL INTELLIGENCE

LIVING WITH ROBOTS

AI researchers' ethics prescriptions

PAGE 415

HUMAN EVOLUTION

ANOTHER FACE IN THE CROWD

A new hominin from Ethiopia's middle Pliocene

PAGES 432 & 483

NATURE.COM/NATURE
28 May 2015 £10
Vol. 521, No. 7553
22
9 770028 083095

Robots that can adapt like animals

Nature, 2015

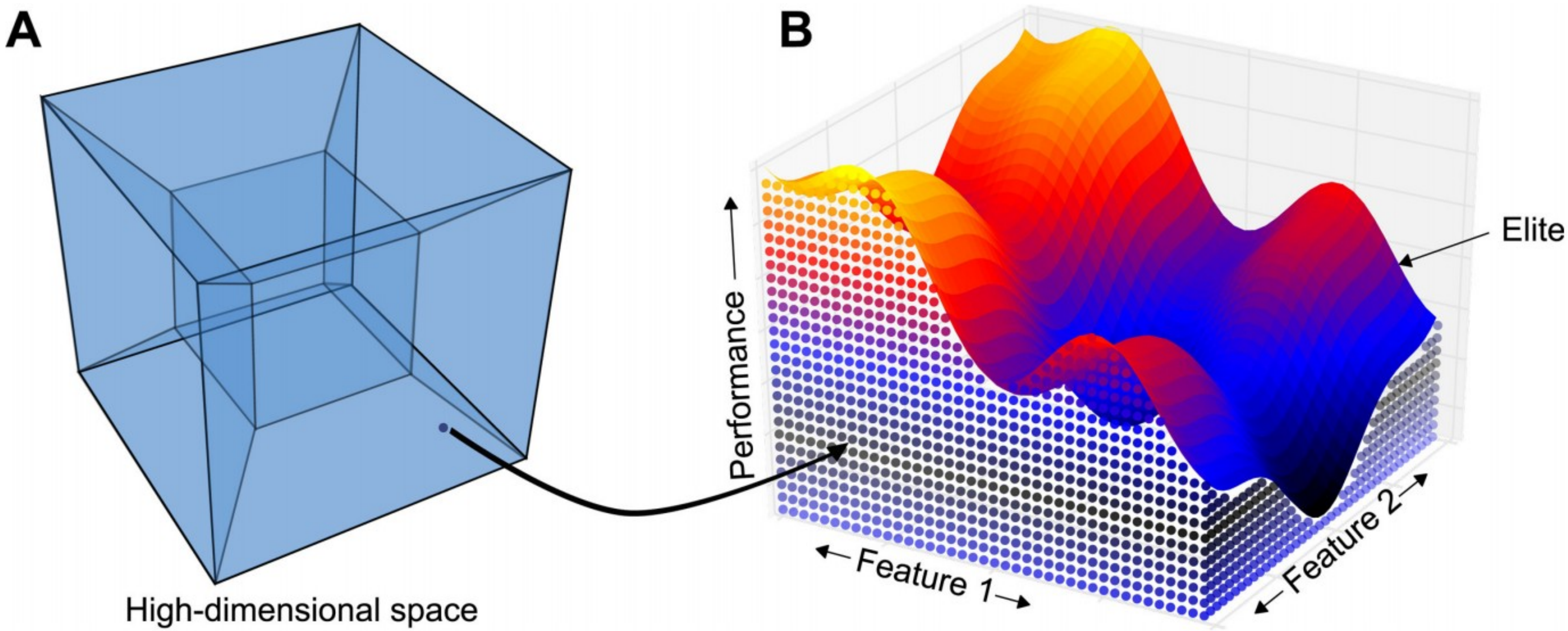
which describes damage recovery via Intelligent Trial and Error

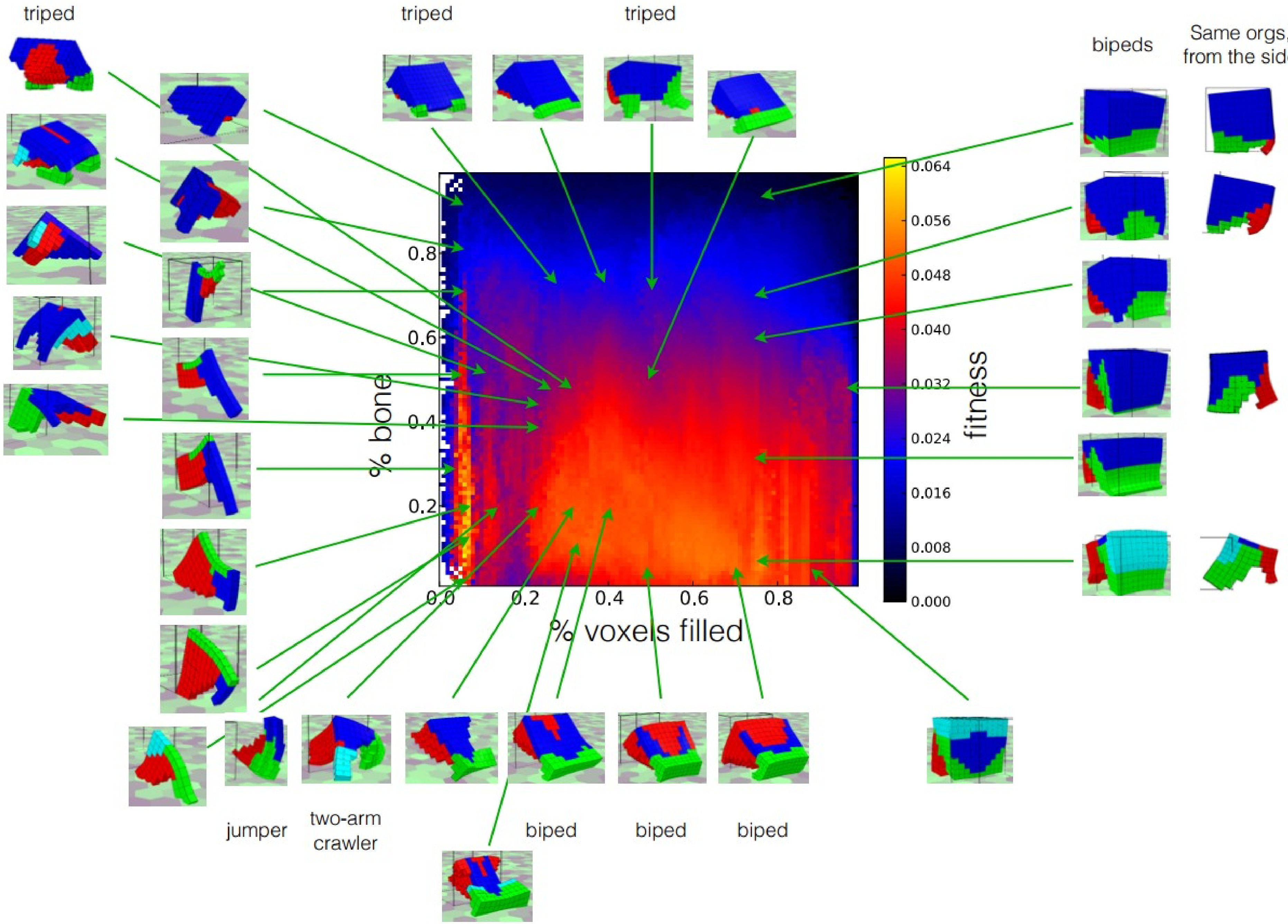
Antoine Cully
UPMC/CNRS
(France)

Jeff Clune
University of Wyoming
(USA)

Danesh Tarapore
UPMC/CNRS
(France)

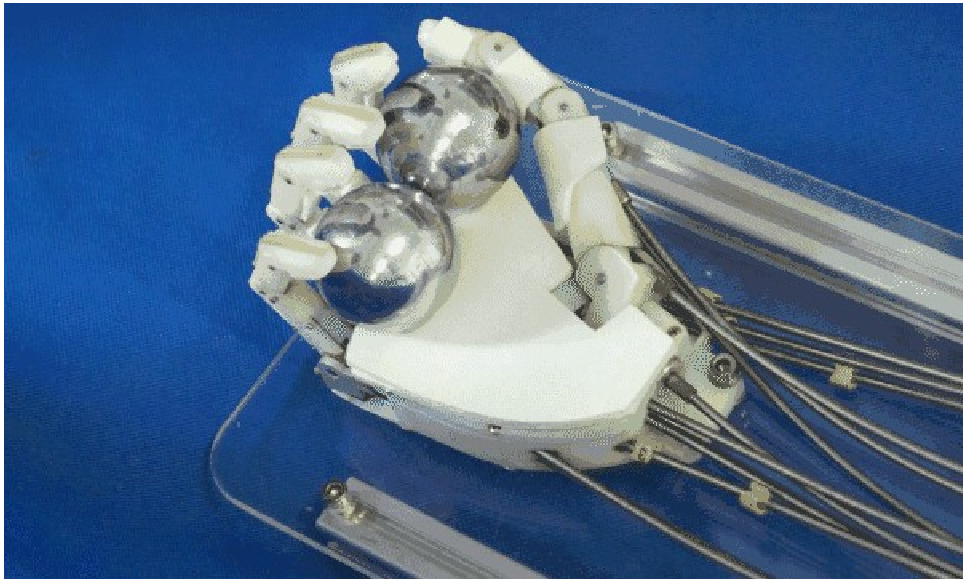
Jean-Baptiste Mouret
UPMC/CNRS/Inria/UL
(France)

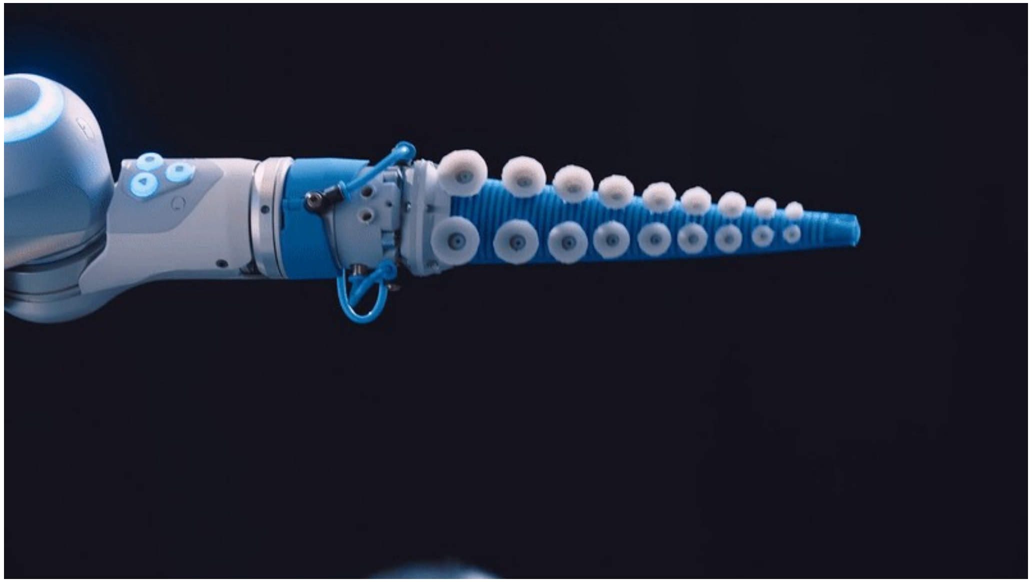

A
High-dimensional space
B
Performance
Feature 1
Feature 2
Elite

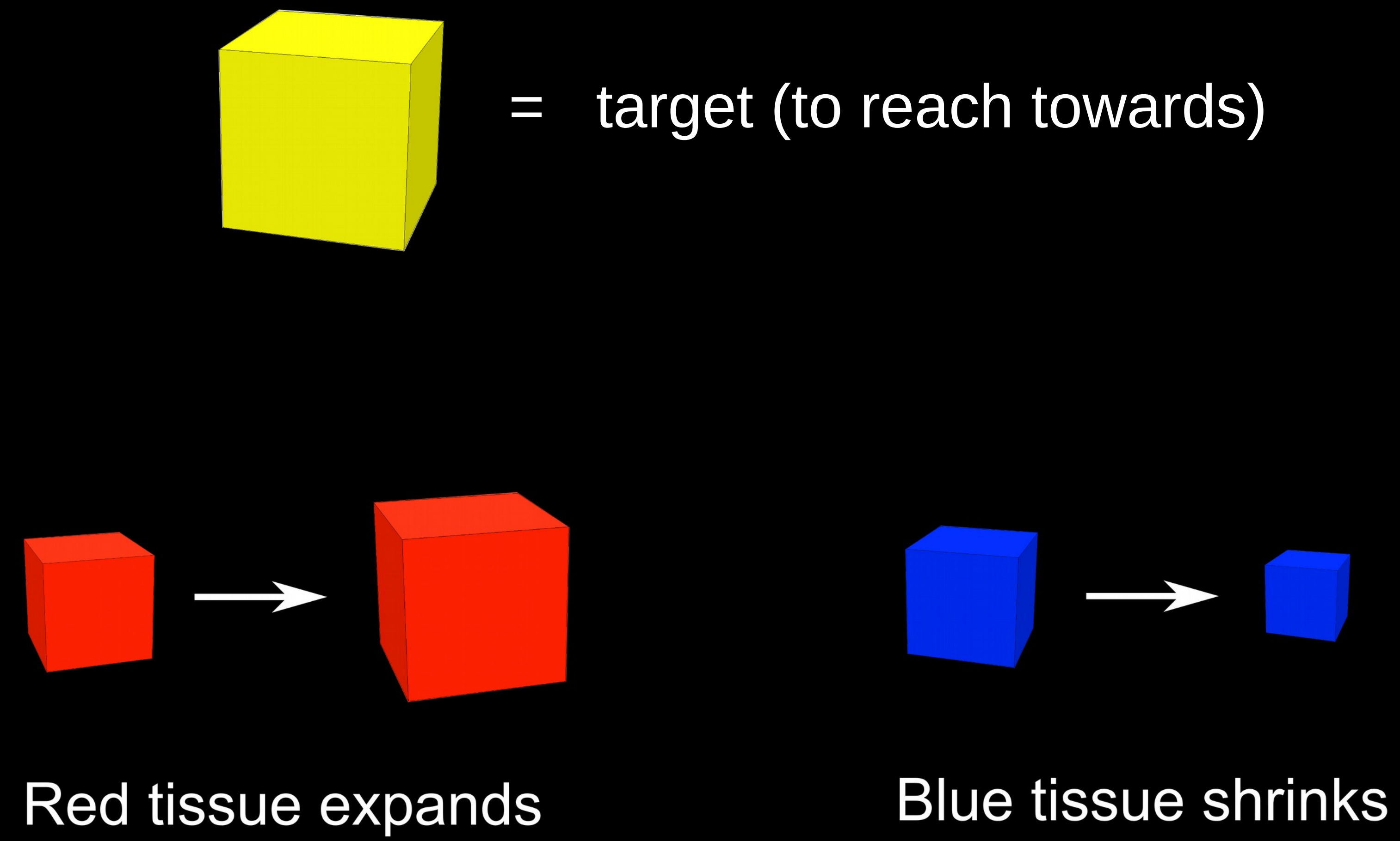


triped
triped
triped
bipeds
Same orgs, from the side
% bone
% voxels filled
fitness
0.0
0.2
0.4
0.6
0.8
0.000
0.008
0.016
0.024
0.032
0.040
0.048
0.056
0.064
jumper
two-arm crawler
biped
biped
biped

we can ask ask questions about the different types of behavioral strategies that arise, investigating how embodiment affects behaviors

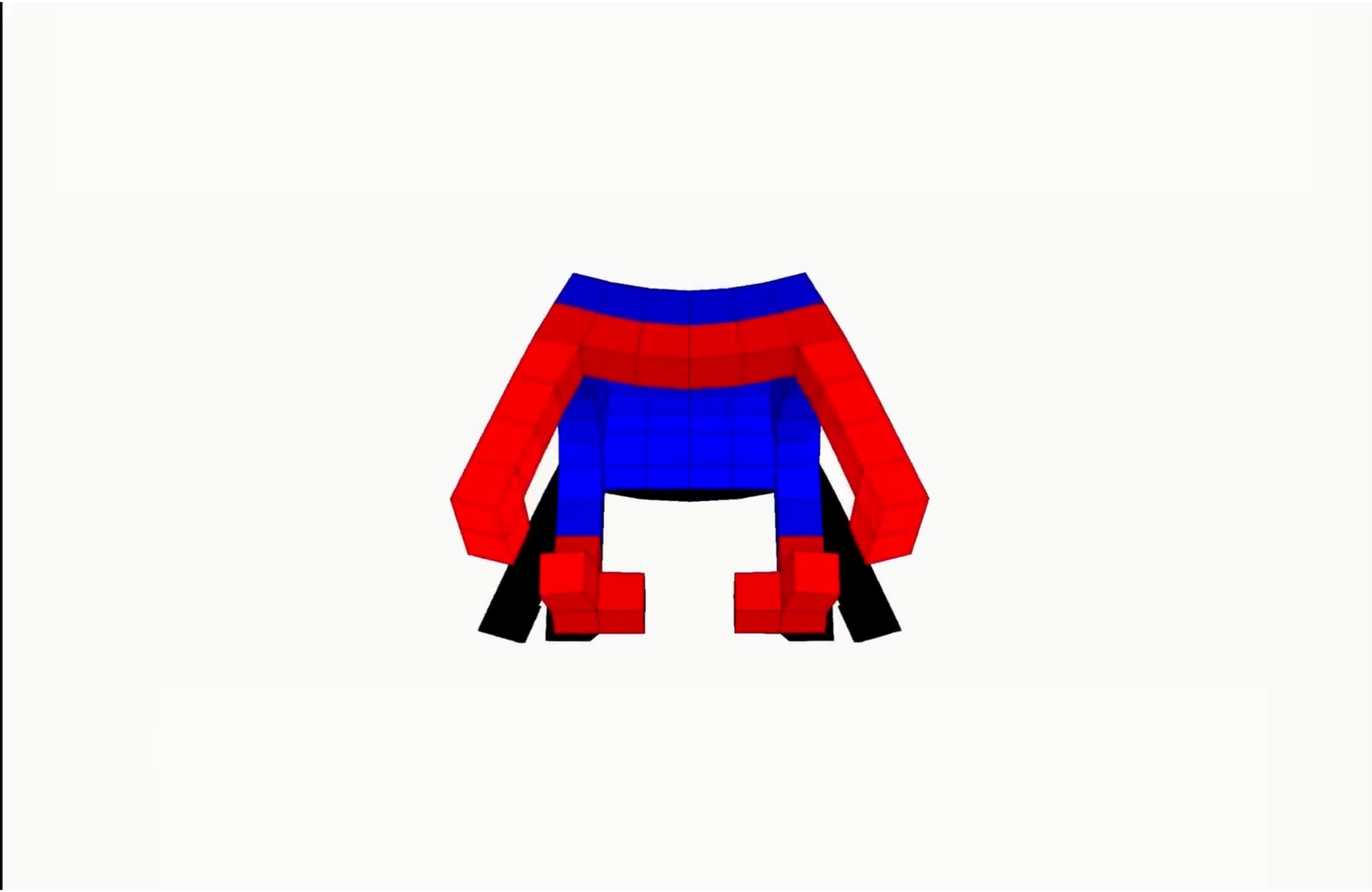





= target (to reach towards)
Red tissue expands
Blue tissue shrinks

Soft materials:

Stiff materials:



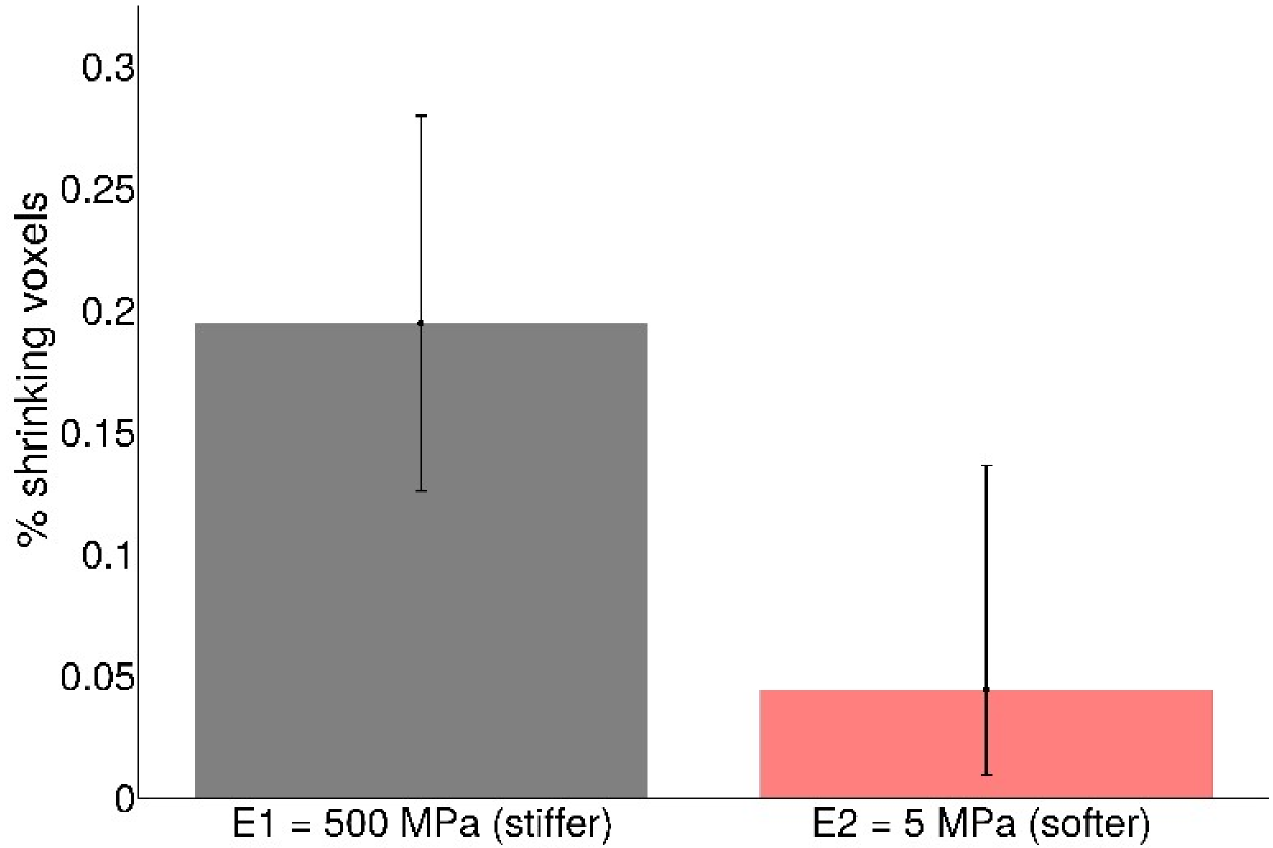


Figure 5: Stiffer robots tend to employ significantly more shrinking voxels than softer ones ($p < 0.002$), in the attempt to actively control the shape.